Center for American Progress

Part of *Progressive Growth*, CAP's Economic Plan for the Next Administration

A National Innovation Agenda

Progressive Policies for Economic Growth and Opportunity Through Science and Technology

By Tom Kalil and John Irons

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Contributors

The editors and authors of *Progressive Growth* thank their colleagues, the fellows, and staff of the Center for American Progress, listed below, who work on related issues and/or contributed to select portions of *Progressive Growth*. While the ideas and analyses of these experts inspired many of the recommendations in *Progressive Growth*, the recommendations in each report are those of that report's authors and the Center's leadership, and do not necessarily represent the views of all associated with the Center.

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A list of earlier reports published by the Center for American Progress describing policy incorporated into the *Progressive Growth* plan can be found on the inside back cover.

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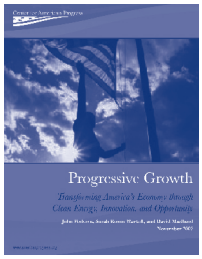
About Progressive Growth



The Center for American Progress offers a fiscally responsible investment plan to:

- *Grow our economy* through the transformation to a low-carbon economy and leadership in innovation, technology, and science.
- *Recreate a ladder of economic mobility* so that Americans may make a better life for themselves and their families, and America may be a land with a thriving and expanding middle class prospering in the global economy.

An overview of the entire plan can be found in:

Progressive Growth
Transforming America's Economy through Clean Energy, Innovation, and Opportunity
By John Podesta, Sarah Rosen Wartell, and David Madland

Other reports detailing aspects of the challenges and recommendations in the *Progressive Growth* plan are:

Capturing the Energy Opportunity
Creating a Low-Carbon Economy
By John Podesta, Todd Stern, and Kit Batten

A National Innovation Agenda
Progressive Policies for Economic Growth and Opportunity through Science and Technology
By Tom Kalil and John Irons

Opportunity and Security for Working Americans
Creating the Conditions for Success in the Global Economy
By Louis Soares, Andrew Jakabovics, and Tim Westrich *(forthcoming)*

Virtuous Circle
Strengthening Broad-Based Global Progress in Living Standards
By Richard Samans and Jonathan Jacoby *(forthcoming)*

Responsible Investment
A Budget and Fiscal Policy Plan for Progressive Growth
By David Madland and John Irons *(forthcoming)*

Other reports developing these and other new ideas will be published as part of the *Progressive Growth* series of economic policy proposals from the Center for American Progress. The first, ***Serving America: A National Service Agenda for the Next Decade***, by Shirley Sagawa, was published in September 2007. Future reports will include: ***New Strategies for the Education of Working Adults***, by Brian Bosworth *(forthcoming)*; and ***Social Entrepreneurship and Impact: Creating a Climate to Foster Social Innovation***, by Michele Jolin *(forthcoming)*.

Progressive Growth: A Summary

The American Dream has been a story of progressive policy establishing conditions in which individuals have been able to seize opportunities and make a better life for themselves, their children, their families, and their communities. It can be so again. The United States faces unprecedented challenges. Yet at the Center for American Progress, we are optimistic about America's economic future. We are confident that the ladder of economic mobility can be rebuilt with the right leadership and progressive policy.

Today, working Americans feel less and less secure, and their prospects for economic mobility seem more and more remote. People are working longer hours than ever before, change jobs more frequently, and have more volatile incomes. Forty-seven million live without health insurance. Few are represented by a union. Many face tough competition from lower-wage workers abroad. The land of the American Dream now has less inter-generational income mobility than many other developed countries. Family incomes have risen on average within generations only because the incomes of women have risen as their participation in the workforce has grown dramatically; incomes of men have stagnated. The additional income from the second earner is essential to cover the rising cost of healthcare, energy, and childcare, among other things.

Each of the traditional pathways to progress is littered with roadblocks. Incomes are not rising; the historical link between greater productivity and higher wages has broken down. Personal savings in the United States is near record lows. From pre-school through high school, we are failing to prepare many for college and the workplace. Those who begin degree or credential programs to improve earnings complete them at alarmingly low rates. Until recently, homeownership was a pathway to wealth accumulation, but many now see their equity slipping away. **American workers feel less secure with good reason. Their prospects for getting ahead are more limited. Working hard and playing by the rules is not enough.**

In recent years, economic growth has been relatively strong, but the economy has added jobs at a lackluster rate compared to similar times in the economic cycle. The share of the nation's income that goes to those in the middle is lower than it has been in 50 years. The benefits of economic growth have all flown to those at the very top.

Key Steps to *Progressive Growth*

Accelerate America's transformation to a low-carbon economy.

- Implement an economy-wide cap-and-trade program for greenhouse gases.
- Dedicate cap-and-trade revenues to, first, offset energy costs for low- and moderate-income consumers and support the employees and communities of carbon-intensive firms, and second, invest in innovation and the transformation to a low-carbon economy.
- Implement complementary policies to reduce emissions and increase energy efficiency in the transportation and electricity sectors.
- Create a White House National Energy Council to manage the transformation and ensure that the federal government leads the way.
- Exercise global leadership.

Spur innovation to sustain productivity growth *and* job creation.

- Make significant new investments to stimulate innovation to address our nation's grand challenges and emerging opportunities.
- Build a flexible, problem-solving workforce that includes more workers with world-class science, technology, engineering, and math skills.
- Restore the integrity of American science.

Rebuild the ladder of opportunity by restoring economic security and mobility.

- Guarantee quality, affordable *health care* regardless of employment or life circumstance.
- Expand access to effective *education* for our children and adult workers to ready the workforce for 21st century jobs in the global innovation economy.
- Make work pay and *incomes* keep pace with growth through the minimum wage, expansion of the Earned Income Tax Credit and Child Tax Credit, the right to organize, and reforms to unemployment insurance and adjustment assistance.
- Provide greater opportunities to build and secure *wealth* through work, retirement savings, affordable and safe financial services, and home ownership.

Create a virtuous circle of rising economic fortunes for a growing global middle class—future consumers of U.S. products and services.

- Refocus the three main elements of our international economic policy—trade, aid, and monetary policy—on achieving progressive growth around the globe.
- Enlist all the international institutions—the International Labor Organization, the International Monetary Fund, the World Bank, the World Trade Organization, and regional multilateral development banks—in a coordinated strategy to promote decent work: quality jobs, fundamental rights at work, social protection, and social dialogue.
- Support construction of the laws and institutions that will enable middle-income nations to share new growth widely within their populations.
- Support low-income nations in meeting basic human needs, advancing decent work, moving more workers into the formal economy, eliminating trade barriers to their exports, and supporting the creation of trade-related infrastructure.

Adopt a responsible fiscal policy to finance needed investments in national priorities.

- Make needed investments in economic growth and restoring economic mobility.
- Dedicate cap-and-trade revenues to ease the transition to a low-carbon economy and invest in policies to spur innovation and the energy transformation.
- Adopt a tax system that is fair and rewards human capital by:
  - Rewarding work and wealth equally.
  - Expanding the Earned Income Tax Credit and Child Tax Credit to help make work pay for low-income workers.
  - Providing tax breaks to employers and employees to encourage more investment in credentialed and portable education of adult workers.
  - Improving retirement security through matching contributions for lower-wage workers in a new Universal 401(k) plan.
  - Lifting the cap on which the employer pays social security taxes while maintaining the employee cap.
  - Permanently reforming the estate tax so that only a tiny fraction of the wealthiest heirs would be subject.
  - Closing loopholes and improving tax enforcement.
- Put America on course to reduce our debt as a share of our Gross Domestic Product.

The prospects for long-term growth are also weak. Our economy is increasingly reliant on unsustainable, debt-driven spending (by consumers and the federal government), instead of innovation and investment. Between March 2001 and March 2007, 84 percent of economic growth came from consumption spending, while less than 4 percent came from investment. The United States has fallen behind many countries when it comes to equipping the workforce with the education and training necessary for individual and national success, doing a mediocre job especially of preparing our children for careers in the innovation economy. Younger cohorts moving into the workforce in coming years will be smaller and have less education than the older generations leaving the workforce.

Globalization and technology have changed the rules of the game. Unsustainable appreciation in the housing market buoyed the economy for too long. And we face a clear and present danger to our economy and the earth itself from global warming. As Rajendra Pachauri, Chairman of the Intergovernmental Panel on Climate Change and recipient of the 2007 Nobel Peace Prize, said recently, "If there's no action before 2012, that's too late. What we do in the next two to three years will determine our future. This is the defining moment." America needs policymakers with a plan for restoring U.S. economic leadership in a global and carbon-constrained economy, making it possible, once again, to dream that our children can look forward to a better future.

The next administration can offer a new vision of America as an economic leader with a growing middle class in a vibrant global economy. America's economy could be driven by ongoing invention and the production of high value-added goods and services. America could lead a global energy transformation based on more efficient technologies and clean, renewable fuels. These forces could fuel the creation of good jobs and good prospects for workers at all skill levels. America's students and workers could be readied to meet the demands of the innovation economy. Moreover, we could ensure the economic security necessary, so that people can take risks and generate wealth for themselves and our country. America could put globalization and change to work for American workers and for millions around the globe.

At the center of this vision is a strategy to address the greatest moral and economic challenge of our time—climate change—and turn it into our greatest opportunity. Left unchecked, the economic disruption caused by climate change will sap our resources and dampen our growth. But with low-carbon technologies and clean, renewable energy, we can capture a new global market, drive American economic growth, and create green jobs for American workers, offering new skills and new earnings opportunities up and down the economic ladder.

CAP's economic blueprint for a new administration would also leverage our creativity, entrepreneurial culture, and a restored leadership in science and technology to create an innovation economy and spur economic growth. It would seek to enhance economic security and mobility for American workers by creating the conditions in which they could protect and improve their own health, education, incomes, and wealth. It would refocus our international economic policy on promoting decent work and higher living

standards around the globe, helping to generate additional demand for American products and services, restoring American leadership, and ensuring that the rising tide produced by economic integration lifts all boats. Finally, CAP's plan offers a responsible pro-growth fiscal policy that would value work and fairness and support necessary investments in our economic future while setting us on a course to reduce the debt as a share of GDP and ready ourselves for the additional demands of the aging baby boom generation.

Restoring economic mobility for Americans, sustaining economic growth in a global economy, and combating global warming are great challenges, but America is up to the task. From sweatshops to segregation to the space race, the progressive commitment to fairness, human dignity, and what FDR called "bold, persistent experimentation" has driven our country to overcome obstacles as great as these we face today.

Introduction and Summary

The Importance of Science, Technology, and Innovation

Science, technology, and innovation have long provided the foundation for America's prosperity. Naturally inquisitive and inventive, the American people have developed new products and technologies that have fueled our economy and improved our quality of life. Consider how different our lives would be without electricity, air travel, antibiotics, computers, and the Internet.

Along the way, myriad new products and services emerged from this shared public and private commitment to science, technology, and innovation, creating entirely new industries and good paying jobs up and down the economic ladder. This creativity still underpins our economy, yet the United States faces intense economic competition in the 21st century and is not adopting the policies that will keep it at the cutting-edge of innovation.

That's why science, technology, and innovation policy must be a top priority for the next administration and a central component of America's national economic strategy.

Science, technology, and innovation are critical to America's future for a variety of reasons. First, innovation—the development of new products, services, and processes—drives economic growth and job creation. Innovation is important not only for high-tech sectors such as advanced manufacturing, aerospace, clean energy, the life sciences, semiconductors, and the Internet. It is also essential for companies that are using technology to develop products more rapidly, harness the "collective IQ" of their customers and employees, and orchestrate sophisticated global supply chains. Innovation is not solely the province of the venture capitalist, the entrepreneur, and the molecular biologist. Innovation can create jobs for workers who are installing broadband networks, retrofitting buildings with energy-efficient technologies, manufacturing biopharmaceuticals, and building a 21st century infrastructure.

Second, even small differences in productivity have a huge impact on America's long-term standard of living. Our average standard of living will double every 23 years if our productivity growth rate is 3 percent, and every 70 years if it is 1 percent. Furthermore, high productivity growth rates will make it much easier to honor our commitments to older Americans, expand access to healthcare for the uninsured, and increase our investments in infrastructure, education, and worker training.

Third, innovation is currently a source of competitive advantage for the United States in the global economy. We have world-class research universities, an entrepreneurial culture, flexible labor markets, and deep capital markets. Americans are twice as likely as adults in Europe and Japan to be "high expectation" entrepreneurs—that is, to start a business with the intention of growing it rapidly. The United States is also one of the quickest and least expensive places to start a new business. It costs less than 1 percent of per capita income to start a business in the United States, compared to 5.1 percent in Germany and 7.5 percent in Japan.[1] The United States can not afford to rest on its laurels, however. Other countries are determined to match and surpass America's investment in research and development and a skilled workforce. We should have a laser-like focus on strengthening our position as an innovation superpower.

Fourth, innovation can play an important role in meeting many of the most important goals we have as a nation. Innovation is pivotal to providing all Americans with longer, healthier lives, fighting global warming, maintaining a strong defense at home and abroad, expanding access to high-quality education and training, and making government more open and efficient.

Fifth, innovation is important in the civic sector as well as the private sector. A new generation of "social entrepreneurs" is changing the way we educate our children, lift people out of poverty, prevent crime, and build vibrant communities. Innovation in the civic sector has the potential to help address some of our toughest and most persistent societal challenges (see box on page 3).

Finally, advancing the frontiers of human knowledge and increasing our understanding of ourselves and the world around us are worthy goals themselves. We want to understand the ultimate fate of the universe, the nature of matter, the origin of life, and how human consciousness emerges from 100 billion neurons and 100 trillion synapses. We want to know why civilizations rise and fall, and how to foster thriving, multi-cultural societies. It is important to support unfettered inquiry to address these and many other questions.

An Innovation Agenda

This report sets forth an innovation policy agenda that will foster economic growth, create high-wage jobs, and help address the critical challenges we face in the 21st century. This agenda is informed by a set of principles (see box on page 4) and an important but limited role for the government in fostering innovation. It builds on the important work of the Council on Competitiveness and the National Academy of Sciences (particularly the *Rising Above the Gathering Storm* report)[2] but with a greater emphasis on harnessing innovation to help meet key economic and societal goals.

The agenda—outlined here and described in greater detail in the pages below, consists of four sets of policy proposals to:

- Increase federal research funding
- Spur private sector investment in research and innovation
- Build a workforce with world-class science and technology skills

The Role for Government in Science, Technology, and Innovation

The responsibility for developing new products, processes, and services clearly rests with the private sector, but the federal government has a catalytic role in promoting and encouraging innovation. Government-financed research and development has led to technologies and industries such as computers, the Internet, and biotechnology. As our economy becomes more dominated by new ideas, this government role becomes more important.

Government has a critical role to play in the creation of new knowledge because ideas are, at least to some extent, "non-excludable." Once the idea has been created, it is difficult to prevent others from using it. This is due to the very economic nature of ideas and knowledge. First of all, ideas are "non-rival," meaning that once an idea has been developed, others can use the idea at no additional cost. As Thomas Jefferson put it, "He who receives an idea from me receives instruction himself without lessening mine—as he who lights his taper at mine, receives light without darkening me."[3] Economists such as Stanford University professor Paul Romer believe that new knowledge can lead to "increasing returns" and that doubling the stock of knowledge in an economy would more than double total output.[4]

Because of these characteristics, the benefits of investment in new knowledge can "spill over" to those who did not create it. Economists find, therefore, that the social return of research and development is much larger than the private return. Economists Charles Jones and John Williams conclude that the socially optimal amount for the United States to invest in R&D is two to four times the current expenditure.[5]

Unfortunately, while science, technology, innovation, and a highly skilled workforce are becoming more important to our future prosperity, U.S. federal investment in R&D, particularly in key disciplines such as the physical sciences and engineering, has actually been declining as a percentage of Gross Domestic Product. Agencies such as the Defense Advanced Research Projects Agency, which have traditionally backed breakthrough technologies (including the Internet), have shifted to funding projects with more immediate payoffs.

And we are falling short as a nation in other key science and technology arenas. We continue to do a mediocre job of preparing our children for careers in science, technology, engineering, and mathematics. Ideologically driven policies such as the Bush administration's restrictions on stem cell research are preventing our scientists from developing potential cures for diseases such as spinal cord injuries, multiple sclerosis, or Alzheimer's. Our immigration policies make it difficult for the "best and brightest" from other countries who receive advanced degrees from our colleges and universities to stay here and contribute to our economy.

