U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE

HEARING CHARTER

Science, Technology and Global Economic Competitiveness

Thursday, October 20, 2005
10:00 a.m. - 12:00 p.m.
2318 Rayburn House Office Building

1. Purpose

On Thursday, October 20, 2005, the House Science Committee will hold a hearing to receive testimony on the report released by the National Academy of Sciences on October 12 entitled, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*. The report, which was requested by Congress, recommends ways to strengthen research and education in science and technology.

2. Witnesses

Mr. Norman R. Augustine, Retired Chairman and CEO of the Lockheed Martin Corporation. Mr. Augustine chaired the National Academy of Sciences (NAS) committee that wrote the report.

Dr. P. Roy Vagelos, Retired Chairman and CEO of Merck & Co. Dr. Vagelos served on the NAS committee that wrote the report.

Dr. William A. Wulf, President of the National Academy of Engineering and Vice Chair of the National Research Council, the principal operating arm of the National Academies of Sciences and Engineering.

3. Overarching Questions

- What are the principal innovation-related challenges the United States faces as it competes in the global economy?

- What specific steps should the federal government take to ensure that the United States remains the world leader in innovation?

4. Brief Overview

- While the U.S. continues to lead the world in measures of innovation capacity—research and development (R&D) spending, number of scientists and engineers, scientific output, etc.—recent statistics on the level of U.S. support for research relative to other countries indicate that this lead may be slipping. Overall U.S. federal funding for R&D as a percentage of gross domestic product (GDP) has declined significantly since its peak in 1965, and the focus of this R&D has shifted away from the physical sciences, mathematics, and engineering—the areas of R&D historically most closely correlated with innovation and economic growth.

- At the same time, other nations—particularly emergent nations such as China and India—have recognized the importance of innovation to economic growth, and are pouring resources into their scientific and technological infrastructure, rapidly building their innovation capacity and increasing their ability to compete with the United States in the global economy.

- In May 2005, at the request of Congress, the National Academy of Sciences (NAS) began a study of "the most urgent challenges the United States faces in maintaining leadership in key areas of science and technology." NAS assembled a high-level panel of senior scientists and business and university leaders and produced a report in five months.

- The NAS report offers four broad recommendations: (A) increase America's talent pool by vastly improving K–12 science and mathematics education; (B) sustain and strengthen the nation's traditional commitment to long-term basic research; (C) make the United States the most attractive setting in which to study and perform research; and (D) ensure that the United States is the premier place in the world to innovate. (The executive summary of the NAS report is attached in Appendix A.)

- The NAS report also describes 20 explicit steps that the federal government could take to implement its recommendations. The report estimates the total cost of these steps to be $9.2 - $23.8 billion per year.

5. Summary of NAS Report

In May of this year, Senators Lamar Alexander and Jeff Bingaman, Chairman of the Energy Subcommittee and Ranking Member of full Senate Committee on Energy and Natural Resources, respectively, asked the National Academy of Sciences (NAS) to conduct a study of "the most urgent challenges the United States faces in maintaining leadership in key areas of science and technology." In June, Science Committee Chairman Sherwood Boehlert and Ranking Member Bart Gordon wrote to the NAS to endorse the Senate request for a study and suggest some additional specific questions (the text of the Senate and House letters are attached in Appendices B and C). The study was paid for out of internal Academy funds, and NAS released the report on October 12.

The Problem

The NAS report begins by describing how science and engineering are critical to American prosperity. Technical innovations, such as electricity and information technology, have increased the productivity of existing industries and created new ones and improved the overall quality of life in the U.S. The report then examines how the U.S. is doing relative to other countries in science and technology today—looking at indicators such as science and engineering publications, R&D investment, venture capital funding, and student proficiency levels—to see if the U.S. is positioned to make the next generation of innovations needed to maintain U.S. competitiveness and security going forward.

"Worrisome indicators" outlined in the report[1] include:

- The United States today is a net importer of high-technology products. Its share of global high-technology exports has fallen in the last two decades from 30 percent to 17 percent, and its trade balance in high-technology manufactured goods shifted from plus $33 billion in 1990 to a negative $24 billion in 2004.
- In 2003, only three American companies ranked among the top 10 recipients of patents granted by the United States Patent and Trademark Office.
- In Germany, 36 percent of undergraduates receive their degrees in science and engineering. In China, the figure is 59 percent, and in Japan 66 percent. In the United States, the corresponding figure is 32 percent.
- Fewer than one-third of US 4th grade and 8th grade students performed at or above a level called "proficient" in mathematics ("proficiency" was considered the ability to exhibit competence with challenging subject matter). About one-third of the 4th graders and one-fifth of the 8th graders lacked the competence to perform basic mathematical computations.

The NAS report concludes that education, research, and innovation are essential if the U.S. is to succeed in providing jobs for its citizenry.

Recommendations and Steps the Federal Government Should Take to Implement Them

The NAS report makes four recommendations, each of which is supported by explicit steps that the federal government could take to implement the recommendations. These recommendations and steps are provided verbatim below; more details on each step are available in the report executive summary in Appendix A.

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[1] See page 22 of this charter for the page of the NAS report that contains the sources for these statistics.

10,000 Teachers, 10 Million Minds and K–12 Science and Mathematics Education

Recommendation A: Increase America's talent pool by vastly improving K–12 science and mathematics education.

Implementation Steps:

- A-1: Annually recruit 10,000 science and mathematics teachers by awarding four-year scholarships and thereby educating 10 million minds.

- A-2: Strengthen the skills of 250,000 teachers through training and education programs at summer institutes, in master's programs, and Advanced Placement and International Baccalaureate (AP and IB) training programs and thus inspire students every day.

- A-3: Enlarge the pipeline by increasing the number of students who take AP and IB science and mathematics courses.

Sowing the Seeds through Science and Engineering Research

Recommendation B: Sustain and strengthen the nation's traditional commitment to long-term basic research that has the potential to be transformational to maintain the flow of new ideas that fuel the economy, provide security, and enhance the quality of life.

Implementation Steps:

- B-1: Increase the federal investment in long-term basic research by 10 percent a year over the next seven years.

- B-2: Provide new research grants of $500,000 each annually, payable over five years, to 200 of our most outstanding early-career researchers.

- B-3: Institute a National Coordination Office for Research Infrastructure to manage a centralized research infrastructure fund of $500 million per year over the next five years.

- B-4: Allocate at least eight percent of the budgets of federal research agencies to discretionary funding.

- B-5: Create in the Department of Energy an organization like the Defense Advanced Research Projects Agency called the Advanced Research Projects Agency-Energy (ARPA-E).

- B-6: Institute a Presidential Innovation Award to stimulate scientific and engineering advances in the national interest.

Best and Brightest in Science and Engineering Higher Education

Recommendation C: Make the United States the most attractive setting in which to study and perform research so that we can develop, recruit, and retain the best and brightest students, scientists, and engineers from within the United States and throughout the world.

Implementation Steps:

- C-1: Increase the number and proportion of U.S. citizens who earn physical-sciences, life-sciences, engineering, and mathematics bachelor's degrees by providing 25,000 new four-year competitive undergraduate scholarships each year to U.S. citizens attending U.S. institutions.

- C-2: Increase the number of U.S. citizens pursuing graduate study in "areas of national need" by funding 5,000 new graduate fellowships each year.

- C-3: Provide a federal tax credit to encourage employers to make continuing education available (either internally or through colleges and universities) to practicing scientists and engineers.

- C-4: Continue to improve visa processing for international students and scholars.

- C-5: Provide a one-year automatic visa extension to international students who receive doctorates or the equivalent in science, technology, engineering, mathematics, or other fields of national need at qualified U.S. institutions to remain in the United States to seek employment. If these students are offered jobs by U.S.-based employers and pass a security screening test, they should be provided automatic work permits and expedited residence status.

- C-6: Institute a new skills-based, preferential immigration option.

- C-7: Reform the current system of "deemed exports."

Incentives for Innovation and the Investment Environment

Recommendation D: Ensure that the United States is the premier place in the world to innovate; invest in downstream activities such as manufacturing and marketing; and create high-paying jobs that are based on innovation by modernizing the patent system, realigning tax policies to encourage innovation, and ensuring affordable broadband access.

Implementation Steps:

- D-1: Enhance intellectual property protection for the 21st century global economy.

- D-2: Enact a stronger research and development tax credit to encourage private investment in innovation.

- D-3: Provide tax incentives for U.S.-based innovation.

- D-4: Ensure ubiquitous broadband Internet access.

Costs of the Recommendations

The NAS report provides a "back of the envelope" estimate of the annual cost to the federal government of each of the implementation steps that are recommended.

- For the three steps in Recommendation A (increase America's talent pool by vastly improving K–12 science and mathematics education): $1.5 - $2.4 billion per year.
- For the six steps in Recommendation B (sustain and strengthen the nation's traditional commitment to long-term basic research): $1.1 - $3.4 billion per year.
- For the seven steps in Recommendation C (make the United States the most attractive setting in which to study and perform research): $1.6 - $3.6 billion per year.
- For the four steps in Recommendation D (ensure that the United States is the premier place in the world to innovate): $5.1 - $14.4 billion per year.

The total cost of these steps would be $9.2 - $23.8 billion per year.

6. Issues Related to Specific Recommendations in the NAS Report and Related Questions for the Witnesses

In the invitation letter for the hearing, each of the witnesses was asked to answer questions about the three specific recommendations discussed below. These were major recommendations that seemed to call for further elaboration.

<u>Recommendation B-1: Increase the federal investment in long-term basic research by 10 percent a year over the next seven years</u>: Numerous reports and groups in recent years have suggested doubling federal funding for basic research, as the NAS report recommends.[2] (The authorization bill for the National Science Foundation the Congress passed in 2002 called for doubling that agency's budget, and Congress did double the budget of the National Institutes of Health over the past six years or so.) While these reports have included a rationale for increasing federal R&D spending, none has explained the reason why a specific level of spending needs to be achieved by a particular date. The U.S. currently spends $56 billion annually on non-defense R&D, more than the rest of the G-7 countries[3] combined. Also, total R&D spending (government and industry) in the U.S. has remained relatively constant as a percentage of the U.S. gross domestic product, indicating that investment in R&D has grown as the U.S. economy has grown, begging the question of why increased federal investment is necessary. (This may be especially true if federal R&D is being invested in the same kinds of research as private R&D rather than in kinds of research, particularly basic research, that might otherwise be neglected.)

In addition, the NAS report argues that federal investment in basic research fuels economic growth by contributing new ideas that can eventually lead to commercial products. Yet recent

[2] For example, the U.S. Commission on National Security in the 21st Century (the Hart-Rudman Commission, Phase III, 2001) recommended doubling the federal research and development budget by 2010.