In short, these issues deserve a much higher level of attention and commitment from our political leadership, as we detail in the main pages of this report. Fifty years ago, in the wake of the Soviet Union's launch of its first Sputnik satellite, President Eisenhower and the Congress created the Advanced Research Projects Agency and the National Aeronautics and Space Administration and passed the National Defense Education Act. President Eisenhower also created the President's Scientific Advisory Council, and met repeatedly with the nation's top scientific talent to discuss many of the key issues of the day.

The challenges we face today are every bit as momentous and warrant an equally serious response. As the Hart/Rudman Commission on National Security concluded, "Second only to a weapon of mass destruction detonating in a U.S. city, we can think of nothing more dangerous than a failure to manage properly science, technology, and education for the common good over the next quarter of a century."[6]

Principles for an Innovation Agenda

The innovation policy of the next administration should be informed by the following principles.

First, we will only be an innovation superpower if all Americans are both participants in and beneficiaries of the innovation economy. We must not think of innovation as the province only of the highly educated. Innovation-driven business models require large numbers of technically proficient, scientifically literate, knowledge workers at every level of the organization than can solve rapidly changing problems. If we want to share the benefits of an innovation economy broadly, a large cross section of our population must be able to participate in the creative process.

Both our current workforce and the workforce of tomorrow must be empowered to become perpetual learners so that they may constantly add to their own capacity for innovation and thus to the nation's wealth. Similarly, the principle of innovation must be applied to the very challenge of improving economic opportunity for all our citizens.

Online learning can help working adults gain the skills they need to compete for higher wage jobs. Universal design principles can make information and communications technologies accessible for people with disabilities, increasing their independence, employability, and standard of living. Low-cost sensors can help people with diabetes and other chronic conditions lead healthier and more productive lives. Customized job training can prepare workers to take advantage of the "green collar" jobs that will be created by rapidly growing clean energy and energy-efficiency industries. Realizing these and other benefits of the technological revolution should be at the heart of America's Innovation Agenda.

Second, the role of the government is to make investments in areas that the private sector will under-invest in relative to their social return, such as fundamental research and a skilled workforce, and to create a policy environment that will foster competition, innovation, and entrepreneurship. The private sector then takes the lead on the commercialization and adoption of new technologies.

Third, while there are significant "market failures" associated with the innovation process, interventions can lead to "government failures" such as pork-barrel politics, rent-seeking by interest groups, regulatory capture, decision-making on the basis of faulty or incomplete information, policies where benefits are greatly exceeded by costs, and lack of flexibility to adapt to changed circumstances and new evidence.[7] When the government does intervene, careful thought needs to be given to the design of the intervention so that the "cure" is not worse than the "disease." Whenever possible, governments should seek to take advantage of market forces as opposed to relying on government programs or top-down regulation.

Fourth, no one can predict the future evolution of technology—not even the participants in the marketplace. In the early 1990s, most of the major players in the media and telecommunications industry were convinced that "video on demand" would drive the development of the "information superhighway." Few predicted the importance of the Internet. For this reason, the government should set broad goals and invest in a portfolio of approaches to achieve that goal.

The government, for example, should support research that has the greatest potential to reduce greenhouse gas emissions, as opposed to the Bush administration's decision to pick the "hydrogen car" as the solution to the energy and climate crisis. Decisions about which research directions are most promising should made in close consultation with the scientific and technical community, and a competitive, merit-based process should be used to allocate funding for individual research projects. The role of the president and the Congress is to establish broad national priorities and to create a venue for the scientific and technical community and other stakeholders to develop research agendas that are responsive to these goals. The president and the Congress should not micromanage the research budget or earmark federal funding for particular research projects.

Fifth, there are a large number of public policies that affect America's general ability to innovate: policies with respect to research funding, education and training, immigration, intellectual property protection, regulation, antitrust enforcement, taxes, regional economic development, and international trade. The ability of particular research-intensive sectors to compete is affected by spectrum policy (wireless industry), the Food and Drug Administration approval process (biotechnology, medical devices, pharmaceuticals), and export controls (computers, satellites). Thus, it is imperative that the next administration embrace innovation as a central organizing principle for its economic strategy. Policymakers in many different agencies need to understand the impact that their decisions have on America's long-term competitiveness.

Principles for an Innovation Agenda *(continued)*

Sixth, America's innovation policy needs to recognize that even the way we change is changing. Haas School of Business professor Henry Chesbrough at the University of California, Berkeley observes that many leading companies are pursuing "open innovation" strategies. Increasingly, they are working with external partners to commercialize their internal innovations, and to identify external innovations that they can commercialize.[8] More than 40 percent of Procter and Gamble's products have a major component that has been sourced externally.[9] Online innovation marketplaces such as InnoCentive, which allows customers to post complex problems, where more than 125,000 engineers, scientists, inventors, business people, and research organizations from 175 countries can compete to solve them.[10]

Eric Von Hippel, head of the Innovation and Entrepreneur Group at the Massachusetts Institute of Technology's Sloan School of Management, notes that innovation is becoming democratized as more users of products and services are able to innovate for themselves. Savvy companies are encouraging this by creating "toolkits" that empower their customers and allow them to quickly and easily customize products and services.[11] A related concept is what scholars such as Yochai Benkler have called "commons-based peer production." The creative energies of large numbers of people are coordinated using the Internet to create information, knowledge, and culture, often without financial incentives or traditional hierarchical organizations. An example is Wikipedia, a free encyclopedia that anyone can edit, and that has over 2 million entries in English.

Many observers also call attention to the important role that design, aesthetics, user experience, and opportunities for self-expression are playing in the marketplace as companies, entrepreneurs, and individual artists seek to differentiate their products and services and avoid "commodity hell."

This capacity to innovate is becoming increasingly globalized, with entrepreneurs creating teams of Bangalore software engineers, Russian mathematicians, and Taiwanese product designers. U.S. policy needs to take into account these and other changes in the nature of innovation.

Finally, the role of the federal government should be to serve as a catalyst. A good example of the "ripple effect" that federal policy can have on national priorities is the National Nanotechnology Initiative, unveiled by President Clinton in January 2000. After the NNI was announced, major research universities, venture capitalists, entrepreneurs, states, and Fortune 500 companies all launched new efforts in nanotechnology research, education, and commercialization. New initiatives should be designed to spark additional investments by industry, academia, states, foundations, and other stakeholders.

- Restore the integrity of U.S. science and technology policy.

The next administration should provide sustained increases in funding for research and development by boosting the budgets of key science agencies such as the National Science Foundation and the National Institutes of Health. Some of these increases should be targeted to help address some of the key challenges we face in the 21st century, such as fighting global warming and developing more effective technologies for education and training. The impact of these investments should be increased by boosting support for research that is multidisciplinary and offers the potential for revolutionary advances in science and technology.

This increased federal support for research must be complemented by policies that will spark private sector investment in research and innovation, such as a permanent Research and Experimentation tax credit, a commitment to build thriving regional economies, and a strategy for promoting the deployment of broadband networks.

America's global competitiveness and capacity to innovate, however, ultimately

Social Entrepreneurship, Social Innovation

By CAP Senior Advisor Michele Jolin

Innovation and entrepreneurship are critical elements of a healthy, thriving non-profit social sector. Over the last decade, "social entrepreneurs,"[12] such as Wendy Kopp of Teach for America, Geoffrey Canada of Harlem Children's Zone, Muhammed Yunus of the Grameen Bank, and President Bill Clinton of the Clinton Global Initiative have developed innovative, results-oriented models that are driving systemic change and reorienting the way philanthropists, the private sector, and policymakers consider addressing some of society's most intractable problems.

Despite the successes of these leading social entrepreneurs, the scope and reach of many social entrepreneurial efforts continue to be constrained by a non-profit environment and infrastructure that does not always support growth or innovation. The next administration needs to invest in scaling high-impact social entrepreneurial models, provide seed capital to encourage a pipeline of future entrepreneurial efforts, and remove outdated provisions in the tax code or regulatory structure that are barriers to social innovation.

Over the last several decades, the non-profit sector in the United States has become an increasingly important and vital "third sector" of the economy, with the total number of non-profit organizations doubling in the last 25 years.[13] Non-profit organizations employed roughly 9.4 million paid workers, which is approximately 7.2 percent of the U.S. economy (larger than the number of people employed by the financial services sector)[14] in 2004. Employment in the non-profit sector grew at a rate of 2.5 percent over the last several decades, compared with 1.8 percent in the private sector or 1.6 percent in government.[15]

Nonprofit organizations have stepped in to fill gaps where neither the government nor the private sector has been able or willing to provide adequate services or support, especially in areas such as education, economic development, and access to health care. In many instances, non-profit organizations have demonstrated that they can tackle social challenges in a manner that is more effective and more efficient than anything that could be done by either the government or the private sector.

To create a better climate for social innovation and to enhance the ability of most successful non-profits to spread and grow, the next administration needs to focus on developing policies and investment tools in four key areas:

Improving Access to Growth Capital

Unlike the for-profit capital markets, there is not a natural and reliable source of capital for high-performing nonprofits or social entrepreneurs who are ready to expand their reach. Many foundations have restrictions on the number of years or the types of organizations they can fund over time, and are simply not structured or organized in a way to provide longer-term, growth capital. Into this capital breach have stepped new sources of social venture capital funding,[16] such as the New Schools Venture Fund, New Profit Inc., and the recently created SeaChange Capital Partners. These are important efforts designed to fill a critical gap, but unfortunately they are still relatively small in size compared with the needs of the non-profit sector, and, thus, their reach is necessarily limited.

Providing Seed Capital for a Pipeline of New Innovations

It is similarly difficult to secure funding for start-up non-profit ventures or for new programs that involve significant risk or experimentation. Traditional funders are justifiably reluctant to use limited philanthropic dollars to fund experiments or efforts that do not have a proven track-record. There are organizations, such as Ashoka, the global association of social entrepreneurs, and Echoing Green, both of which fund entrepreneurial start-ups in the non-profit sector. But again, their number is small and it is not possible for them to support and foster the kind of innovation and experimentation needed in the social sector

Supporting Efforts to Develop Human Capital

High-growth organizations report that finding qualified staff at every level, but particularly middle managers, has slowed their ability to expand, even when financial capital is available. Efforts to recruit and prepare for-profit business managers for work in the non-profit sector show some promise and offer the added benefit of bringing new skills and perspectives to the sector. For entry-level human capital, national service programs such as AmeriCorps have offered many social entrepreneurs a steady source of motivated entrants.

Social Entrepreneurship, Social Innovation *(continued)*

Removing Outdated Tax and Regulatory Barriers to Innovation

Innovation in the non-profit sector is also constrained by outdated legal, regulatory, or tax regimes, especially in instances where the line between the non-profit and for-profit sectors has blurred. Increasingly, there are examples of business entrepreneurs who are using for-profit investments to produce greater social good, especially in the areas of micro enterprise, health care, and the environment. For instance, Pierre Omidyar, founder of Ebay Inc., created a private equity fund to expand the use of microloans and encourage the development of a commercial equity market to serve global microfinance institutions. It is important to explore whether outdated tax and other rules may be limiting more of these and other kinds of hybrid for-profit investments with a social purpose.

To do this, the Center for American Progress will issue a report in December 2007 (as part of its *Progressive Growth* series of economic policy reports) that describes in more detail the need for new policy tools to support and encourage innovation and investment in the non-profit social sector. Specifically, the Center will propose that the next president create a new "White House Office of Social Innovation and Impact" that would be responsible for coordinating and overseeing the president's efforts to highlight and invest in the most effective and creative efforts by social entrepreneurs and others in the non-profit sector.

rests on the skills of its workforce. The next administration should increase our nation's commitment to creating a workforce with world-class skills in science, technology, engineering, and mathematics, while making it easier for the "best and brightest" from all over the world to study here and contribute to our economy.

Finally, the next administration should increase the capacity of the government to understand the forces that are shaping America's economic competitiveness and restore integrity to U.S. science policy.

These bold policy directions must be embraced by the next president and the Congress if the United States is to remain at the forefront of innovation while leading the world toward a more prosperous and sustainable future. The policy prescriptions that follow constitute a comprehensive blueprint to ensure all Americans benefit from sustained productivity and innovation in this new century. Future work by the Center for American Progress will address additional critical innovation policy issues, such as intellectual property.

Funding Science and Technology

The federal government plays an essential role in funding research and development. Increased support is needed across a wide range of science and engineering disciplines to strengthen America's global competitiveness and to help address some of the "grand challenges" of the 21st century such as clean energy. We also need to increase the impact of our investment in R&D and experiment with new tools for promoting innovation such as prizes and Advance Market Commitments.

Increase federal investment in research and development.

There is a compelling case for sustained increases in federal research funding, particularly for university-based research. Federal investment in many key disciplines has actually declined as a fraction of GDP. Currently, agencies can fund only a fraction of the high-quality proposals that they receive.

Even if a research grant is awarded, it is often too small or too short for a researcher to make meaningful progress. Young scientists are discouraged from pursuing a career in research because they must wait until they are, on average, 41.7 years old before they receive their first grant from the National Institutes of Health as an independent investigator.[17]

Below are some of the key science agencies that should receive increased funding. Some of these proposed increases enjoy broad bipartisan support, particularly those for the National Science Foundation, the Department of Energy's Office of Science, and the National Institute of Standards and Technology's core research programs. President Bush has proposed doubling the research budgets of these agencies over 10 years as part of his American Competitiveness Initiative.[18] The House of Representatives and the Senate voted overwhelmingly to pass the America COMPETES legislation, which provides authorization to put the NSF, the DOE's Office of Science, and NIST on a doubling path.

The actual level of support, however, will be determined by the annual appropriations process. In the past, Congress has voted to authorize a doubling of the NSF budget, only to cut it in appropriations bills when the time comes to pay for these critical research programs. Below is a brief description of the key agency research budgets that should be increased by the next administration.

National Science Foundation

NSF is the only federal agency that supports research and education across all fields of science and engineering. NSF supports an average of 200,000 scientists, engineers, educators, and students at universities, laboratories, and field sites all over the United States and throughout the world.

Currently, however, the average research grant from the National Science Foundation is less than $150,000 per year.[19] This is usually insufficient to enable a "critical mass" of faculty, graduate students, and postdoctoral researchers to make real progress on key scientific and technological problems. As a result, university researchers are forced to spend more than more of their time writing grants and scraping together funding from multiple sources, as opposed to focusing on their research.

NSF should increase the size and duration of grants that support individual researchers. They should also allocate more resources to support tightly focused teams of 3 to 5 faculty researchers and their students. These are often more productive than the more diffuse Engineering Research Centers or Science and Technology Centers involving 20 to 30 faculty researchers.

The NSF budget for research and education, which is likely to be at least $6.5 billion in fiscal year 2008, should be increased by 10 percent per year for the next 10 years. This would also enable an expansion of NSF's key educational programs, such as fellowships, graduate student training grants, and programs to improve K-12 math and science education.

National Institutes of Health

NIH-supported scientists have played a critical role in medical advances that help prevent, detect, diagnose, and treat disease and disability, such as heart disease, pediatric leukemia, and breast cancer. Although NIH funding was doubled from 1998 to 2003, it has actually declined by 12 percent in real terms from 2004 to 2008.[20] As CAP Senior Fellow Gene Sperling has observed, the Bush administration's stingy NIH budgets over the last five years sound like a "Discourage Future Scientists Act."[21] This is particularly discouraging at a time when the health needs of an aging population are growing.

Increased NIH funding would also allow us to take advantage of recent advances in areas such as genomics (the study of entire genetic sequences of an organism and the function of genes), nanotechnology, personalized medicine, and early detection of "biomarkers" that can predict the onset of cancer and other diseases. The NIH budget should be doubled over the next 10 years, providing for modest real growth above the rate of biomedical research inflation.

This increase should be offset by increases in the federal taxes on cigarettes and alcohol. These taxes would also reduce the costs of cigarette and alcohol consumption borne by the public due to smoking- and alcohol-related illnesses paid for by Medicare and Medicaid as well as the heavy social costs of alcohol-related accidents.

Department of Defense

According to the Defense Department, "maintaining a technological edge over potential adversaries is a key element of the U.S. national security strategy. With technological superiority, our military forces can more effectively deter conflict or win more quickly and decisively, should conflict be unavoidable."[22]

The Department of Defense has identified six areas of research that are particularly important for future advances in defense technology, including nanoscience, bioengineering, human performance sciences, information dominance, multifunctional materials, and propulsion and energetic sciences. Many of these technologies are likely to generate applications in our civilian economy as well, which is why the Defense Department should pursue a "dual-use" strategy to take advantage of high-volume, low-cost production in the civilian sector.