[3] The six non-U.S. members of the G-7 are France, Great Britain, Germany, Japan, Italy and Canada.

surveys of industry suggest that companies' investments in R&D have had only a very limited impact on the success of the individual companies.[4] What is true for individual companies is not necessarily true for nations as a whole; R&D may contribute greatly to the relative economic success of the U.S. as a whole, while not being so important to any individual company. (This would make sense. Nations stay ahead through innovation, but individual companies may have other comparative advantages.) But the company statistics and attitudes on R&D at least raise the question about whether the contribution of R&D to economic success is exaggerated, and how federal R&D investment contributes to overall economic success.

Questions in the witness letters on this recommendation:

- How did the study panel arrive at the recommended 10 percent annual increase in federally-sponsored basic research over the next seven years? What other options did the panel consider and what led to the choice of 10 percent?
- Recent surveys of industry suggest that basic research performed at universities and transformational technological innovation have only a very limited impact on the success of individual companies. Is the impact of research and innovation different for the economy as a whole than it is for individual companies?

<u>Recommendation B-4: Allocate at least eight percent of the budgets of federal research agencies to discretionary funding</u>: A number of recent reports have expressed concern that the current grant selection system in most agencies shies away from daring proposals. The view is that when funding is tight (like now), researchers and the peer review system both tend to favor *incremental* research proposals—projects that are guaranteed to produce results – results that are generally in keeping with existing ideas. In this situation, high-risk research (especially that proposed by young investigators or involving interdisciplinary studies) can be underfunded or neglected entirely. The NAS report recommends that funding be set aside at federal research agencies (and distributed at program officers' discretion) for high-risk, high-payoff research. While such research is valuable, so is the research that provides steady if incremental advances on existing scientific questions. In addition, not every agency is equally well equipped to solicit and select high-risk projects. Finally, even if setting aside such funding is a good idea, it's unclear whether 8 percent is a reasonable amount.

Questions in the witness letters on this recommendation:

- How did the study panel arrive at the recommended 8 percent allocation within each federal research agency's budget to be managed at the discretion of technical program managers to catalyze high-risk, high-payoff research? What other options did the panel consider and what led to the choice of 8 percent?

<u>Recommendation B-5: Create in the Department of Energy an organization like the Defense Advanced Research Projects Agency called the Advanced Research Projects Agency-Energy (ARPA-E)</u>: The recommendation seems to assume that the main reason the U.S. has not made

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[4] Booz Allen Hamilton's Global Innovation 1,000 study was released on October 11, 2005 and is available on line at http://www.boozallen.com. An example of their findings is that companies in the bottom 10 percent of R&D spending as a percentage of sales under-perform competitors on gross margins, gross profit, operating profit, and total shareholder returns. However, companies in the top 10 percent showed no consistent performance differences compared to companies that spend less on R&D.

more progress in deploying technologies that use less energy or that use alternative energy sources is that the technology is not being developed. But numerous studies have concluded that the primary problem in energy technology is that existing advanced technologies never get deployed. These studies tend to recommend policy changes to encourage the deployment of advanced technologies, as opposed to recommending (or merely recommending) programs to develop new technologies. For example, a recent American Council for an Energy Efficient Economy study estimated that "adopting a comprehensive set of policies for advancing energy efficiency could lower national energy use by 18 percent in 2010 and 33 percent in 2020."[5] Similarly, a 2001 NAS study on automotive fuel economy described numerous existing technologies that could reduce dependence on foreign oil, but are not yet deployed.

In addition, it is not clear whether the DARPA analogy is entirely apt. DARPA funds advanced technologies that will eventually be used by the Pentagon. The government itself would not be the main purchaser of technologies developed by ARPA-E, so those technologies would still face existing problems in finding markets. It is also unclear how the research that would be supported by ARPA-E would differ from that already funded by the Department of Energy's current conservation and renewable energy research programs.

Questions in the witness letters on this recommendation:

- Industry and government have both developed numerous energy production and energy efficiency technologies that have not been deployed. How did the study panel arrive at its implicit conclusion that technology development is the greater bottleneck (as opposed to policy) in developing energy systems for a 21st century economy?

7. General Issues

Overall Federal Support for R&D

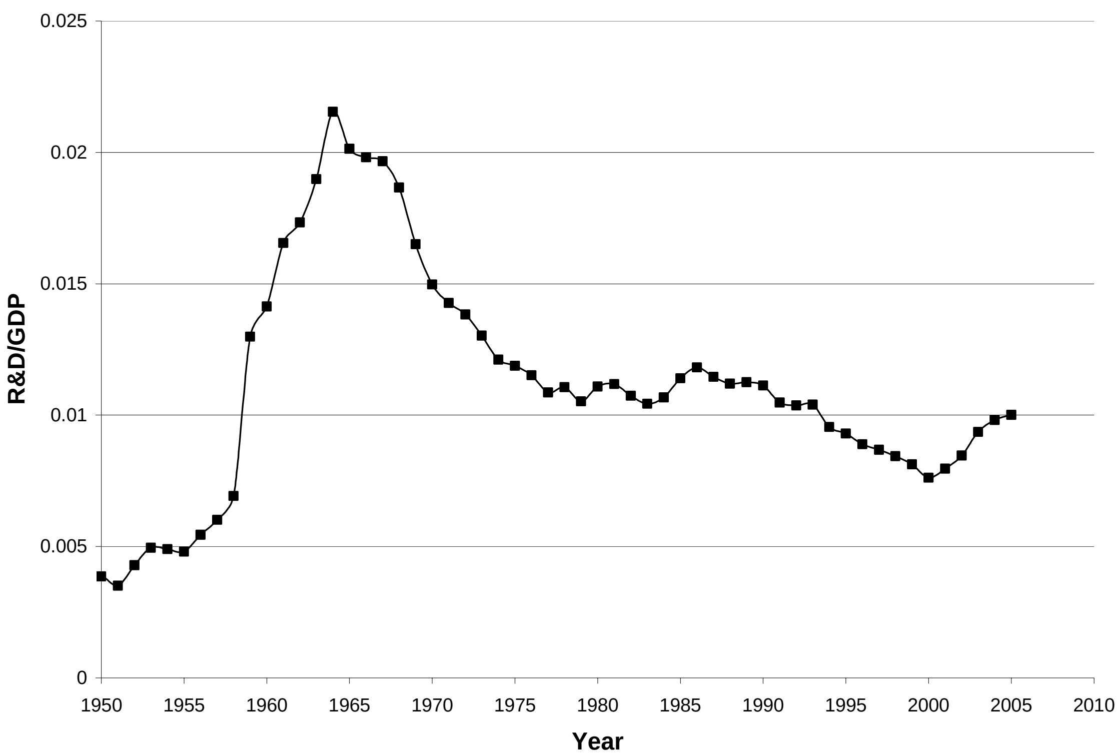
The amount of the country's overall wealth devoted to federal R&D has declined significantly since the post-Sputnik surge in support for R&D. According to Office of Management and Budget statistics, in 1965, funding for federal R&D as a percentage of GDP (measured as outlays), also known as R&D intensity, was slightly over 2 percent (Chart 1). In 2005, it is estimated to be 1.07 percent.