To strengthen America's technological edge, Congress and the Defense Department should reallocate the agency's funding so as to increase support for basic and applied research by 10 percent per year over the next 10 years. In FY2008, the Congress is likely to provide roughly $6.6 billion for DOD's support for basic and applied research.

Department of Energy

The Department of Energy ranks first among federal agencies in supporting the physical sciences, and second in mathematics and computer science. The DOE also plays a critical role in supporting unique national user facilities such as Lawrence Berkeley National Lab's Advanced Light Source, which produces x-rays that are 1 billion times brighter than the sun.

The Department of Energy's Office of Science budget should be doubled over the next 10 years, up from a likely appropriation level of $4.8 billion in FY2008.

Department of Commerce

The National Institute of Standards and Technology conducts key research related to measurement technology and standards. NIST's Advanced Measurement Laboratory, for example, will be able to measure distances in increments tinier than the radius of an atom, and measure the strength of the chemical bond between a single virus and antibody.

NIST's internal budget should be doubled over the next 10 years, up from a likely appropriations level of $420 million in FY2008. This will help NIST keep pace with our economy's needs for increasingly sophisticated measurement technology.

NIST also has a program called the Technology Investment Program (formerly known as the Advanced Technology Program), which provides cost-shared funding to industry for the development of high-risk technologies. Numerous evaluations have demonstrated the effectiveness of this program, including a high ratio of benefits to costs, the accelerated commercialization of new technologies, and the so-called "halo effect" that helps participating companies attract additional investors.[23]

This is one of the few government programs that helps bridge entrepreneurs' fabled "valley of death" between invention and innovation, where funding to commercialize a new technology is often unavailable from private investors. The Technology Investment Program also helps address the gap between the "proof of principle" (demonstrating technical feasibility) and "reduction to practice" (demonstrating the feasibility of cost-effective, repeatable manufacturing).[24]

This is critical. As Harvard University economist Martin Weitzman observes, "The ultimate limits to growth may lie not as much in our ability to generate new ideas, so much as in our ability to process an abundance of potentially new seed ideas into usable forms."[25] Despite

this, the Bush administration has repeatedly proposed eliminating the program. The next administration should increase the funding of this program to $1 billion a year, up from the $70 million that the Congress is likely to provide in FY2008.

Identify new research directions: "grand challenges" and emerging opportunities.

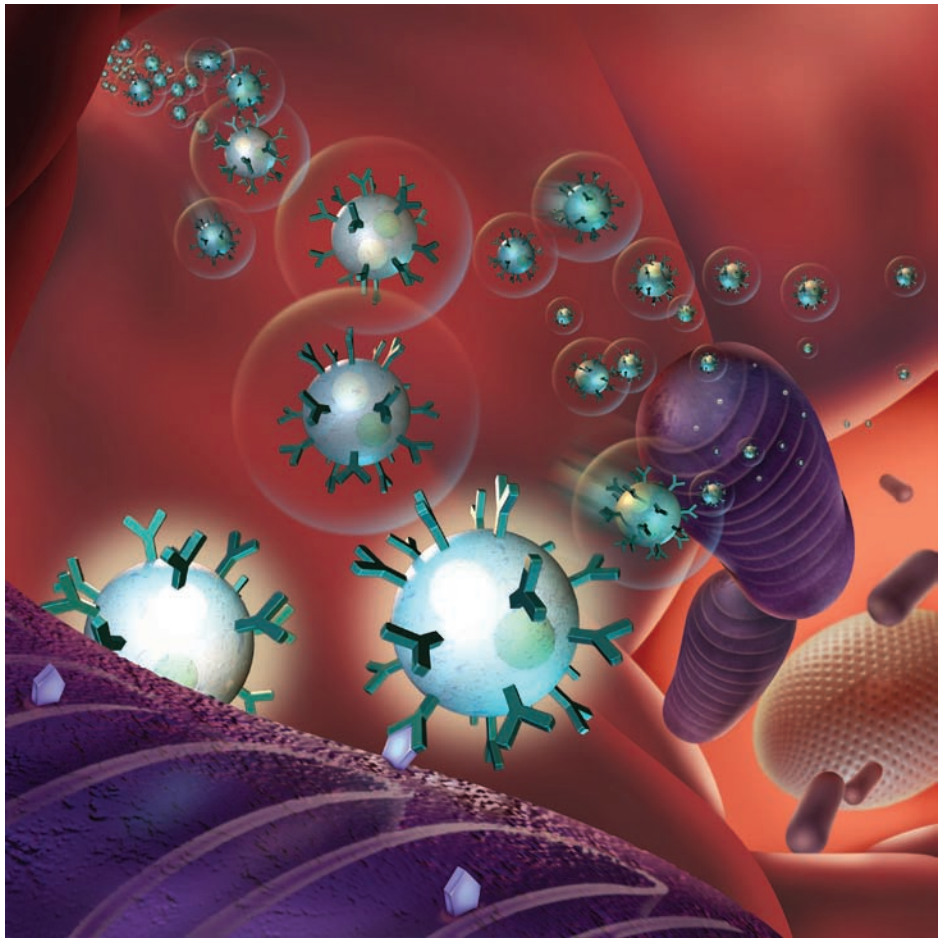
Most of the proposed increases in research funding should augment the core disciplinary programs of science agencies that support investigator-initiated projects in biology, the physical sciences, engineering, the behavioral sciences, and the social sciences. Curiosity-driven research leads to an expansion of the frontiers of human knowledge, which is an end in itself. But it also leads to medical and technological breakthroughs of immense importance.

The 2006 Nobel Prize in Medicine, for example, was shared by Dr. Andrew Fire of Stanford University, a researcher studying the roundworm. He discovered that ribonucleic acid, or RNA, could be used to selectively "silence" genes—a discovery that is being used to develop treatments for cancer, HIV, hepatitis, and macular degeneration. (RNA is a molecule that plays a key role in producing proteins in the cells of all living beings.)

Some of the increase in funding, however, should be targeted to multi-disciplinary initiatives that respond to national priorities and emerging opportunities.

As noted previously (see box on page 3 on the Role of Government), the president and the Congress should set broad goals, and rely on the scientific and technical community (and other stakeholders) to identify the most promising research directions. Existing initiatives that should be supported include the multi-agency efforts in information technology and nanotechnology R&D.

New efforts should be launched in learning science and technology, science and technology to help address major challenges in developing countries such as global health and safe drinking water, and clean energy. These are described in greater detail in the boxes on pages 14, 16, and 17, respectively. Other strong candidates for new initia-



Nanotechnology can create smart anti-cancer therapies that deliver drugs only to diseased cells. Illustration by Christopher Burke, cjburke@umich.edu

tives will allow Americans to lead longer, healthier lives and create the foundation for faster productivity growth and the creation of high-skill, high-wage jobs.

Improving chronic care

More than half of Americans suffer from one or more chronic diseases, and the most common chronic diseases cost the economy more than $1 trillion annually, a cost which could rise to $6 trillion by the middle of this century.[26] Our current health care system is designed to provide acute care, and it does not do a good job of disease prevention or treating chronically ill patients.

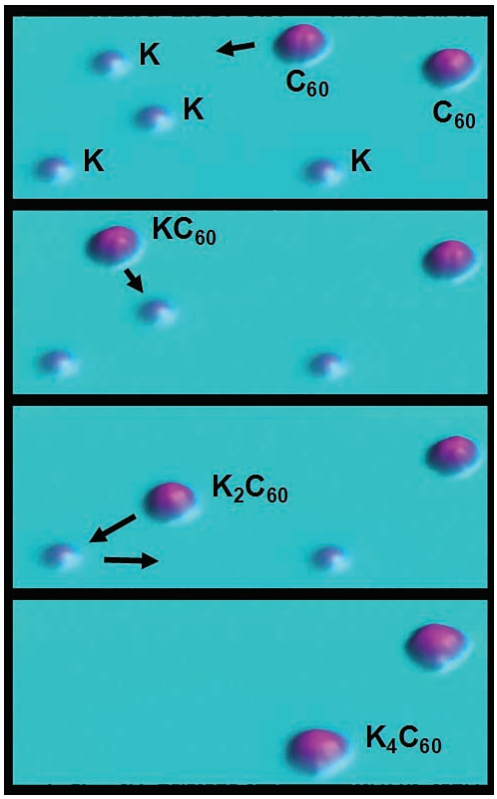
New technologies combined with new ways of delivering and organizing care can save lives and money. Technology can provide frequent communication between patients and caregivers, remotely monitor a patient's vital signs, offer personalized patient guidance and education, help ensure that caregivers are following evidence-based practice guidelines, and improve the coordination of care between multiple providers.

Information technology has played an important role in the startling improvements in the quality of care provided by the Veterans Health Administration. As author Phillip Longman at the New American Foundation observes, health IT systems "remind doctors to prescribe appropriate care for patients when they leave the hospital, such as beta blockers for heart attack victims, or eye exams for diabetics. It also keeps track of which vets are due for a flu shot, a breast cancer screen, or other follow-up care—a task virtually impossible to pull off using paper records."[27]

The IT industry has estimated that Medicare could save $30 billion and avoid 1.7 million hospitalizations by implementing a similar chronic care improvement program for its highest risk 4 million patients.[28] More research is needed to improve the underlying technology, to identify which approaches are cost-effective and lead to improvements in the quality of care, and to determine what incentives, such as "paying for performance," are needed to promote the broad adoption of these innovations.

Synthetic biology

Synthetic biology has been defined as "the design and construction of new biological parts, devices, and systems and the redesign of existing natural biological systems for useful purposes."[29] Synthetic biologists want to design more complex and useful biological systems from reusable "parts" made from genes, enzymes,



Molecular computing would allow us to store the equivalent of the Library of Congress in the device the size of a sugar cube. Image courtesy of Michael Crommie/UC Berkeley.

and metabolic pathways—in the same way that electrical engineers build computers from transistors, circuits, and chips.

Because of advances in technology, we have the ability to read and write DNA at amazing rates. Although synthetic biology is still in its infancy, researchers are already using it to engineer bacteria and yeast that can lower the cost of making the most effective anti-malaria drug by a factor of 10, discover and destroy tumors, turn sugar into gasoline, and clean up toxic waste sites. A national initiative in synthetic biology should address not only the research challenges, but the important ethical and biosecurity issues as well.

Neurotechnology

Brain-related disorders are estimated to cost $1 trillion—a huge economic burden for the nation.[30] Drugs and devices to treat these diseases, including Alzheimer's, multiple sclerosis, stroke, spinal cord injury, Parkinson's, and chronic pain, are emerging rapidly. Yet there is very poor coordination of the basic science with the potential technological applications.

The United States currently has the lead in neuroscience but other countries are developing centers of excellence in neurotechnology and could overtake us in the 21st century, thereby reaping both the human and economic benefits of this expanding area. A neurotechnology initiative would develop infrastructure, sponsor an interagency research and development program, and facilitate the transfer of new knowledge of the brain and nervous system to private sector innovators.

Following the model of the Human Genome Project,[31] a significant portion of funds for a neurotechnology initiative should be dedicated to studying the ethical, legal, and societal implications of greater understanding and control over the human brain and nervous system.

Services science

The services sector now accounts for roughly 80 percent of the U.S. economy.[32] Companies such as IBM that have traditionally been in the hardware business now derive more than half of their revenue from services. Currently, however, there is no discipline that promotes innovation and productivity in the services sector in the same way that electrical engineering has led to technological advances in the computer chip industry.

What is needed is a new academic field that would draw on disciplines such as computer science, management, operations research, and organizational behavior.[33] This would increase U.S. competitiveness in the services sector at a time when there is growing concern that basic services will be commoditized and offshored.

21st century infrastructure

The tragic collapse of the Interstate 35W bridge in Minneapolis is a dramatic illustration of the need to increase our national investment in infrastructure. In 2005, the American Society of Civil Engineers gave our infrastructure a "D," and warned that a failure to invest would lead to "congested highways, overflowing sewers and corroding bridges."[34] Although a comprehensive solution to this problem is beyond the scope of this paper, new technologies can help address this crisis.

The federal government should increase investment in research, development, and demonstration projects that will help improve our public infrastructure. For instance, researchers at UC Berkeley and

Advanced Learning Technologies

Investing in human capital tools is key for productivity growth

For decades, advocates of educational technology have argued that technology, used creatively, can transform the way teachers teach and students learn. Significant progress has been made in connecting classrooms to the Internet and expanding student access to computers, and there are many individual "success stories" of educational technology in communities throughout the United States.

Yet there is no evidence of a widespread revolution in learning. Even in the heart of Silicon Valley, one Stanford researcher found that "less than five percent of teachers have integrated computer technology into their regular curricular and instructional routines."[35] A 2007 Department of Education report to the Congress concluded that students using 16 different educational software packages for reading and math did not score significantly higher on standardized tests.[36]

It would be a huge mistake to give up on learning technologies. According to Nobel laureate Gary Becker, "human capital is estimated to be to three to four times the value of stocks, bonds, housing, and other assets."[37] Even a small increase in the productivity of education and life-long learning would yield huge returns.

Moreover, it took decades of experimentation and private-sector investment in information technology before the United States enjoyed the sustained increase in productivity that began in the mid-1990s. Similar investments may be required before we see a comparable payoff from new education technologies.

One of the reasons that there is such a gulf between the potential of learning technology and its actual impact to date is that the federal government invests 0.03 percent of total kindergarten to 12th grade expenditures on research and development.[38] The market for educational software and digital content, particularly at the K-12 level, is unattractive to private sector investors. School spending on software is only $10 per student,[39] the market is fragmented and hard to reach, especially for new entrants, and the review and adoption process is lengthy.[40] The home market for educational software in the United States has declined precipitously from $498 million to $152 million in 2004.[41]

The federal government should launch a major new research, development, and demonstration initiative in advanced learning technologies.[42] The goal of the initiative would be to increase our understanding of how to use technology to improve student performance in K-12, higher education, and life-long learning. Funding for the initiative would eventually reach $1 billion per year, with a goal of stimulating an additional $2 billion in investment by states, philanthropists, and the private sector. The initiative would support:

- Fundamental research on the science of learning, drawing on disciplines such as cognitive science, neuroscience, psychology, education, and social science
- The development of next generation educational software, games, digital libraries, and learning environments that incorporate insights from the learning sciences
- Rigorous evaluations and large-scale demonstration projects in real-world settings to increase our understanding of the effectiveness and current limitations of learning technologies
- Professional development for teachers and the formation of online "communities of practice" to allow teachers to share their experiences
- Experimentation with different approaches to encourage private sector investment in high-quality, research-based learning technologies, including using federal procurement power for training related to defense and homeland security needs, and the establishment of prizes for companies that develop products that successfully demonstrate dramatic advances in learning outcomes in key areas, such as early reading, middle school math and science, and adult basic education

Below are two examples of research challenges that would be supported by such an initiative.

Develop software that is as effective as a one-on-one tutor

Some research suggests that the average student taught by an individual instructor performs better than 98 percent of the students in a standard classroom.[43] Obviously, it is not economically feasible to provide every student with a one-on-one tutor. Researchers, however, have been working to develop "Intelligent Tutoring Systems" that have some of the benefits of infinitely patient, individual instructors. The long-term goal is to create systems that:

- Continuously assess the current strengths and weaknesses of the student's understanding of the subject material.
- Generate instructional material that is tailored to the progress of the individual student.
- Contain a computer model of what an expert knows in a particular subject area.
- Employ a variety of pedagogical techniques, including explanations, guided discovery learning, coaching, and critiquing.
- Monitor, evaluate, and improve their teaching performance over time.[44]

Scientists at Carnegie-Mellon University have collaborated with an award-winning math teacher to create a "Cognitive Tutor" for Algebra I. Students who have used the tutor have performed 15 percent to 25 percent better on standardized tests, and 50 percent to 100 percent better on assessments of complex mathematical problem solving. High school students that used the Cognitive Tutor were more than twice as likely to enroll in Algebra II than students who took the traditional Algebra I course.[45] Additional research in Intelligent Tutoring Systems could increase their effectiveness, lower the cost of developing them, and demonstrate their potential across a wider range of subject areas.

Create "games for learning" as compelling and engaging as the best video game

America is becoming a nation of game players. Today, the average game player is 30, and one-third of players are women. More than eight in 10 young people have a video-game console at home. By 2020, 174 million Americans will be between the ages of 5 and 44, and will have grown up with video games in their early childhood and teens.[46]

Although most games on the market are designed to entertain, the industry is creating a powerful set of capabilities that could also be used for learning. Playing a good game can lead to a mental state that University of Chicago psychologist Mihali Csikszentmihalyi calls "flow," with clear goals, a high degree of concentration on an intrinsically rewarding activity, direct and immediate feedback, and a balance between ability level and challenge.[47]

Games can also teach teamwork and collaboration. Massively multiplayer online role-playing games such as World of Warcraft now have 9 million subscribers, and require the formation of teams of 40 to "work together with the coordination of synchronized swimmers" to reach the top levels.[48] Games are also pushing the state-of-the art in artificial intelligence, graphics, and mobility (with handheld games).

Experts convened by the Federation of American Scientists have identified a series of research questions that need to be addressed to realize the potential of games for learning, including:

- Discovery of the best features of games to apply to learning
- Using games for higher-order thinking and doing skills that 21st century employers are demanding, such as such as rapid information acquisition, problem identification and problem-solving, managing the allocation of scarce resources, adapting to rapid change, and team building
- Determining how to strike the right balance between the "fun factor" of games and the "educational density," or the amount of learning that takes place per unit of time
- Designing simulated actors or "avatars" with specific skills, knowledge or personalities
- Exploring how educational and training institutions (organizational structures, instructional practices, and incentives) will need to evolve to take advantage of games.[49]

A game developed by the Federation of American Scientists teaches immunology in a fun and engaging way. Images courtesy of Federation of American Scientists, www.FAS.org.

Weapons of Mass Salvation

Innovation for the developing world

The United States should launch a new initiative to harness its scientific and technological prowess to help address the needs of the developing world, and to develop what Columbia University professor Jeffrey Sachs has called "weapons of mass salvation."[50] This initiative would address issues such as poverty alleviation, global health, agricultural productivity, safe drinking water, and "digital inclusion."

This initiative should also build new partnerships between U.S. and developing country academic institutions, non-profit groups, companies interested in providing goods, services, and jobs to communities in developing countries, and "social enterprises" that seek opportunities with both financial and social returns on investment. The creation of such a pro-poor "innovation ecosystem" is necessary to not only develop new technologies that meet the needs of the poor, but also to ensure that they are widely deployed.

Some of the technologies in question are very sophisticated, such as a "lab on a chip" for point-of-care diagnosis of infectious diseases and new vaccines. Others are not high-tech, but benefit from research efforts to improve their design, evaluate their effectiveness in real-world settings, and identify the economic and social barriers to their widespread deployment. Think of cleaner burning cookstoves, an "anti-shock" garment that stops pregnant women in rural villages from dying of post-partum hemorrhage, solar disinfection of water in clear plastic bottles, and pedal-powered micro-irrigation pumps.

There are compelling humanitarian, foreign policy, and economic reasons to launch such an initiative. First, it is inexcusable that 2.7 billion people live on less than $2 per day,[51] that more than a billion people lack access to safe drinking water,[52] and that almost 10 million children die every year before the age of five.[53] Although technology cannot solve these problems, it can help, particularly when combined with sound public policies and creative business models.

Second, the foreign and military policies of the current administration have done significant damage to America's international reputation. This initiative would help restore the image (and underlying reality) of America as a nation committed to improving the human condition.

Finally, as markets in the developed world become saturated, emerging markets are becoming an increasingly important source of growth for U.S. exporters. The United States would benefit economically from increased expertise in designing products, services, and technologies that meet the needs of the developing world.

One priority for such an initiative should be the development and adoption of cost-effective, global health technologies. Currently, only 10 percent of global health R&D is devoted to diseases that affect 90 percent of the world's population.[54] The United States should accelerate the development of global health technologies such as vaccines, therapies, medical devices, and low-cost diagnostics, using a mix of technology "push" and market "pull" mechanisms.

Case in point: The United States should join with other developed countries and support so-called "Advance Market Commitments" for vaccines for diseases of the poor such as tuberculosis and malaria. Under AMC, donor governments "make markets" by committing to buy a certain number of doses of a vaccine that is safe and effective.[55]

The United States should also support research that increases our understanding of how to deliver particular global health interventions, and how to strengthen health systems in developing countries. Other potential topics might include:

- The development of low-cost, easy-to-use water treatment devices, such as filters with antimicrobial coatings.
- Innovations that increase Africa's agriculture productivity, such as crops with micronutrients and greater protein content and crops that are resistant to heat, drought, salt water, and disease.
- Information and communications technologies that are designed with the needs of developing countries in mind. For example, researchers at UC Berkeley have adapted WiFi technology so that it can be used to provide Internet connectivity in rural communities in India. And Aravind Eye Hospital is using it to remotely screen patients in rural villages to determine whether they need eye surgery.[56]

New Technologies for a Low-Carbon Economy

Some key proposals from the* Progressive Growth *plan companion report "Capturing the Energy Opportunity: Creating a Low-Carbon Economy"

"Capturing the Energy Opportunity," a companion report to the Center for American Progress' *Progressive Growth* economic plan, discusses the need to accelerate America's transformation from a high-carbon economy dependent on imported oil and dirty coal to a low-carbon economy with clean energy and dramatically improved energy efficiency. This report in the series addresses the risks of global warming and our nation's dependence on foreign oil and then details now the next president and Congress can spark the creation of new industries and jobs by rising to the challenges posed by these threats.

Part of this strategy involves doubling support for energy research, development, and demonstration. America's energy innovation strategy must include support for early stage research that will create entirely new options for the future, such as:

- Nanotechnology-based solar cells as cheap as paint
- The use of synthetic biology to create organisms that can convert sunlight directly to next-generation fuels
- Improvement in battery technology for plug-in hybrids
- Cost-effective energy storage that allows for increased use of intermittent sources of energy such as wind and solar
- Advances in carbon capture-and-storage technologies for responsible use of coal
- Predictive modeling of combustion devices to design more efficient engines, using supercomputers capable of quadrillions of calculations per second
- Solid-state lighting that is 50 percent more efficient than today's compact fluorescents
- An "intelligent grid" that is self-healing, offers special rates for purchases of energy-efficient appliances, provides real-time pricing to reduce peak load, and can handle increased use of distributed energy resources
- Smart windows that can go from clear to translucent in an instant, saving billions of dollars in lighting, cooling, and heating costs
- Zero-energy buildings that produce all of their energy from renewable sources

These and other energy- and climate change-related proposals, together with the policy initiatives designed to accelerate their deployment, are discussed in detail in another report in our series.

other universities have developed wireless sensor networks that can monitor the structural health of bridges and reduce highway congestion by providing a real-time "map" of traffic flows.

Innovation is also desperately needed in our air traffic control system to help cope with a doubling or even tripling of passengers by 2025. A next generation system would use technologies such as satellite-based precision navigation, Global Positioning System capabilities, advanced networks, improved weather forecasting, and traffic flow management tools. Such a system would shift decision-making from the ground to the cockpit, increasing capacity and safety while reducing delays, fuel consumption, noise, and emissions.[57]

Increase the impact of America's research investments

Although increasing our overall investment in R&D is important, it is also critical that we address some of the shortcomings of today's science policies that limit the impact of these investments.

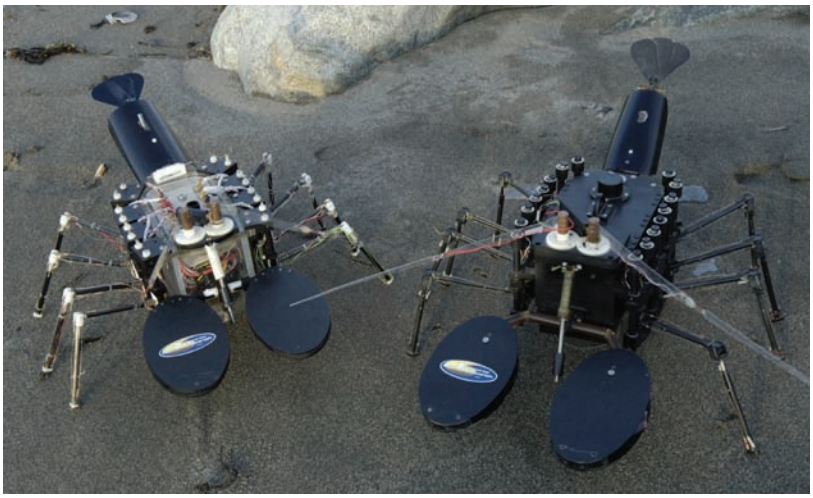
Specifically, we should:

Expand support for high-risk, high-return research.

It is essential that the federal government provide long-term support for high-risk, high-return research. This is precisely the kind of research that industry is unable or unwilling to fund since it is often very difficult to justify to shareholders making investments that may not pay off for decades, if at all.

In recent years, the government has retreated from supporting high-risk, high-return research. DARPA, which has a long and distinguished track record of investing in cutting-edge research, is now making "go, no-go" decisions about whether continue a research project a mere 12 to 18 months after its inception. University researchers, to the extent that they are involved at all, are increasingly serving as sub-contractors to defense companies. This reduces their ability to pursue longer-term research goals.

A study by the Defense Science Board concluded that DARPA's withdrawal from investing in key technologies such as microelectronics "has created a vacuum." The report concludes that "the problem, for DOD, the IT industry, and the nation as a whole, is that no effective leadership structure has been substituted."[58]



The Biomimetic Underwater Robot, Robolobster, at Northeastern University's Marine Science Center in Nahant, MA. Biomimetic robots are, in principle, relatively small, agile and relatively cheap, relying on electronic nervous systems, sensors and novel actuators. Most importantly, they can take advantage of capabilities proven in animals for dealing with real-world environments. U.S. Navy photograph by John F. Williams—3/2/2006.

This is not just a problem at DARPA. More generally, researchers joke that they "have to do the experiment before they write the grant." If a science agency is able to support only 10 percent (or less) of research proposals, the peer review process becomes increasingly conservative. It may take only one reviewer on a peer review panel to block an innovative but risky research proposal.

In this environment, researchers become cautious and conservative and propose incremental advances based on previous results. They do not "swing for the fences" by pursuing ideas that will lead to breakthrough technologies or open up new lines of scientific inquiry. To address this serious problem, the next administration should:

- Restore DARPA's historical role in backing long-term, high-risk research.
- Implement the recent recommendations of the National Science Board report on "transformative research," which they define as "ideas that have the potential to radically change our understanding of an important existing scientific or engineering concept or leading to the creation of a new paradigm or field of science and engineering."[59]
- Give program managers in science agencies greater authority to support high-risk, high-return research. In *Rising Above the Gathering Storm*, the National Academy of Sciences recommends setting aside 8 percent of federal

research budgets to invest in high-risk, high-return approaches.[60]

- Expand programs such as the NIH Director's Pioneer Award.

This last award provides significant, five-year funding for exceptionally creative scientists with ideas for research that has the potential to be transformative, but may be "too novel, span too diverse a range of disciplines, or be at a stage too early to fare well in the traditional peer review process."[61] In the current year of the program, NIH will only provide five to 10 such awards, which is too modest an effort to have a significant impact on the research enterprise. This program should be significantly expanded at NIH, and similar programs should be launched at other science agencies.

Foster partnerships between universities and industry to address new challenges.

Many of the corporate research labs that had the ability to pursue long-term research are a shadow of their former selves. Bell Labs, formerly the premier industrial research laboratory in the world, once played a key role in the development of foundational information and communications technologies such as the transistor, the laser, information theory, programming languages, the UNIX operating system, and wireless technology. Bell Labs still exists, but it now employs just 1,000, down from a peak of 25,000.[62]

Increasingly, industry leaders are looking to academia to replace the void left by the decline of corporate research labs such as Bell Labs. The semiconductor industry, for example, is concerned that they will be unable to double the computing power of semiconductors every 12 months to 18 months after 2020 without radical breakthroughs in information technology. The industry has started to fund a university-based Nanoelectronics Research Initiative to address this challenge, but the government has provided only modest support for this effort.

Similarly, progress in information technology could grind to a halt unless researchers can develop novel approaches to easily and efficiently programmed computers that have dozens or even hundreds of processors on a single chip. The federal government should provide matching funds for university-industry collaborations that address these and other long-term challenges.

Actively encourage multidisciplinary research and education.

Because of the depth and breadth of America's research enterprises, we have a unique opportunity to lead in multidisciplinary research and education. Many key scientific, technological, and societal challenges—among them making the transition to a low-carbon economy and more accurately predicting the affects of climate change—cannot be solved by researchers in any one discipline. And innovation often arises from combining the tools, techniques, insights, and interests of researchers in different fields.

There are a growing number of fruitful research collaborations between engineers and biologists that highlight the importance of multidisciplinary research. Mother Nature has had billions of years to develop amazing solutions to a wide variety of problems, and engineers are interested in using the structure and function of living systems as a source of inspiration. Working with biologists, engineers are studying how geckoes walk up walls,

how the microbes in the hind-gut of a termite help it digest wood, the ability of plankton to make exquisite nanostructures at room temperature using seawater, and the ability of beetles to detect a forest fire from 20 miles away.[63]

Although it is important to continue to invest in disciplinary excellence, the federal government should take additional steps to foster interdisciplinary research and education, such as:

- Greater support for small, tightly focused interdisciplinary teams, with grants of at least $1 million to $2 million per year supporting the faculty, graduate students, and postdoctoral researchers in 3 to 5 different labs.
- Targeted research solicitations in emerging interdisciplinary areas such as computational biology or biomolecular materials, with review panels capable of evaluating interdisciplinary proposals.
- Increased funding for interdisciplinary training grants that allow graduate students to work at the intersection of two or more disciplines. The NSF has such a program (Integrative Graduate Education and Research Traineeship), but this year it will be able to fund only 20 of the 440 proposals it received.[64]

Although the federal government can serve as a catalyst for interdisciplinary research and education, much of the work to build successful collaborations that span disciplines will need to be done by academic institutions, industry, professional societies, and ultimately teams of committed researchers and students. Key roles for these different groups have been identified in a 2004 National Academy of Sciences report, *Facilitating Interdisciplinary Research*.

Expand government capacity to foster innovation in a broad range of national goals

Noted science fiction author William Gibson once observed that "The future is here, it's just not evenly distributed." A similar comment could be made about the ability of the U.S. government and the research community to help create the future.

Some agencies, such as the Department of Defense, the National Institutes of Health, and the National Aeronautics and Space Administration, have the budget and the capacity to support research and innovation on problems that are related to their missions. Others, including the Environmental Protection Agency, the U.S. Agency for International Development, and the Departments of Education, Labor, State, and Housing and Urban Development, have little or no such capability.[65]

This imbalance may limit our ability to support research in what Princeton University professor Donald Stokes referred to as "Pasteur's Quadrant," or research that pursues fundamental understanding but is also motivated by consideration of some practical problem.[66] If the agency charged with advancing a particular set of national goals has little or no ability to support research, and if such research is not an attractive investment for firms, then there may be important and systemic gaps in the nation's research portfolio.

To evaluate the opportunity costs of these gaps, it is necessary to understand the benefits that can flow from creating high-quality, well-supported, multidisciplinary communities of researchers that are interested in helping to meet a particular national policy objective. Such multidisciplinary research can advance the state of the art in an area of science and technology that will

make it easier or less expensive to meet a given national goal, or even re-frame the way that a policy issue is debated or discussed. The old adage that "if all you have is a hammer, the whole world looks like a nail" is certainly true for federal agencies.

Research can also help create a more rigorous basis for making decisions or setting public policy. For example, some areas of policy (such as welfare policy and adult training) have benefited significantly from randomized field trials analogous to the clinical trials conducted by medical researchers. The researcher randomly assigns some individuals to a control group and others to an experimental group that receives the "treatment" that is being evaluated.[67]

Researchers generally have greater confidence in conclusions reached by randomized field trials than those produced by non-experimental research. Although randomized field trials are not always feasible and cannot shed light on all policy questions of interest, they are clearly underutilized in some important policy areas such as education. Case in point: A recent analysis of 144 contracts for program evaluation awarded by the Department of Education between 1995 and 1997 found that only five used a randomized controlled design to measure the impact of federal programs.[68]

Government support for university-based research helps create or expand a workforce with specialized skills. Creating such a workforce may be critical to achieving a particular policy objective. Recently, for example, the federal government has acted to increase the number of undergraduate and graduate students with a background in cybersecurity, since the government was unable to recruit enough people with the necessary skills.[69]

Similarly, NIH has recognized that exploiting the revolution in genomics will require addressing the shortage of researchers in bioinformatics. Agencies that lack the ability to support university-based research, fellowships, and traineeships will not be able to help create this kind of specialized workforce.