While this ratio has recently begun to increase again, turning upward over the last five years, the majority of those increases have gone toward short-term defense development and homeland security applications. For example, the Department of Defense (DOD) R&D increases alone—most of which have supported development projects that have very little impact on innovation or broader economic development—has accounted for almost 70 percent of the overall R&D increases of the last five years. Of the remaining increases, 75 percent has gone to the National Institutes of Health (NIH) and the Department of Homeland Security (DHS). At $71 billion and $29 billion, respectively, the R&D budgets of DOD and NIH now account for over 75 percent of all federal R&D. Meanwhile, funding for the physical sciences and engineering—the areas historically most closely associated with innovation and economic growth—have been flat or declining for the last thirty years.

[5] *Energy Efficiency Progress and Potential,* American Council for an Energy-Efficient Economy, no date.

Also, the long-term outlook for the federal budget does not favor future increases in discretionary spending (through which almost all R&D is funded). Absent major policy changes, the growth in mandatory federal spending—primarily for health and retirement benefits and payments on the national debt interest—will demand a significantly greater share of the government's resources.

Chart 1. Federal Spending (Outlays) on Research and Development as a Percentage of GDP, FY1950-FY2005. (Source: Office of Management and Budget Historical Tables, Fiscal Year 2006.)



Shift of Private Sector R&D

During the heyday of the corporate research laboratory in the middle decades of the 20th century, U.S. corporate laboratories supported all stages of R&D, from knowledge creation to applied research to product development, and were quite successful in their efforts to nurture innovation. The most notable example of this was AT&T's Bell Laboratories, which grew to be one of the world premier research organizations of the last century, developing numerous breakthrough technologies that changed American life, including transistors, lasers, fiber-optics, and communications satellites. Researchers at Bell Labs and other corporate laboratories were eligible for, and received, grants from federal research agencies such as the National Science Foundation and DOD, but they received core support from the parent company and they conducted basic and applied research directed toward developing technology relevant to the company's business.

While overall growth of industry-funded R&D has remained strong in recent years, the focus of this R&D has shifted significantly away from longer-term basic research in favor of applied research and development more closely tied to product development. Because of market demands from investors to capitalize on R&D quickly, large corporate laboratories of the Bell Labs model are increasingly rare (notable exceptions include companies such as IBM and GE). Instead, corporations now focus research projects almost exclusively on lower-risk, late-stage R&D projects with commercial benefits, leaving the federal government as the predominant supporter of long-term basic research.

Increasing Competitiveness of Foreign Countries

While trends of support for the innovation system in the U.S. have showed signs of slowing, other nations are committing significant new resources to building their science and technology enterprises. More than one-third of OECD (Organization for Economic Cooperation and Development) countries have increased government support for R&D by an average rate of over 5 percent annually since 1995. The European Union has recently established a target to achieve EU-wide R&D intensity of 3 percent of the EU economy by 2010. (By comparison, the current U.S. R&D intensity, public and private sector combined, is 2.6 percent of GDP.) Similarly, individual nations, including South Korea, Germany, the U.K. and Canada, have recently pledged to increase R&D spending as a percentage of GDP.

However, no nation has increased its support for innovation as dramatically as China. It has doubled its R&D intensity from 0.6 percent of its GDP in 1995 to 1.2 percent in 2002 (this during a time of rapid GDP growth). R&D investments in China by foreign corporations have also grown dramatically, with U.S. investments alone increasing from just $7 million in 1994 to over $500 million in 2000. China is now the third-largest performer of R&D in the world, behind only the U.S. and Japan.

The increased innovation capacity of other countries is also becoming evident in output-based R&D benchmarks. For example, the U.S. share of science and engineering publications published worldwide declined from 38 percent in 1988 to 31 percent in 2001, while Western Europe and Asia's share increased from 31 to 36 percent and 11 to 17 percent, respectively. Similar trends have occurred in the area of U.S. patent applications and citations in scientific journals.