More importantly, perhaps, government support for multidisciplinary research can lead to innovation in the development and use of new technologies. Working with entrepreneurs and venture capitalists, researchers can start new companies that commercialize these technologies. They can suggest "figures of merit" that create new metrics for measuring technological progress or develop open technical standards, such as the core protocols for the Internet, that serve as the platform for entirely new industries. They can create test beds that offer insights into the impact of novel combinations of technologies in real-world settings. They can help dramatically lower the cost of a given activity, such as sequencing genomes and storing, transmitting, and processing information. Finally, once a research community with an interest in tackling a given problem has been created, its members will be able to identify future advances in fundamental understanding or technological capability that are feasible and relevant.

An example of an agency that currently has a modest capacity to support innovation is the Environmental Protection Agency. EPA currently pursues the goal of a cleaner environment primarily through command-and-control regulation, as opposed to supporting the creation and diffusion of technologies that minimize pollution in the first place. Greater emphasis on the latter approach might allow the United States to achieve its environmental

objectives while reducing the economic costs imposed by regulations.

Most of EPA's existing research budget supports regulatory decision-making and the assessment of environmental and human health risks; little is left to support the development of technologies that would minimize pollution to begin with. EPA should be given the budget, mandate, and expert workforce to support innovation in areas such as "sustainable chemistry," designing for reuse and remanufacturing, low-cost sensors for monitoring air and water quality, and engineered microorganisms that can slash the cost of cleaning up toxic waste sites.[70]

In short, policymakers should stop treating the current funding structure for research as a given and begin experimenting with different ways in which science, technology, and innovation can contribute to a broader set of national goals. One such strategy is to increase the capacity of existing mission agencies to support research and innovation. This might involve one or more of the following steps:

- Appointing or elevating the position of the chief scientist at different agencies
- Using the National Academies to identify potentially relevant research issues
- Aggressively using the Intergovernmental Personnel Act to recruit researchers from universities and national labs
- Establishing external advisory committees
- Determining where an incremental investment might allow the agency to leverage science and technology funded by industry and other federal research agencies
- Gradually increasing the agency's R&D budget as it demonstrates the ability to successfully manage a high-quality extramural research program.

These steps would increase the role that science, technology, and innovation can play in advancing a broader set of national goals, such as environmental protection, poverty alleviation, and education and training

Use more prizes and Advance Market Commitments to stimulate innovation

Inducement prizes are an old but currently underutilized tool for stimulating technological innovation.[71] Inducement prizes encourage efforts by contestants to accomplish a particular goal, as opposed to recognition prizes such as the Nobel Prize which reward researchers for past achievements.

Historically, prizes have been used by the British Parliament to discover an accurate way to measure a ship's longitude, by Napoleon to feed the French army with preserved food, and by a New York hotel owner to motivate Charles Lindbergh's trans-Atlantic flight. In recent years, prizes have enjoyed a renaissance, in part due to the success of the Ansari X PRIZE.

In 1996, space entrepreneur Peter Diamandis established the X PRIZE to "promote the development and flight of spaceships able to provide low-cost commercial transport of humans into space." The X PRIZE Foundation offered a $10 million prize to the team that, without government support, developed a craft that would successfully send the pilot and two passengers to a suborbital altitude of at least 100 kilometers, and

repeat the flight within two weeks. The prize was won by aerospace designer Burt Ruttan and his team at Scaled Composites in October 2004.[72]

Since then, the X PRIZE Foundation has announced a $10 million prize for the inexpensive and rapid sequencing of the human genome. The foundation is also exploring new prizes in high-mileage autos, space, the environment, nanotechnology, medicine, and social entrepreneurship.

A related policy tool is an Advance Market Commitment. Under an AMC, governments commit to purchase a product that does not yet exist, thereby stimulating private-sector investment in R&D and manufacturing. As discussed previously in the box "Social Entrepreneurship, Social Innovation" on page 6, experts have proposed creating AMCs for diseases of the poor such as tuberculosis and malaria.

Although prizes are not a substitute for government support for research, under certain circumstances, they have some advantages over traditional funding mechanisms. Specifically:

- Prizes allow the government to establish a goal without deciding the best way to achieve the goal or choosing the team that is most likely to be successful.
- Inducement prizes are awarded only if a team meets a predefined objective, as opposed to a grant, which is awarded even if the recipient is unsuccessful.
- Prizes can stimulate philanthropic and private-sector investment that is greater than the cash value of the prize.
- Prizes can attract entrepreneurs with new ideas who would never do business with the federal government because of procurement regulations and other red tape.
- The publicity surrounding the competition can increase public interest in and support for science and technology.

Currently, only a few federal agencies (DARPA and NASA) are using prizes. Congress should pass legislation that gives federal agencies the authority to support prizes and Advance Market Commitments. This legislation should encourage agencies to partner with non-profit groups and the private sector, which would take the lead on public relations, defining the rules, recruiting additional and philanthropic sponsors, and selecting the judges.

The legislation should make clear that the government can make commitments to prizes and AMCs that are legally binding, and not subject to the whims of the annual appropriations process. Finally, the legislation should allow agencies to experiment with a broad range of topics, prize amounts, and rules.

DARPA Grand Challenge, October 9, 2005. Stanford University's Stanley was the first to cross the finish line. Image courtesy of DARPA.

Building a Workforce for the Innovation Economy

Investment in Human Capital to Support Science, Technology, and Innovation

In addition to investing in research and development, the federal government also needs to ensure that the United States has a workforce capable of thriving in an "innovation economy." The *Progressive Growth* companion report, "Opportunity and Security in the Global Economy," (forthcoming) describes CAP's proposals to improve our education system so it better prepares students for the innovation economy, including proposals like the Teacher Excellence for All Children Act to ensure that all children are taught by high-quality teachers and all teachers have the support they need to do their job well. This section describes other policies that can help create an innovation-ready workforce, such as specific measures to upgrade the STEM (science, technology, engineering, and mathematics) skills of our workforce and changes to immigration policy that will allow the "best and brightest" from all over the world to study in our universities and contribute to the U.S. economy.

Create a Workforce with World-class Science and Technology Skills

America is not on track to create the workforce that we need to remain globally competitive in the 21st century, particularly in science, technology, engineering, and mathematics. Improved math and science literacy is becoming increasingly important in a wide range of jobs—not just for chip designers and computer programmers.

This problem exists along the entire education "pipeline." Sixty-eight percent of U.S. 8th graders receive instruction from a mathematics teacher who did not hold a degree or certification in mathematics. U.S. 15-year-olds rank 24th out of 40 participating countries in an international test that measures the ability of students to apply mathematical concepts to real-world problems. In the United States, only 15 percent of all U.S. undergraduates receive a degree in the natural sciences and engineering, compared to 50 percent in China and 67 percent in Singapore.[73]

Moreover, global competition and rapid technological change are "raising the bar" on the skills that workers must possess to thrive. Business writer Daniel Pink, author of the book *A Whole New Mind: Why Right-Brainers Will Rule the Future*, argues that logical and analytical skills are necessary but not sufficient for professional success in today's world. Workers also need "right brain" skills such as the capacity to "detect patterns and opportunities, to create artistic and emotional beauty, to craft a satisfying narrative, and to

combine seemingly unrelated ideas into something new."[74]

Organizations such as the Partnership for 21st Century Skills, comprised of the National Education Association and major high-tech employers such as Apple and Cisco, argue that students must master not only core subjects, but acquire skills related to critical thinking, problem solving, creativity, innovation, collaboration, and information and media literacy.[75] Obviously, there is no one single initiative that will address this challenge, and it will not be solved overnight. Consequently, the next administration must embrace a range of educational reforms.

Improve the quantity and quality of K-12 math and science teachers.

The National Academies recommends that the federal government provide 10,000 four-year, merit-based scholarships to students who are receiving a K-12 teacher certification and a bachelor's degree in a STEM (Science, Technology, Engineering or Mathematics) field. Students would have to agree to teach for at least five years.

The "UTeach" program at the University of Texas at Austin demonstrates that this approach can work. UTeach has attracted large numbers of math and science majors to teaching. Since 1997, they have doubled the number of math majors and increased by five to six times the number of science majors being certified.[76]

Increase funding for partnerships between industry and community colleges.

Federal funding to develop customized job training and associate's degrees for technicians at local community colleges will expand America's high-tech workforce. The NSF Advanced Technological Education program, for example, has supported the development of curriculum in areas such as biotechnology, IT security, semiconductor manufacturing, and aerospace. One such initiative is the Nebraska-based Midwest Center for Information Technology, which has identified the skills that community college students need to get jobs in rapidly growing fields, such as health informatics and homeland security, and has significantly increased the number of community college faculty that have obtained industry certification in IT skills.[77]

Support programs that increase the diversity of the STEM workforce.

Programs that get more young boys and girls excited about science and engineering will prepare our future workforce for the skills they will need to compete in a global economy. One such program is FIRST (For Inspiration and Recognition of Science and Technology), launched by

2007 BAE Granite State Regional FIRST Robotics Competition in Manchester, NH. Images courtesy of BAE Systems.

inventor Dean Kammen. FIRST gives teams of students six weeks to build a robot from a common set of parts, and has attracted 32,000 students, 18,000 mentors and 2,000 corporate partners from across the country.[78]

Students that participate in FIRST, compared with a group of students with similar backgrounds and achievement, are three times as likely to pursue a career in engineering.[79] FIRST receives modest funding from the federal government, but most of its funding comes from companies and philanthropists such as Boston Scientific Corp., Delphi Corp, Motorola Inc., and venture capital firm Kleiner Perkins Caufield & Byers. Challenge grants from the federal government would allow FIRST and other successful programs to expand.

Boost federal grants for science and engineering degrees.

Providing grants to colleges and universities that expand the number of undergraduates that receive a bachelor's degree in science and engineering could increase the size of our high-tech workforce. Stanford University professor Paul Romer has argued that such universities with a fixed investment in faculty that teach in areas outside of science and engineering may face "internal political pressures to maintain the relative sizes of different departments."[80]

As a result, they many respond to increased student demand for degrees in science and engineering by making it more difficult for students to complete a degree. Training grants that are linked to the number of undergraduates receiving degrees in science and engineering would increase the incentives for universities to hire additional faculty in science and engineering.[81]

Triple the number of the National Science Foundation's Graduate Research Fellowships.

These fellowships should climb to 3,000 from 1,000.[82] The number of NSF graduate fellowships has remained unchanged since the early 1960s, despite a large increase in the size of the undergraduate population. Funding fellowships also gives graduate students more autonomy in choosing their research projects.

Strengthen the system for immigration of highly educated workers in the context of broader immigration reform

America's capacity to be a leader in innovation depends upon the talents, skills, and spirit of the entire U.S. workforce. In another report in the *Progressive Growth* series of papers on National Economic Policy titled "Opportunity and Security in the Global Economy: Progressive Polices to Promote Success for Working Americans," our colleagues at the Center for American Progress set forth a policy agenda designed to help enhance education and workforce training so that all of our children are prepared for a role in the 21st century innovation economy and adult workers can be continuous learners, upgrading their skills to enhance their employability and get ahead in a rapidly changing global economy.[83]

It is essential that the next president challenge employers to do more to upgrade the skills of their existing workforce, invest federal resources in education and workforce development, and work with schools and universities on long-term efforts to further science, technology, engineering and math education.[84] But our workforce is not made up of U.S.

natives exclusively; almost 25 million, or 15.3 percent, are foreign born workers who immigrate to the United States temporarily or permanently, largely drawn by the opportunity here.[85]

Immigration affects all aspects of the U.S. economy from the corner store to the multinational corporation, from lettuce fields to biotech laboratories, and from the lowest paid to the most highly compensated work. Our capacity for innovation is therefore dependent upon getting all aspects of our immigration policy right for a 21st century economy.

Recent efforts at immigration reform have sought to pit the interests of the United States in attracting those with education and high skills against the interests of the United States in respecting the integrity of families—without adequate recognition of the value that family-based immigration has played in allowing immigrants to establish roots, invest in new companies, and spur economic growth. America's long-term economic interests require us to think more broadly about immigration and to reject such efforts to portray the debate as an either-or choice.

In that spirit, we offer specific objectives to ensure that the immigration policy of the United States helps to provide our economy with the skilled workforce that it needs. We set this need to provide opportunities for more highly educated workers to become a part of American society, in the broader context of a comprehensive and effective pro-economic growth policy that would advance our economic interests while protecting our security and our values.

A comprehensive and effective immigration policy for the 21st century (described in more detail in the Center for American Progress' "Principles for Immigration Reform") should be based on the following guidelines:

Accept increased labor mobility.

Globalization has made the movement of capital and goods and services across national borders increasingly more efficient. Labor mobility has not kept pace. For the United States to retain our economic leadership and ability to grow economically, we must move toward a well-regulated, legal global labor market.

Increase and diversify legal immigration.

The demands of global competitiveness require increased overall levels of legal immigration. Demographic trends show that an aging America will need more workers across all occupation levels. "High-skilled" immigration and family-based forms of immigration should not be pitted against one another in determining the overall target levels of legal immigration. A combination of education- and employment-based immigration and the more traditional form of family-based immigration would be true to our values and would capitalize on the ability of these varied forms of immigration to be engines of economic growth and dynamism.

Protect U.S. workers.

In the context of an increasingly globalized labor market and expanded legal immigration, reforms must protect U.S. workers by safeguarding the ability of all workers to defend their rights, including the rights to change jobs freely, to organize without fear, and to earn a fair wage.

Incorporate robust enforcement and safeguards.

The federal government has a responsibility to protect the country by intelligently patrolling our borders and points of entry while advancing the economic and moral imperatives that should shape immigration reform. An increase in legal immigration must also be accompanied by efforts to ensure that a revised legal immigration system embraces a respect for both the rule of law and privacy, so that all, including employers and employees, understand that unauthorized presence in the country will not be tolerated.

Resolve the status of the undocumented.

Immigration reform efforts cannot ignore that millions of people currently enhance our economy without recognized legal rights. More than 12 million people reside in the shadows of our society. Effective reform must establish a tough, rigorous, but fair means for these individuals to become full contributing members of our society. A clear path to earned legalization would help restore the rule of law, avoid exploitation of immigrant workers, and protect opportunity for all workers, including native U.S. workers.

Foster an inclusive American identity.

Increased legal immigration creates concerns among many regarding possible effects on our American identity. Immigration reform efforts must take these concerns into account and support the ongoing process of shaping the American identity influenced, as it has always been, by new immigrants, yet grounded in traditional core values of equality, freedom, and opportunity. To that end, both government and the private sector need to invest in more programs of English language acquisition and civic education.

Consistent with the reform principles laid out above, the United States needs urgent action to reform the element of immigration policy that most directly affects innovation in the U.S. economy. Steps must be taken to enhance the ability of the United States to attract and retain immigrants who are engines of innovation and economic dynamism.

This is critical for a number of reasons. Currently, 56 percent of engineering Ph.D.s and 34 percent of the Ph.D.s in the natural sciences in the United States are awarded to foreign-born students.[86] Skilled immigrants also play a key role in innovation and job creation. Immigrants have founded one in four of the publicly traded venture-backed companies started between 1990 and 2005. Immigrant-founded publicly traded U.S. venture-backed companies generated more than $130 billion in revenue and employed 220,000 U.S. workers.[87]

Prominent public companies founded by immigrants include Intel Corp, Solectron Inc., Sun Microsystems Inc., eBay Inc., Yahoo! Inc., and Google Inc. Moreover, foreign nationals residing in the United States were inventors or co-inventors of 25.6 percent of the international patent applications filed from the United States in 2006, up from 7.6 percent in 1998.[88]

Current policy often makes it difficult for the world's "best and brightest" to study, work, and start a business here. One recent study estimates that more than 1 million people in the United States are waiting in line for 120,000 employment visas, indicating that almost nine years' worth of employment visas are already

spoken for.[89] The number of employment-based visas that can be issued to immigrants from any one country is less than 10,000 per year, even for large countries such as China and India.[90] Foreign students that receive advanced technical degrees from U.S. universities are often forced to return to their home country. Even if they can receive a temporary visa, they cannot leave their employer for another job or to start their own company.

In working with Congress, the next administration should:

Retain U.S.-educated advanced degree students in the workforce and promote scientific exchange.

Existing visa and export control policies send a message to international students, scholars, scientists, and engineers that they are not welcome in the United States and deter international scientific exchange. Those policies should be reformed. For example, a "fast track" system should be created to allow foreign students that receive advanced technical degrees from U.S. universities to receive an employment-based visa without having to return to their home country.

Address the backlog of highly educated workers.

Effective steps must be taken to clear the backlog of highly educated immigrants waiting to become permanent residents. Such efforts could begin by increasing the employment-based visas from 140,000 to 290,000 per year.

Effectively addressing this concern also requires some adjustment to the country-based limits to recognize that different countries offer smaller and larger pools of potentially more educated immigrants. We should also ensure that our immigration system provides more increased permanent resident visas to satisfy other occupational needs, with differing educational requirements. These changes should be made without reducing the number of otherwise available avenues for permanent residency.

Recognize employers' insights about their own skills needs.

Although the government must retain an important vetting function, reforms designed to increase high-skilled immigration, both temporary and permanent, should take into account that employers, not the federal government, will be best able to determine what skills they need and, assuming that those skills are not available in the United States, which potential immigrants would fill that need.

Develop a new, responsive, and fair temporary worker visa program.

The existing high-skilled worker temporary visa program, the H1-B visa program, does not meet current demand. Employers are desperate for its expansion. That desire can and should be met, in part, through an expansion of the number of permanent visas available for employment-based immigration as described above. A new temporary worker visa program, however, also should be created to meet short-term needs of employers without doing damage to domestic U.S. workers.

A temporary highly educated workers program must not create incentives for companies to seek foreign workers before looking for qualified U.S. workers. It should also protect against abuses of the existing program, such as companies us-

ing temporary workers as part of a plan to train overseas workers and offshore existing U.S. jobs. Finally, foreign workers who enter the country through the temporary worker program who wish to become permanent members of our society should not be forced to remain tethered to their original sponsoring employer throughout the permanent resident application process. Those workers must be free to accept a better job from a qualified employer without fear of reprisal and without eliminating the possibility of permanent immigration.

Finally, the Department of Labor must be given adequate administrative resources to effectively enforce the new program's requirements, focusing especially on the labor market test and prevailing wage rules for firms dependent on these temporary workers.

In short, we need both immediate and structural reforms to fix our current dysfunctional system. An immigration system consistent with these principles would be worthy of our modern society, an engine for growth and shared prosperity, and a way to help ensure that the U.S. economy remains a dynamic leader in innovation.

Stimulating Private Sector Investment in Research and Innovation

The government's role in supporting basic research needs to be complemented by policies that will encourage private sector investment in R&D, strong regional economies, and broadband networks. Although the federal government can help create the right environment for economic growth, prosperity is ultimately dependent on entrepreneurship and investment in new and rapidly growing businesses. The next administration should expand private-sector incentives to invest in R&D, promote private-sector investment in broadband networks and applications of information and communications technologies that improve our quality of life, and support the development of strong regional economies.

Expand Private Sector Incentives To Invest in R&D

Private-sector companies do not capture all of the benefits from their investment in R&D. Economic analysis shows that the benefits to the economy as a whole from private investment in R&D are significantly larger than the returns that flow to individual firms. As a result, companies will underinvest in R&D (see discussion in the box on the Role of Government on page 3).

One way to address this is to provide a tax credit for companies that invest in research and development, which the United States has done since 1981. Unfortunately, this credit has been renewed 11 times and expired twice, most recently in 2006. This undermines its effectiveness, since companies are not able to rely on the existence of the credit when making investment decisions.

Moreover, the United States once provided the most generous tax incentives for R&D among the industrialized member nations of the Organisation for Economic Cooperation and Development—in the late 1980s—but by 2004 we had fallen to 17th place. This helps explain why, from 1998 to 2003, U.S. majority-owned affiliates operating abroad invested 52 percent more in R&D overseas, compared to 26 percent domestically. Private sector investment in R&D as a percentage of GDP declined every year from 2000 to 2003, from 1.84 percent to 1.67 percent.[91]

At a minimum, the United States should make its R&D tax credit permanent. The next administration should also consider proposals to expand and increase the effectiveness of the credit, such as increasing the credit's rate from 20 percent to 40 percent, or creating a flat credit for research that is conducted in partnership with industry consortia, universities, or national labs.

Promote the Benefits of an Information Society

The sustained improvements in information and communications technologies are astounding. Consider, for example, that the first hard drive (developed by IBM in 1956) was the size of two refrigerators, weighed one ton, and stored 5 megabytes of data.[92] Since then, storage density has improved by a factor of 65 million, and the industry may be able to improve storage by another three orders of magnitude before reaching fundamental technological limits.[93]

Companies are now selling hard drives that can store a terabyte (a trillion bytes) of information, at a cost of $399, or 40 cents per gigabyte. To put that in perspective, the entire printed collection of the Library of Congress would fit in a 10 terabyte hard drive.

Information and communications technologies are also being adopted at a very rapid rate. Over 1 billion people are connected to the Internet, and 2.3 billion people have a cellphone.[94] Unlike previous media technologies, such as broadcast television, the Internet allows individuals to be producers as well as consumers of information.

The Internet also provides an open platform for new services and technologies. The result: The sophistication, versatility, and usefulness of the Internet has also evolved rapidly, with dramatic improvements in technology for search, remote storage, three-dimensional virtual environments, secure transactions, Web publishing, sharing of rich media, electronic marketplaces, and online communities.

The next administration should identify appropriate steps that the federal government can take to promote its economic and societal benefits of the Information Revolution. The goals of this agenda should include:

- Eliminate or reform legal and regulatory barriers to the further expansion of global electronic commerce.
- Ensure that IT is designed to be accessible to people with disabilities, thereby increasing their ability to work and improving their quality of life.
- Promote applications of health information technology that reduce medical errors, slash administrative costs, and allow patients to make more informed decisions about their health care needs. (The Center for American Progress has proposed a strategy for expanding the use of health information technology in the short, medium, and long-term in its paper titled "Navigating American Health Care: How IT Can Foster Health Care Improvement").
- Develop multimedia digital libraries that place our shared cultural and historic heritage at the fingertips of every American.
- Empower adults that are struggling to meet the competing demands of work and family to acquire new skills through online learning, which will allow them

to gain new skills at a time, place, and pace that is convenient for them.

- Promote applications that are specifically designed to address the needs of underserved and low-income communities, such as high-quality, compelling software for English as a Second Language and Adult Basic Education

- Make government more open, transparent, efficient, and user-friendly by taking a page from Carl Malamud, who, as a CAP fellow, successfully urged C-SPAN to expand citizen access to its online video of congressional hearings, agency briefings, and White House events.

- Require government to make it easy for citizens, community-based organizations, and the private sector to add value to data, especially given the power of "mashups" and other Web 2.0 tools and techniques.

- Deploy interoperable wireless networks for public safety, law enforcement, and "first responders" responsible for homeland security.

- Invest in intelligent transportation systems that reduce traffic congestion, emission of greenhouse gases, and injuries and fatalities from accidents.

The federal government should identify ways to promote these and other applications by working with the private sector, states, civil society, and the research community. Although the appropriate role for the government will depend on the application in question, strategies might include eliminating legal and regulatory barriers, creating frameworks for the protection of privacy and security, and supporting research and pilot projects.

Possible government action might also include valuating the costs and benefits of IT applications, promoting industry-led efforts to develop open standards for interoperability, and making the government a more intelligent user of IT.

The United States should also make it a priority to restore our leadership in broadband technology. The United States, the birthplace of the Internet, ranks only 15th out of 30 OECD countries in broadband deployment.[95] A study commissioned by the Communication Workers of America concluded that average broadband speeds in the United States were less than 2 megabits per second, compared to 61 mbps in Japan and 45 mbps in South Korea.[96]

Some of the applications described above will help stimulate demand for broadband. Other actions that the government should take include:

- Create tax incentives for companies that invest in next-generation broadband networks and provide access to underserved urban and rural communities.[97]

- Permanently extend the moratorium on taxes on Internet access.

- Allocate additional spectrum on a licensed and unlicensed basis, with the goal of making wireless a viable competitor to cable and phone companies in the residential broadband market—resulting in lower prices, faster deployment of advanced networks, and a lower risk of anticompetitive behavior that stifles the openness of the Internet.[98]

- Invest in R&D that will allow us to make better use of the existing spectrum, such as "cognitive radio" that will be able to intelligently detect

which channels are in use and which are not, and maximize our use of the spectrum while avoiding interference.

- Support state efforts to accelerate broadband deployment.

An excellent example of this last recommendation is ConnectKentucky, a partnership launched in 2004 which has resulted in $500 million in private investment in Kentucky's telecommunications infrastructure, over 400,000 additional households with broadband access, and a growth in broadband usage of 46 percent in the last two years. This partnership, comprised of universities, government agencies, and companies such as Intel and Cisco, works by creating detailed maps of Kentucky's broadband networks, and creating "eCommunity teams" that document local demand for broadband and improve the business case for private sector teams.[99]

Build Thriving Regional Economies

Even in the global economy of the 21st century, geography still matters. Much of America's high-tech activity is located in regional "clusters." Biotechnology is heavily concentrated in San Diego, Cambridge, Mass., the San Francisco Bay Area and, more recently, the Research Park Triangle in North Carolina. Silicon Valley, of course, is the birthplace of many "category-defining" companies in sectors such as microprocessors (Intel Corp.), semiconductor manufacturing equipment (Applied Materials Inc.), workstations (Sun Microsystems Inc.), printing (Hewlett-Packard Co.), and the Internet (Google Inc., Yahoo Inc., and eBay Inc.). Central Florida has become a hub of activity for modeling and simulation, with applications in national and homeland security, education, and medical training. And Minnesota's Twin Cities are home to "Life Sciences Alley," a group of over 500 companies and organizations in sectors such as medical devices, pharmaceuticals, and healthcare services.

Companies, workers, and investors in related industries benefit from being close to each other for a variety of reasons. Employers need workers with specialized skills, and workers find it useful to be in a region with many employers to choose from. This reduces the risks associated with layoffs, creates more opportunities for career advancement as well as new markets for specialized products and services, such as capital equipment or professional services. This trend of clustering has happened despite theorists' claims that new communications technology would lead to a decentralization of industry.

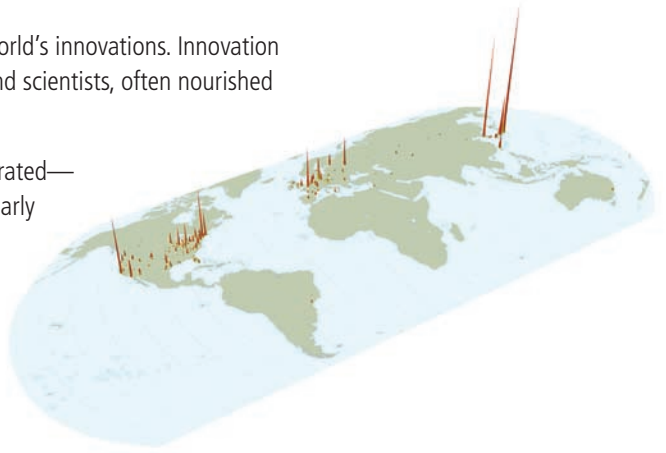
In the ideal industrial district, each company typically specializes in one or a few phases of a complete production process, although it may change its specialty in response to signals from the market. On any particular project, small companies in such a cluster will often cooperate with one another on one project, sharing materials, information, and even skilled workers, yet compete for a share of the next new project or market opportunity. These networks become both flexible and specialized, capable of rapidly reconfiguring themselves to meet the fluctuating demands of the global market. And because of their nimbleness, the collection of firms in a cluster gives them both economies of both scope *and* scale.[100]

Some research also suggests that workers in clusters are more productive, adding to the efficiency of the regional market. A 2006 study of economic development in Canada, for example, found that between

INNOVATION IS SPIKY

Geography of Innovation Just a few places produce most of the world's innovations. Innovation remains difficult without a critical mass of financiers, entrepreneurs, and scientists, often nourished by world-class universities and flexible corporations.

Commercial innovation and scientific advance are both highly concentrated—but not always in the same places. Several cities in East Asia—particularly in Japan—are home to prolific business innovation but still depend disproportionately on scientific breakthroughs made elsewhere. Likewise, some cities excel in scientific research but not in commercial adaptation. The few places that do both well are very strongly positioned in the global economy. These regions have little to fear, and much to gain, from continuing globalization.



Source: "The World in Numbers: The World is Spiky," *The Atlantic Monthly*, October 2005.

1998 and 2005, both employment and average income in clustered industries in "city-regions" grew more than twice as fast as in non-clustered industries.[101] Similarly, a study of 220 metropolitan areas in the United States found that workers in the manufacturing sector that have otherwise equivalent profiles earn higher wages when they are in urban labor markets that have a larger share of national or metropolitan employment in *their same* occupation.[102] Another study found that wages for workers in industry clusters were about 6 percent higher than for workers in the same industry in a nonclustered location.[103]

Furthermore, regional economies benefit from "knowledge spillovers." As observed by the influential English economist Alfred Marshall, who first wrote about clusters when studying industrial regions in England in the 1920s, "if one man starts a new idea, it is taken up by others and combined with suggestions of their own; and thus it becomes the source of further new ideas."[104] Clusters also support innovation because companies in the same industry compete intensely with one another—yet together cooperate with customers, suppliers, and local research institutions.[105]

Several researchers point to California's ban on "post-employment non-compete" covenants as a reason for the growth of clusters there. Many former employees of Hewlett Packard Co., for example, split off to start smaller technology firms of their own in the Bay Area. Splits such as this have led to exponential growth, as HP's alumni and its core technology spread out across the region.[106]

Finally, clusters often support the formation of new companies by so called "repeat entrepreneurs" who were previously successful at forming a startup company. Clusters boast more people with the prior experience, interest, reputation, and relationships needed to successfully launch a new start-up.[107] Furthermore, the concentration of persons with specialized skills creates local social, cultural, and political institutions that are place-specific.

This further reinforces the sense of cooperation and collaboration in a given sec-

tor and in a given location.[108] Researchers such as George Mason University professor Richard Florida also conclude that creative, innovative workers—the type likely to continue to drive growth and technology—tend to make lifestyle choices to live in areas rich in diversity and cultural amenities.[109]

Although it is exceedingly difficult for public policy to deliberately create new clusters, state and local policymakers have identified a series of steps that can be taken to reinforce and upgrade emerging or existing clusters—steps which the next administration and the new Congress should examine before deciding what role the federal government can play in the development of high tech clusters.

Undertaking all of the necessary steps is a complex task. Connecting workers, especially those at lower skill and wage levels, to opportunities in a cluster strategy involves a whole range of training, assessment, and retention policies. And further, not every region has the unique strengths to become another Silicon Valley.

Rather than imitating other clusters, leaders of regions need to understand their unique strengths and create policy around them. Nevertheless, state, local, and federal policy can be effective at creating these linkages. These initiatives include:

Creating intermediary mentorship organizations to foster new entrepreneurs.

Often, entrepreneurship can be fostered by creating an atmosphere in which existing innovators are encouraged to invest their time and expertise mentoring new entrepreneurs in their region. The CONNECT program in San Diego, for example, links entrepreneurs in the high-tech and life sciences arenas with the resources they need, including technology, money, markets, management, partners, and support services. It was founded in 1985 at the urging of San Diego's business community to grow the region's technology sector by bringing together university research centers, business leaders, and government.

To date it has assisted over 800 technology companies. CONNECT operates with dues from its members as well as corporate support for specific programs. The Springboard program sponsored by CONNECT gives entrepreneurs 3 to 8 weeks of coaching from an "Entrepreneur in Residence," and the opportunity to have their business plan critiqued by a venture capitalist, a seasoned entrepreneur with domain expertise, an accountant, corporate and patent attorneys, a marketing professional, and an executive from a successful company in the same industry.[110]

Collaborating with community colleges and local universities.

State and local governments ought to partner with higher education institutions to ensure that the skills taught and research undertaken there are specialized to the employment opportunities of that region. Many state leaders view community colleges and universities as "cluster hubs," or a resource that industry can rely on to understand the market as well as to ensure a flow of qualified workers into the workforce. Ideally, students can have access to the knowledge of the economy there, access information about employers in the region, and have the opportunity to network with them.

North Carolina, for example, has been using a cluster hub model to grow its emerging biotechnology industry. With

support from a major foundation, its BioNetwork initiative started in 2003 and now funds the training of instructors at several of the state's community colleges and two of its state colleges. These grants also allow undergraduates to be trained in a mobile laboratory that circulates among these campuses and provide for a job fair to create connections between firms and new graduates.[111]

Another example is the Georgia Research Alliance, a tripartite coalition of business, government, and university partners in that state. The Alliance continually works with its university scholars to pinpoint those areas of research and development that have the greatest potential for building a sustained, technology-rich economy for Georgia. Based on the universities' research priorities, the Alliance develops its investment portfolio focused on its scholars. The technology is then transferred to its business partners.