Education and Workforce Issues

While the supply and demand of future scientists and engineers is notoriously difficult to predict, most experts believe that the transition to a knowledge-based economy will demand an increased quality and quantity of the world's scientific and technical workforce. As is the case with R&D figures, trends in the distribution of the world's science and engineering workforce are also unfavorable to long-term U.S. competitiveness.

The world is catching up and even surpassing the U.S. in higher education and the production of science and engineering specialists. China now graduates four times as many engineering students as the U.S., and South Korea, which has one-sixth the population of the U.S., graduates nearly the same number of engineers as the U.S. Moreover, most Western European and Asian countries graduate a significantly higher percentage of students in science and engineering. At the graduate level, the statistics are even more pronounced. In 1966, U.S. students accounted for approximately 76 percent of world's s science and engineering PhDs. In 2000, they accounted for only 36 percent. In contrast, China went from producing almost no science and engineering PhDs in 1975 to granting 13,000 PhDs in 2002, of which an estimated 70 percent were in science and engineering.

Meanwhile, the achievement and interest levels of U.S. students in science and engineering are relatively low. According to the most recent international assessment, U.S. twelfth graders scored below average and among the lowest of participating nations in math and science general knowledge, and the comparative data of math and science assessment revealed a near-monopoly by Asia in the top scoring group for students in grades 4 and 8. These students are not on track to study college level science and engineering and, in fact, are unlikely ever to do so. Of the 25 – 30 percent of entering college freshmen with an interest in a science or engineering field, less than half complete a science or engineering degree in five years.

All of this is happening as the U.S. scientific and technical workforce is about to experience a high rate of retirement. One quarter of the current science and engineering workforce is over 50 years old. At the same time, the U.S. Department of Labor projects that new jobs requiring science, engineering and technical training will increase four times higher than the average national job growth rate.

Industry Concerns and Reports

Some leading U.S. businesses have become increasingly vocal about concerns that the U.S. is in danger of losing its competitive advantage. In an effort to call attention to these concerns, several industry organizations have independently produced reports specifically examining the new competitiveness challenge and recommending possible courses of action to address it. Prominent among these efforts is the National Innovation Initiative (NII), a comprehensive undertaking by industry and university leaders to identify the origins of America's innovation challenges and prepare a call to action for U.S. companies to "innovate or abdicate." The December 2004 NII final report, *Innovate America: Thriving in a World of Challenge and Change*, is intended to serve as a roadmap for policymakers, industry leaders, and others working to help America remain competitive in the world economy.

Other industry associations that have also produced recent reports include AeA (formerly the American Electronics Association), the Business Roundtable, Electronic Industries Alliance, National Association of Manufacturers, and TechNet. While the companies and industry sectors represented by these organizations varies widely, one general recommendation was common to all of the reports: the federal government needs to strengthen and re-energize investments in R&D and science and engineering education. The Science Committee held a hearing on July 21, 2005 on *U.S. Competitiveness: The Innovation Challenge* to examine the issues raised in these reports and how federal science and engineering research and education investments impacts U.S. economic competitiveness.

Appendix A: Executive Summary of National Academy of Sciences Report, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*

The United States takes deserved pride in the vitality of its economy, which forms the foundation of our high quality of life, our national security, and our hope that our children and grandchildren will inherit ever-greater opportunities. That vitality is derived in large part from the productivity of well-trained people and the steady stream of scientific and technical innovations they produce. Without high-quality, knowledge-intensive jobs and the innovative enterprises that lead to discovery and new technology, our economy will suffer and our people will face a lower standard of living. Economic studies conducted before the information-technology revolution have shown that even then as much as 85% of measured growth in US income per capita is due to technological change.[6]

Today, Americans are feeling the gradual and subtle effects of globalization that challenge the economic and strategic leadership that the United States has enjoyed since World War II. A substantial portion of our workforce finds itself in direct competition for jobs with lower-wage workers around the globe, and leading-edge scientific and engineering work is being accomplished in many parts of the world. Thanks to globalization, driven by modern communications and other advances, workers in virtually every sector must now face competitors who live just a mouse-click away in Ireland, Finland, China, India, or dozens of other nations whose economies are growing.

CHARGE TO THE COMMITTEE

The National Academies was asked by Senator Lamar Alexander and Senator Jeff Bingaman of the Committee on Energy and Natural Resources, with endorsement by Representatives Sherwood Boehlert and Bart Gordon of the House Committee on Science, to respond to the following questions:

> What are the top 10 actions, in priority order, that federal policy-makers could take to enhance the science and technology enterprise so that the United States can successfully compete, prosper, and be secure in the global community of the 21st Century? What strategy, with several concrete steps, could be used to implement each of those actions?

The National Academies created the Committee on Prospering in the Global Economy of the 21st Century to respond to this request. The charge constitutes a challenge both daunting and exhilarating: to recommend to the nation specific steps that can best strengthen the quality of life in America—our prosperity, our health, and our security. The committee has been cautious in its analysis of information. However, the available information is only partly adequate for the committee's needs. In addition, the time allotted to develop the report (10 weeks from the time of the committee’s meeting to report release) limited the ability of the committee to conduct a

[6] For example, work by Robert Solow and Moses Abramovitz published in the middle 1950s demonstrated that as much as 85% of measured growth in US income per capita during the 1890-1950 period could not be explained by increases in the capital stock or other measurable inputs. The big unexplained portion, referred to alternatively as the "residual" or "the measure of ignorance", has been widely attributed to the effects of technological change.

thorough analysis. Even if unlimited time were available, definitive analyses on many issues are not possible given the uncertainties involved.

This report reflects the consensus views and judgment of the committee members. Although the committee includes leaders in academe, industry, and government—several current and former industry chief executive officers, university presidents, researchers (including three Nobel prize winners), and former presidential appointees—the array of topics and policies covered is so broad that it was not possible to assemble a committee of 20 members with direct expertise in each relevant area. Because of those limitations, the committee has relied heavily on the judgment of many experts in the study's focus groups, additional consultations via email and telephone with other experts, and an unusually large panel of reviewers. Although other solutions are undoubtedly possible, the committee believes that its recommendations, if implemented, will help the United States achieve prosperity in the 21st century.

FINDINGS

Having reviewed trends in the United States and abroad, the committee is deeply concerned that the scientific and technical building blocks of our economic leadership are eroding at a time when many other nations are gathering strength. We strongly believe that a worldwide strengthening will benefit the world's economy— particularly in the creation of jobs in countries that are far less well-off than the United States. But we are worried about the future prosperity of the United States. Although many people assume that United States will always be a world leader in science and technology, this may not continue to be the case inasmuch as great minds and ideas exist throughout the world. We fear the abruptness with which a lead in science and technology can be lost—and the difficulty of recovering a lead once lost, if indeed it can be regained at all.

This nation must prepare with great urgency to preserve its strategic and economic security. Because other nations have, and probably will continue to have, the competitive advantage of a low-wage structure, the United States must compete by optimizing its knowledge-based resources, particularly in science and technology, and by sustaining the most fertile environment for new and revitalized industries and the well-paying jobs they bring. We have already seen that capital, factories, and laboratories readily move wherever they are thought to have the greatest promise of return to investors.

RECOMMENDATIONS

The committee reviewed hundreds of detailed suggestions—including various calls for novel and untested mechanisms—from other committees, from its focus groups, and from its own members. The challenge is immense, and the actions needed to respond are immense as well.

The committee identified two key challenges that are tightly coupled to scientific and engineering prowess: creating high-quality jobs for Americans and responding to the nation's need for clean, affordable, and reliable energy. To address those challenges, the committee structured its ideas according to four basic recommendations that focus on the human, financial, and knowledge capital necessary for US prosperity.

The four recommendations focus on actions in K–12 education (*10,000 Teachers, 10 Million Minds*), research (*Sowing the Seeds*), higher education (*Best and Brightest*), and economic policy (*Incentives for Innovation*) that are set forth in the following sections. Also provided are a total of 20 implementation steps for reaching the goals set forth in the recommendations.

Some actions involve changes in the law. Others require financial support that would come from reallocation of existing funds or, if necessary, from new funds. Overall, the committee believes that the investments are modest relative to the magnitude of the return the nation can expect in the creation of new high-quality jobs and in responding to its energy needs.

10,000 TEACHERS, 10 MILLION MINDS IN K–12 SCIENCE AND MATHEMATICS EDUCATION

Recommendation A: *Increase America's talent pool by vastly improving K–12 science and mathematics education.*

Implementation Actions

The highest priority should be assigned to the following actions and programs. All should be subjected to continuing evaluation and refinement as they are implemented:

Action A-1: Annually recruit 10,000 science and mathematics teachers by awarding 4-year scholarships and thereby educating 10 million minds. Attract 10,000 of America's brightest students to the teaching profession every year, each of whom can have an impact on 1,000 students over the life of their careers. The program would award competitive 4-year scholarships for students to obtain bachelor's degrees in the physical or life sciences, engineering, or mathematics with concurrent certification as K–12 science and mathematics teachers. The merit-based scholarships would provide up to $20,000 a year for 4 years for qualified educational expenses, including tuition and fees, and require a commitment to 5 years of service in public K–12 schools. A $10,000 annual bonus would go to participating teachers in underserved schools in inner cities and rural areas. To provide the highest-quality education for undergraduates who want to become teachers, it would be important to award matching grants, perhaps $1 million a year for up to 5 years, to as many as 100 universities and colleges to encourage them to establish integrated 4-year undergraduate programs leading to bachelor's degrees in science, engineering, or mathematics *with teacher certification*.

Action A-2: Strengthen the skills of 250,000 teachers through training and education programs at summer institutes, in master's programs, and Advanced Placement and International Baccalaureate (AP and IB) training programs and thus inspires students every day. Use proven models to strengthen the skills (and compensation, which is based on education and skill level) of 250,000 *current* K–12 teachers:

- *Summer institutes*: Provide matching grants to state and regional 1- to 2-week summer institutes to upgrade as many as 50,000 practicing teachers each summer. The material covered would allow teachers to keep current with recent developments in science, mathematics, and technology and allow for the exchange of best teaching practices. The Merck Institute for Science Education is a model for this recommendation.
- *Science and mathematics master's programs*: Provide grants to universities to offer 50,000 current middle-school and high-school science, mathematics, and technology teachers

(with or without undergraduate science, mathematics, or engineering degrees) 2-year, part-time master's degree programs that focus on rigorous science and mathematics content and pedagogy. The model for this recommendation is the University of Pennsylvania Science Teachers Institute.

- *AP, IB, and pre-AP or pre-IB training*: Train an additional 70,000 AP or IB and 80,000 pre-AP or pre-IB instructors to teach advanced courses in mathematics and science. Assuming satisfactory performance, teachers may receive incentive payments of up to $2000 per year, as well as $100 for each student who passes an AP or IB exam in mathematics or science. There are two models for this program: the Advanced Placement Incentive Program and Laying the Foundation, a pre-AP program.
- *K–12 curriculum materials modeled on world-class standards*. Foster high-quality teaching with world-class curricula, standards, and assessments of student learning. Convene a national panel to collect, evaluate, and develop rigorous K–12 materials that would be available free of charge as a *voluntary* national curriculum. The model for this recommendation is the Project Lead the Way pre-engineering courseware.