Leverage public funds to attract and build "angel" networks of investors.

Angel investors—affluent individuals who provide capital for startups in exchange for debt or ownership equity—have become critical to filling in the gap between seed funding for new business and venture capital. Private investors who are willing to provide early-stage investments in the riskiest part of a start-up company's formation are critical to the development of clusters. Angel investors were critical to starting several well-known technology companies, including Google Inc., Amazon.com Inc, Kinko's Inc., LinkedIn Corp., and Digg Inc., These funders are the largest source of seed and start-up capital. In 2006, they provided $25.6 billion in investment, with 46 percent of angel investments in the seed and start-up stage.[112]

An increasing number of angel investors are organizing themselves into angel groups or angel networks to share information and pool their investment capital. Venture capitalists located in Silicon Valley and Boston tend to invest in nearby startups so that they can support them and monitor their performance, making it difficult for entrepreneurs in clusters in other regions to obtain risk capital.

States are pursuing a variety of different strategies to address the shortage of early-stage investment in new startups. Ben Franklin Technology Partners of Southeast Pennsylvania, for example, is a program created by the state's legislature that provides a number of services, among which is linking several networks of angel investors to burgeoning technology companies in the five-county region in which it operates. Established in 1982, the Ben Franklin program is partially funded by the state of Pennsylvania, and helps to package and manage the loans between investors and technology firms.[113]

In addition to providing business expertise to its clients, its loans of up to $500,000 have gone a long way to increase the biotechnology, information technology, and physical sciences presence in the Philadelphia region. While the startups must be located in Philadelphia, money may come from investors from anywhere. More programs like these are needed to help angel investors identify investment opportunities across the country—not just in existing "hot spots" such as Silicon Valley and Boston.

One concrete step that the federal government could take to increase the availability of risk capital is to remove the regulatory barriers that prevent foundations from investing more of their assets in entrepreneurial companies for regional

economic development purposes. According to the Council on Competitiveness, current federal tax code regulations are "complex and somewhat vague" as to what kinds of investments by America's foundations are allowable.[114]

Investing in university-based centers of excellence.

These centers of excellence focus on the needs of regional companies. For example, Clemson University's International Center for Automotive Research, currently under construction in Greenville, South Carolina, aspires to be a world-class research facility for automotive engineering and will award masters and doctoral degrees. It was developed in partnership with a range of companies with a presence in that region, including German automaker BMW AG, Microsoft Corp., and French tiremaker Michelin SA, most of which will have offices on-site to increase their own research and development. The center was built on a stretch of I-85 near the Millennium Campus, which has been built to attract more investment by large companies.[115]

Likewise, the University of Rochester's Center for Electronic Imaging Systems was developed by New York State's Office of Science, Technology and Academic Research. Its mission is to develop new technology and transfer it to the electronic imaging and microelectronics companies located in that state. The center is very important to the economy of the Rochester region—among its largest employers are Eastman Kodak Co., Xerox Corp., and several smaller companies in the imaging and printing sector. This sector of the economy has changed dramatically over the past decade because of the rapid evolution of digital technologies, and this research center can help firms in this region stay on the cutting-edge.[116]

This type of university-driven partnership with local businesses also works at small- and medium-sized businesses, in which the educational institutions develop manufacturing extension services tailored to the needs of local enterprises.

Support "workforce partnerships" among employers and regional stakeholders.

A new trend in economic development is "workforce partnerships," which are partnerships that brings together the stakeholders that create a regional labor market: workers, employers, unions, workforce, and economic development professionals and educators. Their mission is to both enhance workers' skills and help businesses in a given region be more productive.

The best partnerships have a deep understanding of worker and employer issues in a particular region and industry sector. They then act as coordinator of multi-agency services, integrate funding streams and information resources, and provide a forum for all stakeholders to innovate. Many workforce partnerships have a particular emphasis on linking underemployed, low-wage workers with opportunities for training to increase their earnings.

SkillWorks Boston, for example, began in 2003 and focuses on creating career ladders for low-skill, low-wage workers. Since its inception, it has worked with 2,100 individuals, placing 400 workers in jobs with wages of $11 per hour to $12 per hour. Over 250 of its participants have received promotions.

Innovation and the U.S. Workforce

Investment in science, technology, and the creation of new knowledge has always had an impact on the labor market. The automobile put many blacksmiths and coopers on the trail of new employment opportunities, but the auto industry became a source of high wage employment for many. As the examples below demonstrate, with some training and education, there are a growing number of innovation-driven jobs available to working Americans. Sometimes it is difficult to see the opportunities for new job creation as the adaptation of new technologies speeds up and as the economy becomes more globally integrated, but in fact new job opportunities will definitely emerge in an innovation-led economy.

Policymakers have a responsibility to assist working Americans to transition into new opportunities created by technological advancement by providing access to that training. Job opportunities in the future include both innovation workers and innovation-enabled workers.

Below we provide some typical employment opportunities in fields created by science and innovation that are accessible to working Americans with appropriate education and training.

Innovation Workers directly work with new technologies.

BIOMEDICAL TECHNICIAN

Work Snapshot and Trends

Biomedical technicians combine technical skills in biology and chemistry with practical lab skills to assist biological and medical scientists in laboratories for research purposes. They operate and maintain laboratory instruments and equipment, monitor experiments, make observations, and calculate and record results.

As genetic- and biology-based medicine grows as an industry, biotech workers may become the new "blue collar" workforce. Through 2014, employment is expected to increase by 22 percent, creating many new opportunities.

Compensation

The median annual salary in 2006 was $35,700, and the salary for the highest pay category is $57,900.

Education and Skills

An associate's degree in life sciences with applied lab skills is required. As more experimental work is done across disciplines, the ability to communicate and think outside one's knowledge base is growing in importance.

ETHANOL LAB TECHNICIAN

Work Snapshot and Trends

Ethanol lab technicians apply scientific principles and technical skills in support of fermentation plant processes. Primary responsibilities include performing chemical and biological analysis, providing documentation of testing for outbound shipments, and the general upkeep of laboratory.

Ethanol is a $32 billion industry that is adding capacity each year. New plants under construction will double production capacity.

Compensation

Base Salary range, according to Salary.com, is $40,000 to $50,000 a year.

Education and Skills

An associate's degree in a biology or chemistry. Strong mathematical and reasoning skills are also required.

Innovation-Enabled Workers. *These workers leverage new technologies, in particular information technology, and their capacity for expert thinking (solving problems for which there are no rules-based solutions) and complex communication to add value usually in existing industries.*

WINDMILL MANUFACTURING TECHNICIAN

Work Snapshot and Trends

A Windwill Manufacturing Technician participates in the production of windmills, working with computer-driven machinery and engineers to place and install the equipment and troubleshoot operations.

Growing concern over fossil fuel dependence and climate change is creating interest in wind-generated power. While the industry is still emerging, venture capitalists are investing in the sector, and installed capacity for wind energy is increasing every year.

Compensation

Currently, windmill production technicians are averaging an estimated $40,000 per year according to Monster and Careerbuilder.

Education and Skills

A windmill technician requires two to eight years experience in power operation and transmission or substation systems or two years with an associate's degree in engineering.

Workers will need to learn the basics of how wind energy works and interpret information from customers to troubleshoot solutions.

PHYSICAL THERAPIST ASSISTANT

Work Snapshot and Trends

Physical Therapists Assistants work with physical therapists to help patients regain mobility after illness or medical procedures. They use technological tools and hands-on care to coach the patient toward normal movement. They need knowledge of the body's chemistry, physics, and biology, as well as some understanding of medical technologies used to promote mobility.

An aging population is generating a great deal of demand for health care positions that assist people with maintaining quality of life as they deal with chronic and acute conditions.

Through 2014, Physical Therapists Assistants is expected to be one of the fastest growing occupations in the economy. PTA training can also serve as a platform to move up the health care ladder to be a physical therapist or a nurse.

Compensation

The median salary in 2006 was $41,400 and the salary for the highest pay category is $90,000.

Education and Skills

An associate's degree is required with a licensing process and assessment in many states. Applied science and the ability to communicate with others are key skills.

Models such as Skillworks are beginning to emerge in Baltimore, Boston, Chicago, Los Angeles, New York City, Pennsylvania, Rhode Island, San Diego, San Francisco, and Washington, D.C.—all of them inspired by and funded through collaborations of large national foundations including the Annie E. Casey Foundation, the Ford Foundation and the Rockefeller Foundation. Just this year, these foundations plus the Hitachi and Weinberg Foundation and the U.S. Department of Labor announced $20 million for a $50 million effort, called the National Fund for Workforce Solutions, to strengthen and expand the high-impact workforce partnerships in these regions and commit to identifying at least 20 more regional and local collaboratives.[117]

The Fund's investments will support these local initiatives by providing financial support, technical assistance, evaluation, research, and other capacity-building services to local funding collaboratives investing in these high-performing workforce partnerships.

Create a Regional Economic Innovation Corporation.

A Regional Economic Innovation Corporation,[118] affiliated with the U.S. Department of Commerce with the flexibility to adapt quickly to economic and market trends, could coordinate and consolidate the various regional development programs run by the federal government. The corporation would ensure that the federal government is an effective partner to regions with coherent strategies that might involve skills upgrading, university-industry collaboration, and increased access to risk capital to further the innovation capacity of states and regions.

Although the responsibility for promoting these clusters should rest primarily at the state and regional level, the next administration can and should do more to support these efforts through this new federal entity. This is particularly the case if regions have done a careful analysis of their strengths and weaknesses, built a shared vision of their future involving industry, academia, workers, government, and local philanthropists, and have demonstrated the willingness to invest the time, energy, and money needed to realize this vision.

On the federal level, currently there are hundreds of individual categorical grant programs that can support cluster development or regional development, each with their own guidelines, funding levels, restrictions, and reporting requirements. The Council on Competitiveness has estimated that the federal government provides $20 billion in economic development assistance.[119] Examples include Empowerment Zone tax incentives, support for partnerships between business and community colleges from the National Science Foundation, and direct assistance to business from the Small Business Association.

The next administration should review existing regional development programs to see if some of them could be consolidated to support larger competitive grants. At a minimum, regions that have developed an integrated strategy that they are prepared to invest in should be given a significant preference in existing grants. But more effective action would come through a Regional Economic Innovation Corporation, which could work closely with state governments and regional clusters.

Restore the Integrity of U.S. Science and Technology Policy

There are two important steps that the next administration must take to improve the process by which science, technology, and innovation policy is made. The first is to increase the capacity of the government to understand the forces that are shaping America's economic competitiveness, and the policy choices that could undermine or enhance this competitiveness. The second is to restore integrity to U.S. science policy, and to make decisions on the basis of the best possible evidence.

Increase Government Analytic Capabilities to Understand U.S. Competitiveness

The U.S. government has little capacity to understand the forces that are shaping the long-term competitiveness of the U.S. economy and to weigh the impact that current and future public policies are having on the ability of companies to innovate and compete in the global marketplace. The reason: Many policies affect the competitiveness of research-intensive sectors of the U.S. economy.

Consider the biotechnology industry, which is affected by policies such as the level of funding for NIH, approval of patents by the U.S. Patent and Trademark Office, drug reimbursement policy, tax policy, and the ability of the FDA to approve safe and effective drugs on a timely basis. While America's biotechnology industry is currently very competitive, maintaining this competitive edge in the face of pressure to restrain rapidly growing health care costs will not be easy.

Moreover, changes in public policy will definitely be required to take advantage of future biomedical innovations. Future advances in "personalized medicine" and the ability to sequence the entire human genome for $1,000 will make it possible to more precisely diagnose diseases and their sub-types and help doctors select the type and dose of medication that is optimized for particular groups of patients. Whether our society realizes the potential benefits of personalized medicine will depend on policy issues such as clinical trial rules, the regulatory framework for genetic testing, public and private reimbursement of molecular diagnostic tests, and the evolution of a National Health Information Network.

Recent evidence suggests that public policy can increase U.S. productivity by increasing the competitive intensity of different sectors of the economy. A study by the McKinsey Global Institute, for example, concluded that only six sectors of the economy (whole-

sale trade, retail trade, security brokers, microprocessors, computer assembly, and mobile phone services) accounted for 75 percent of the productivity growth acceleration that the U.S. economy enjoyed in the second half of the 1990s.[120] Although some of these increases in productivity were due to business model innovations, such as the impact that "big box" stores with regional distribution centers has had on the retail and wholesale sector, others were due to changes in spectrum policy that encouraged new entrants in the business, such as increased productivity in the mobile communications sector. This suggests that the next administration should make it a priority to identify policies that are likely to increase the competitive intensity of large sectors of the economy.

U.S. high-tech companies are also affected by foreign governments' policies. China, for example, is moving aggressively to establish itself as the center of semiconductor manufacturing. In addition to generous tax incentives, local governments are actually providing billions of dollars to build new plants for the Shanghai Manufacturing International Corporation, a major semiconductor foundry.[121] These subsidies are making it difficult for the United States to remain a competitive location for semiconductor manufacturing, which has implications for our global competitiveness in R&D and design activities as well.

The next administration should increase the analytic capability of the federal government to understand how current and proposed policies will affect America's future competitiveness. Not all of this data gathering and analytic capacity needs to exist "in house," within government agencies. The government should take advantage of external expertise, such as the Sloan Foundation's Industry Centers, located at major research universities across the country, and research conducted by investment analysts and management consulting firms. But the federal government needs enough internal talent to be an intelligent consumer of external research and analysis, and to identify the specific policy implications that flow from this analysis.

The Department of Commerce should be given additional funding to hire a multidisciplinary team of economists, policy analysts, and experts in particular industry sectors to perform this role. To be effective, this office will need a close relationship with White House policy councils such as the Office of Science and Technology Policy and the National Economic Council.

Restore Integrity to U.S. Science Policy

The Bush administration has undermined the integrity of U.S. science policy. It has stacked scientific advisory boards, suppressed research results and reports that conflict with its political agenda, refused to make decisions on the basis of the best available evidence, and prevented scientists from speaking openly with the public and the media.

The Union of Concerned Scientists has documented dozens of cases of political interference in science by the Bush administration.[122] The Center for Disease Control's Childhood Lead Advisory Board was stacked with individuals likely to oppose the tightening of the federal lead poisoning standards, including individuals with financial ties to the industry and "fringe" views on the link between lead and cognitive problems in children. Members of the President's Council on Bioethics who disagreed with the administration's position on stem cells, such as noted biomedi-

cal research Dr. Elizabeth Blackburn, were replaced with individuals who supported the administration's position.

Or consider the politicization of global warming. Officials from the National Oceanic and Atmospheric Administration report that Bush administration officials have "chastised them for speaking on policy questions; removed references to global warming from their reports, news releases and conference Web sites; investigated news leaks; and sometimes urged them to stop speaking to the media altogether."[123]

Increasingly, making sound decisions regarding health, the environment, energy and climate change, and national security requires input from the scientific community. The public is not well-served when the advice of scientists is suppressed, distorted, or ignored. The next administration should:

- Select people to federal advisory committees on the basis of their scientific and technical expertise, as opposed to their party affiliation or voting record.
- Commit to making decisions on the basis of the best available scientific evidence.
- Ensure that government scientists are free to communicate the findings of their research to the public and the press, without censorship or the threat of retaliation.
- Restore the stature of the President's Science Advisor, which has been downgraded under the current administration.

This last point is very important. The current Director of the Office of Science and Technology Policy no longer serves as Assistant to the President for Science and Technology and does not report to the president. Furthermore, most of the OSTP staff have been moved out of the White House complex. The president's Science Advisor should report directly to the president, and be given the clout and stature needed to keep science and technology at the top of the administration's agenda.

Conclusion

This paper, we believe, makes a compelling case for making science, technology, and innovation policy a top priority for the next administration. These issues are critical for ensuring economic prosperity in the 21st century, and for helping to achieve a wide range of national goals, such as accelerating the transition to a low-carbon economy and improving our children's performance in math and science. The policy initiatives outlined in this component of CAP's *Progressive Growth* plan are bold but affordable steps that our nation can and must undertake.

After the 2008 elections are over and as the new president and new Congress prepare for the hard task of economic policymaking in an increasingly competitive global economy, we argue that this Innovation Agenda should be the starting point for a bipartisan restoration of science and technology as the foundation of America's future prosperity.