Action A-3: Enlarge the pipeline by increasing the number of students who take AP and IB science and mathematics courses. Create opportunities and incentives for middle-school and high-school students to pursue advanced work in science and mathematics. By 2010, increase the number of students in AP and IB mathematics and science courses from 1.2 million to 4.5 million, and set a goal of tripling the number who pass those tests, to 700,000, by 2010. Student incentives for success would include 50% examination fee rebates and $100 mini-scholarships for each passing score on an AP or IB mathematics and science examination.

The committee proposes expansion of two additional approaches to improving K–12 science and mathematics education that are already in use:

- *Statewide specialty high schools*. Specialty secondary education can foster leaders in science, technology, and mathematics. Specialty schools immerse students in high-quality science, technology, and mathematics education; serve as a mechanism to test teaching materials; provide a training ground for K–12 teachers; and provide the resources and staff for summer programs that introduce students to science and mathematics.
- *Inquiry-based learning*. Summer internships and research opportunities provide especially valuable laboratory experience for both middle-school and high-school students.

SOWING THE SEEDS THROUGH SCIENCE AND ENGINEERING RESEARCH

Recommendation B: ***Sustain and strengthen the nation's traditional commitment to long-term basic research that has the potential to be transformational to maintain the flow of new ideas that fuel the economy, provide security, and enhance the quality of life.***

Implementation Actions

Action B-1: Increase the federal investment in long-term basic research by 10% a year over the next 7 years, through reallocation of existing funds[7] or if necessary through the investment of new funds. Special attention should go to the physical sciences, engineering,

[7] The funds may come from anywhere in an agency, not just other research funds.

mathematics, and information sciences and to Department of Defense (DOD) basic-research funding. This special attention does not mean that there should be a disinvestment in such important fields as the life sciences (which have seen growth in recent years) or the social sciences. A balanced research portfolio in all fields of science and engineering research is critical to US prosperity. This investment should be evaluated regularly to realign the research portfolio—unsuccessful projects and venues of research should be replaced with emerging research projects and venues that have greater promise.

Action B-2: Provide new research grants of $500,000 each annually, payable over 5 years, to 200 of our most outstanding *early-career* researchers. The grants would be made through existing federal research agencies—the National Institutes of Health (NIH), the National Science Foundation (NSF), the Department of Energy (DOE), DOD, and the National Aeronautics and Space Administration—to underwrite new research opportunities at universities and government laboratories.

Action B-3: Institute a National Coordination Office for Research Infrastructure to manage a centralized research-infrastructure fund of $500 million per year over the next 5 years –through reallocation of existing funds or if necessary through the investment of new funds—to ensure that universities and government laboratories create and maintain the facilities and equipment needed for leading-edge scientific discovery and technological development. Universities and national laboratories would compete annually for these funds.

Action B-4: Allocate at least 8% of the budgets of federal research agencies to discretionary funding that would be managed by technical program managers in the agencies and be focused on catalyzing high-risk, high-payoff research.

Action B-5: Create in the Department of Energy (DOE) an organization like the Defense Advanced Research Projects Agency (DARPA) called the Advanced Research Projects Agency-Energy (ARPA-E).[8] The director of ARPA-E would report to the under secretary for science and would be charged with sponsoring specific research and development programs to meet the nation's long-term energy challenges. The new agency would support creative "out-of-the-box" transformational generic energy research that industry by itself cannot or will not support and in which risk may be high but success would provide dramatic benefits for the nation. This would accelerate the process by which knowledge obtained through research is transformed to create jobs and address environmental, energy, and security issues. ARPA-E would be based on the historically successful DARPA model and would be designed as a lean and agile organization with a great deal of independence that can start and stop targeted programs on the basis of performance. The agency would itself perform no research or transitional effort but would fund such work conducted by universities, startups, established firms, and others. Its staff would turn over about every 4 years. Although the agency would be focused on specific energy issues, it is expected that its work (like that of DARPA or NIH) will have important spin-off benefits, including aiding in the education of the next generation of

[8] One committee member, Lee Raymond, does not support this action item. He does not believe that ARPA-E is necessary as energy research is already well funded by the federal government, along with formidable funding of energy research by the private sector. Also, ARPA-E would put the federal government in the business of picking "winning energy technologies" —a role best left to the private sector.

researchers. Funding for ARPA-E would start at $300 million the first year and increase to $1 billion per year over 5-6 years, at which point the program's effectiveness would be evaluated.

Action B-6: Institute a Presidential Innovation Award to stimulate scientific and engineering advances in the national interest. Existing presidential awards address lifetime achievements or promising young scholars, but the proposed new awards would identify and recognize persons who develop unique scientific and engineering innovations in the national interest at the time they occur.

BEST AND BRIGHTEST IN SCIENCE AND ENGINEERING HIGHER EDUCATION

Recommendation C: Make the United States the most attractive setting in which to study and perform research so that we can develop, recruit, and retain the best and brightest students, scientists, and engineers from within the United States and throughout the world.

Implementation Actions

Action C-1: Increase the number and proportion of US citizens who earn physical-sciences, life sciences, engineering, and mathematics bachelor's degrees by providing 25,000 new 4-year competitive undergraduate scholarships each year to US citizens attending US institutions. The Undergraduate Scholar Awards in Science, Technology, Engineering, and Mathematics (USA-STEM) would be distributed to states on the basis of the size of their congressional delegations and awarded on the basis of national examinations. An award would provide up to $20,000 annually for tuition and fees.