Endnotes

1 Council on Competitiveness, "Where America Stands: Entrepreneurship" (2007).

2 National Academy of Sciences, "Rising Above The Gathering Storm," (2007).

3 Thomas Jefferson, Letter to Isaac McPherson, August 13, 1813.

4 Paul M. Romer "Increasing Returns and Long-Run Growth," The Journal of Political Economy 94 (5) (1986): 1002-1037.

5 Charles Jones and John Williams, "Measuring the Social Return to R&D," Quarterly Journal of Economics 113 (1998) 1119-1135.

6 United States Commission on National Security/21st Century, "Road Map for National Security: Imperative for Change," (2001).

7 Clifford Winston, "Government Failure versus Market Failure," (Washington: AEI-Brookings Joint Center for Regulatory Studies, 2006).

8 Henry Chesbrough, Open Innovation (Boston: Harvard Business School Press, 2003).

9 Larry Huston and Nabil Sakkab, "Connect and Develop: Inside Procter and Gamble's New Model for Innovation," Harvard Business Review (March 2006).

10 Innocentive, available at http://www.innocentive.com (last accessed October 2007).

11 Eric Von Hippel, Democratizing Innovation (Cambridge: MIT Press, 2005).

12 "Social entrepreneurs" are individuals who have developed new and innovative solutions to tackle serious social problems and they are focused on implementing their solutions on a large scale to change an entire system, either by scaling their organization or inspiring others to replicate the idea. Social entrepreneurs, like their counterparts in the private sector, have unique personal characteristics that they use to successfully implement their solution—creativity, inspiration, persistence, focus, and a willingness to take risks. Social entrepreneurs are results-oriented, creative in finding ways around the barriers and challenges that arise, and constantly testing and focusing on the best strategy to achieve their goals. Ventures created by social entrepreneurs are usually organized as nonprofits, although some are for-profits with a clear and direct social mission. Roger L Martin & Sally Osberg, "Social Entrepreneurship: The Case for Definition," Stanford Social Innovation Review, Spring 2007

13 The Internal Revenue Code defines over 27 categories of organizations exempt from federal income taxes, including private country clubs, labor unions, business associations, fraternal organizations, universities and many others. About 1.5 million of these organizations make up the "independent sector." The "independent sector" encompasses the charitable, social welfare, and faith-based portions of the non-profit sector. Throughout this section, when we refer to "nonprofits" we are referring to these "independent sector" groups.

14 Lester Salamon and S. Wojciech Sokolowski, "Employment in America's Charities: A Profile," (Baltimore: The Johns Hopkins Center for Civil Society Studies, December 2006) pg. 3. American charities employed 9.4 million paid workers and engaged another 4.7 million full-time equivalent (FTE) volunteer workers for a total workforce of more than 14 million workers. Taken together, the paid workforce and the volunteer workforce of the charitable nonprofit sector thus represents 10.5 percent of the country's total workforce.

15 Independent Sector, Nonprofit Almanac, Facts and Findings, available at http://www.independentsector.org/PDFs/npemployment.pdf

16 Social Venture Capital funders invest in organizations for a social return on their investment rather than monetary profit. They generally provide multi-year funding and a range of strategic advice and other support.

17 Federation of American Societies for Experimental Biology, "Federal Funding For Biomedical And Related Life Sciences Research: FY2008" (2007).

18 Domestic Policy Council and the Office of Science and Technology Policy, "American Competitiveness Initiative: Leading the World in Innovation" (2006).

19 National Science Foundation, FY2008 Budget Request to Congress, 2007, Summary Tables, p. 11.

20 American Association for the Advancement of Science. "AAAS Report XXXII: Research and Development FY 2008" (2007).

21 Gene Sperling, "How to Get Fewer Scientists," Washington Post, July 24, 2007, p. A15.

22 "DoD's Support of Basic Research," available at http://www.dod.mil/ddre/text/t_basic_research.html (last accessed September 2007).

23 William J. White and Michael P. Gallaher, "Benefits and Costs of ATP Investments in Component-Based Software" (National Institute of Standards and Technology, 2002).

24 Phillip E. Auerswald and others, "Understanding Private-Sector Decision Making for Early-Stage Technology Development," (Washington: National Institute for Standards and Technology, 2005).

25 Ibid.

26 Ross DeVol and Armen Bedroussian, "An Unhealthy America: The Economic Burden of Chronic Disease" (Milken Institute, 2007).

27 Phillip Longman, "The Best Care Anywhere," Washington Monthly, January/February 2005.

28 Information Technology Association of America, "Chronic Care Improvement: How Medicare Transformation Can Save Lives, Save Money, and Stimulate an Emerging Technology Industry" (2004).

29 Synthetic Biology, available at http://syntheticbiology.org (last accessed October 2007).

30 Zach Lynch, "Brain Tech is Here," Science Progress, October 4, 2007.

31 "Ethical, Legal, and Social Implications (ELSI) Research Program," available at http://www.genome.gov/10001618 (last accessed October 2007).

32 Henry Chesbrough and Jim Spohrer, "A research manifesto for services science," Communications of the ACM 49 (7) (2006): 35-40.

33 Ibid.

34 American Society of Civil Engineers, "2005 Report Card for America's Infrastructure," (2005).

35 Larry Cuban, Oversold & Underused: Computers in the Classroom (Cambridge: Harvard University Press, 2001).

36 National Center for Education Evaluation and Regional Assistance, Effectiveness of Reading and Mathematics Software Products (Department of Education, 2007).

37 Gary Becker, "Why A Crash Won't Cripple The Economy," Business Week, April 14, 1997.

38 President's Information Technology Advisory Committee, Using Information Technology To Transform the Way We Learn, (Executive Office of the President, 2001), p. 14.

39 Software and Information Industry Association, 2002 Education Market Report: K-12, (2002).

40 James Harvey, "The Market for Educational Software" (Santa Monica: RAND, 1995).

41 Matt Richtel, "Once a Booming Market, Educational Software for the PC Takes a Nose Dive," The New York Times, August 22, 2005.

42 This initiative is described in greater detail in Thomas Kalil, "Designing a Digital Opportunity Investment Trust," Spectrum Series Working Paper #2 (New America Foundation, 2002).

43 Benjamin S. Bloom, "The 2 Sigma Problem: The Search for Methods of Group Instruction as Effective as One-to-one Tutoring," Educational Researcher 13 (6) (1984) : 4-16.

44 Beverly Park Woolf and others, "Growth and Maturity of Intelligent Tutoring Systems," Kenneth D. Forbus and Paul J. Feltovich, Smart Machines in Education, (Cambridge: MIT Press, 2001).

45 Kenneth R. Koedinger, "Cognitive Tutors as Modeling Tools and Instructional Models," in Kenneth D. Forbus and Paul J. Feltovich, Smart Machines in Education, (Cambridge: MIT Press, 2001).

46 Douglas Lowenstein, "E3 State of the Industry Address" (Washington: Entertainment Software Association, 2004).

47 Mihaly Csikzentmihalyi, Flow: The Psychology of Optimal Experience, (New York: Harper Perennial, 1993).

48 Seth Schiesel, "Kill the Big, Bad Dragon (Teamwork Required)" The New York Times, January 28, 2006.

49 Federation of American Scientists, "Harnessing the Power of Video Games for Learning," (2006).

50 Jeffrey Sachs, "Weapons of Mass Salvation," The Economist, October 26, 2002.

51 World Bank, "Understanding Poverty," available at http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTPOVERTY/0,,contentMDK:20153855~menuPK:373757~pagePK:148956~piPK:216618~theSitePK:336992,00.html#measuring (last accessed October 2007).

52 World Health Organization, "Health through safe drinking water and sanitation," available at http://www.who.int/water_sanitation_health/mdg1/en/index.html (last accessed October 2007).

53 UNICEF, "Young Child Survival and Development," available at http://www.unicef.org/childsurvival/index_40850.html (last accessed October 2007).

54 Global Forum for Health Research, "10/90 Report on Health Research" (2004).

55 Ruth Levine, Michael Kremer, and Alice Albright, "Making Markets for Vaccines: Ideas to Action," (Washington: Center for Global Development, 2005).

56 University of California, Berkeley Research, "Wireless networking brings eye care to rural India," available at http://research.chance.berkeley.edu/page.cfm?id=11&aid=55 (last accessed October 2007).

57 Joint Planning and Development Office, Next Generation Air Transportation System In Brief (2006).

58 Defense Science Board, *High Performance Microchip Supply,* (Department of Defense, 2005), p. 87-88.

59 National Science Board, *Enhancing Support of Transformative Research at the National Science Foundation,* May 7, 2007, p. 10.

60 National Academy of Sciences, "Rising Above The Gathering Storm," (2007).

61 National Institutes of Health, "NIH Director's Pioneer Award," available at http://nihroadmap.nih.gov/pioneer/ (last accessed October 2007).

62 "The rise and fall of corporate R&D," *The Economist,* March 1, 2007.

63 Peter Forbes, *The Gecko's Foot* (New York: W.W. Norton & Company, 2006).

64 Personal communication from Carol Van Hartesveldt, Program Director, National Science Foundation, June 2007.

65 Thomas Kalil, "A Broader Vision for Government Research," *Issues in Science and Technology,* Spring 2003.

66 Donald E. Stokes, *Pasteur's Quadrant: Basic Science and Technological Innovation* (Washington: Brookings Institution Press, 1997).

67 Coalition for Evidence-Based Public Policy, *Rigorous Evidence: The Key to Progress in Education?* (2002).

68 Coalition for Evidence-Based Policy, *Bringing Evidence-Driven Progress To Education: A Recommended Strategy for the U.S. Department of Education,* (2002).

69 See for example, National Science Foundation, "Federal Cyber Service: Scholarship for Service," available at http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5228 (last accessed October 2007).

70 Kalil, "A Broader Vision for Government Research."

71 Thomas Kalil, "Prizes for Technological Innovation," Discussion Paper 2006-08 (Hamilton Project, 2006).

72 Michael Coren, "SpaceShipOne captures X Prize," CNN.com, October 4, 2004, available at http://www.cnn.com/2004/TECH/space/10/04/spaceshipone.attempt.cnn/index.html (last accessed October 2007).

73 National Academy of Sciences, "Rising Above The Gathering Storm," (2007).

74 Daniel H. Pink, *A Whole New Mind: Moving from the Information Age to the Conceptual Age,* (New York: Riverhead Books, 2005).

75 Partnership for 21st Century Skills, "Framework for 21st Century Learning," (2007).

76 "Testimony about UTeach before Senate," available at https://uteach.utexas.edu/index.cfm?objectID=BE6459EA-E672-C746-4E42FC7CE7CF75AE (last accessed October 2007).

77 National Science Foundation, *ATE Centers Impact: 2006-2007* (October 18, 2006).

78 Spencer E. Ante, "Building Robots Builds Scientists." *Business Week,* April 13, 2007.

79 Ibid.

80 Paul M. Romer, "Should the Government Subsidize Supply or Demand in the Market for Scientists and Engineers." Working Paper 7723 (National Bureau of Economic Research, 2000).

81 Ibid.

82 Richard B. Freeman, "Investing in the Best and Brightest: Increased Fellowship Support for American Scientists and Engineers," Discussion Paper 2006-09 (Hamilton Project, 2006).

83 Brian Bosworth, "*New Strategies for the Education of Working Adults.*" (Washington DC: The Center for American Progress, *forthcoming December 2007).*

84 Sarah Rosen Wartell, Louis Soares, Andrew Jakabovics, and Tim Westrich, "Opportunity and Security for Working Americans: Creating the Conditions for Success in the Global Economy." (Washington DC: The Center for American Progress, forthcoming 2007).

85 See Aaron Terrazas, Jeanne Batalova, and Velma Fan, "Frequently Requested Statistics on Immigrants in the United States" (Migration Policy Institute, October 1, 2007). Available at http://www.migrationinformation.org/USfocus/display.cfm?id=649.

86 National Academy of Sciences, "Rising Above The Gathering Storm" (2007).

87 Stuart Anderson and Michaela Platzer, "American Made: The Impact of Immigrant Entrepreneurs and Professionals on U.S. Competitiveness" (Washington: National Venture Capital Association, 2006).

88 Vivek Wadhwa, Guillermina Jasso, Ben Rissing, Gary Gereffi, and Richard B. Freeman, "Intellectual Property, the Immigration Backlog, and a Reverse Brain-Drain: America's New Immigrant Entrepreneurs, Part III" (August 22, 2007). Available at SSRN: http://ssrn.com/abstract=1008366

89 Ibid.

90 Ibid.

91 Dr. Robert D. Atkinson, "Expanding the R&D Tax Credit to Drive Innovation, Competitiveness and Prosperity" (Washington: The Information Technology and Innovation Foundation, 2007).

92 Steven Levy, "The Hard Disk That Changed The World." *Newsweek,* August 7, 2006.

93 Michael Kanellos, "Half a century of hard drives," *CNET NEWS.COM,* September 11, 2006.

94 "100 Wireless Facts," available at http://www.ctia.org/content/index.cfm/AID/10380 (last accessed October 2007).

95 Organisation for Economic Co-operation and Development, "OECD Broadband Statistics to December 2006" (2007).

96 Communication Workers of America, "Speed Matters: A Report on Internet Speeds in All 50 States," (2007).

97 See for example, *The Broadband Deployment and Acceleration Act of 2007* H.R. 1818, 110 Cong. 1 sess., introduced by Representative Matsui.

98 See, for example, Pierre de Vries, "Populating the Vacant Channels: The Case For Allocating Unused Spectrum In The Digital TV Bands To Unlicensed Use For Broadband And Wireless Innovation," Working Paper 14 (New America Foundation Wireless Future Program, 2006).

99 Connect Kentucky, "What is Connect Kentucky?" available at http://www.connectkentucky.org/about (last accessed October 2007).

100 Bennett Harrison, *Lean and Mean: Why Large Corporations Will Continue to Dominate the Global Economy.* (Guilford, 1997).

101 Council on Competitiveness and National Governors Association, "Cluster-Based Strategies for Growing State Economies" (2007)

102 William C. Wheaton and Mark J. Lewis, "Urban Wages and Labor Market Agglomeration" *Journal of Urban Economics* 51(3) (May 2002): 542-562.

103 R.M. Gibbs and G.A. Bernat, "Rural Industry Clusters Raise Local Earnings" *Rural Development Perspectives* (12) (1998.): 18-25.

104 Alfred Marshall, *Principles of Economics, 8th Ed.* (London: Macmillan, 1920).

105 Joseph Cortright, "Making Sense of Clusters: Regional Competitiveness and Economic Development" (Washington: Brookings Institution, March 2006).

106 Joseph W. Bartlett "Can Silicon Valley Be Cloned Around the Country… the World? The Metrics," *Entrepreneurial Business Law Journal* 1 (2) (2006).

107 Cortright, "Making Sense Of Clusters."

108 Harrison, *Lean and Mean.*

109 Richard Florida, "The Economic Geography of Talent" *Annals of the Association of American Geographers,* 92 (4) (2002): 743-755.

110 Connect, available at http://www.connect.org (last accessed November 2007).

111 Ibid. at 2.

112 Brian Perry, "U.S. Center for Venture Research 2006 Report," *Angel Investor Magazine,* March 19, 2007.

113 Ben Franklin Technology Partners, available at http://www.benfranklin.org (last accessed November 2007).

114 Council on Competitiveness, "Innovate America," (2004).

115 Available at http://www.clemson.edu/autoresearch (last accesed November 2007).

116 Available at http://www.ceis.rochester.edu (last accessed November 2007).

117 "National Fund for Workforce Solutions," available at http://www.nfwsolutions.org/newsreleases.html (last accessed October 2007).

118 Adapted from The Past and Future of America's Economy: Long Waves of Innovation that Power Cycles of Growth, Robert D. Atkinson, Edward Elgar Publishing, 2004. Atkinson proposes a National Innovation Corporation to replace Department of Commerce. We advocate for a new entity within DOC.

119 Ibid.

120 William W. Lewis, *The Power of Productivity* (Chicago: University of Chicago Press, 2004).

121 Alan Wm. Wolff, "Seeing Through Preconceptions: A Deeper Look at China and India," *Issues in Science and Technology,* Spring 2007.

122 "The A to Z Guide to Political Interference in Science," available at http://www.ucsusa.org/scientific_integrity/interference/a-to-z-guide-to-political.html (last accessed October 2007).

123 Juliet Eilperin, "Climate Researchers Feeling Heat From White House," *Washington Post,* April 6, 2006, p. A27.

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