Action C-2: Increase the number of US citizens pursuing graduate study in "areas of national need" by funding 5,000 new graduate fellowships each year. NSF should administer the program and draw on the advice of other federal research agencies to define national needs. The focus on national needs is important both to ensure an adequate supply of doctoral scientists and engineers and to ensure that there are appropriate employment opportunities for students once they receive their degrees. Portable fellowships would provide funds of up to $20,000 annually directly to students, who would choose where to pursue graduate studies instead of being required to follow faculty research grants.

Action C-3: Provide a federal tax credit to encourage employers to make continuing education available (either internally or though colleges and universities) to practicing scientists and engineers. These incentives would promote career-long learning to keep the workforce current in the face of rapidly evolving scientific and engineering discoveries and technological advances and would allow for retraining to meet new demands of the job market.

Action C-4: Continue to improve visa processing for international students and scholars to provide less complex procedures and continue to make improvements on such issues as visa categories and duration, travel for scientific meetings, the technology-alert list, reciprocity agreements, and changes in status.

Action C-5: Provide a 1-year automatic visa extension to international students who receive doctorates or the equivalent in science, technology, engineering, mathematics, or other fields of national need at qualified US institutions to remain in the United States to seek employment. If these students are offered jobs by United States-based employers and pass a security screening test, they should be provided automatic work permits and expedited residence status. If students are unable to obtain employment within 1 year, their visas would expire.

Action C-6: Institute a new skills-based, preferential immigration option. Doctoral-level education and science and engineering skills would substantially raise an applicant's chances and priority in obtaining US citizenship. In the interim, the number of H-1B[9] visas should be increased by 10,000, and the additional visas should be available for industry to hire science and engineering applicants with doctorates from US universities.

Action C-7: Reform the current system of "deemed exports".[10] The new system should provide international students and researchers engaged in fundamental research in the United States with access to information and research equipment in US industrial, academic, and national laboratories comparable with the access provided to US citizens and permanent residents in a similar status. It would, of course, exclude information and facilities restricted under national-security regulations. In addition, the effect of deemed-exports regulations on the education and fundamental research work of international students and scholars should be limited by removing all technology items (information and equipment) from the deemed-exports technology list that are available for purchase on the overseas open market from foreign or US companies or that have manuals that are available in the public domain, in libraries, over the Internet, or from manufacturers.

INCENTIVES FOR INNOVATION AND THE INVESTMENT ENVIRONMENT

Recommendation D: ***Ensure that the United States is the premier place in the world to innovate; invest in downstream activities such as manufacturing and marketing; and create high-paying jobs that are based on innovation by modernizing the patent system, realigning tax policies to encourage innovation, and ensuring affordable broadband access.***

Implementation Actions

[9] The H-1B is a nonimmigrant classification used by an alien who will be employed temporarily in a specialty occupation of distinguished merit and ability. A specialty occupation requires theoretical and practical application of a body of specialized knowledge and at least a bachelor's degree or its equivalent. For example, architecture, engineering, mathematics, physical sciences, social sciences, medicine and health, education, business specialties, accounting, law, theology, and the arts are specialty occupations. See http://uscis.gov/graphics/howdoi/h1b.htm

[10] The controls governed by the Export Administration Act and its implementing regulations extend to the transfer of technology. *Technology* includes "*specific information* necessary for the 'development,' 'production,' or 'use' of a product" [emphasis added]. Providing information that is subject to export controls—for example, about some kinds of computer hardware—to a foreign national within the United States may be "deemed" an export, and that transfer requires an export license. The primary responsibility for administering controls on deemed exports lies with the Department of Commerce, but other agencies have regulatory authority as well.

Action D-1: Enhance intellectual-property protection for the 21st century global economy to ensure that systems for protecting patents and other forms of intellectual property underlie the emerging knowledge economy but allow research to enhance innovation. The patent system requires reform of four specific kinds:

- Provide the Patent and Trademark Office sufficient resources to make intellectual-property protection more timely, predictable, and effective.
- Reconfigure the US patent system by switching to a "first-inventor-to-file" system and by instituting administrative review *after* a patent is granted. Those reforms would bring the US system into alignment with patent systems in Europe and Japan.
- Shield research uses of patented inventions from infringement liability. One recent court decision could jeopardize the long-assumed ability of academic researchers to use patented inventions for research.
- Change intellectual-property laws that act as barriers to innovation in specific industries, such as those related to data exclusivity (in pharmaceuticals) and those which increase the volume and unpredictability of litigation (especially in information-technology industries).

Action D-2: Enact a stronger research and development tax credit to encourage private investment in innovation. The current Research and Experimentation Tax Credit goes to companies that *increase* their research and development spending above a base amount calculated from their spending in prior years. Congress and the administration should make the credit permanent,[11] and it should be increased from 20% to 40% of the qualifying increase so that the US tax credit is competitive with that of other countries. The credit should be extended to companies that have consistently spent large amounts on research and development so that they will not be subject to the current *de facto* penalties for previously investing in research and development.

Action D-3: Provide tax incentives for United States-based innovation. Many policies and programs affect innovation and the nation's ability to profit from it. It was not possible for the committee to conduct an exhaustive examination, but alternatives to current economic policies should be examined and, if deemed beneficial to the United States, pursued. These alternatives could include changes in overall corporate tax rates, provision of incentives for the purchase of high-technology research and manufacturing equipment, treatment of capital gains, and incentives for long-term investments in innovation. The Council of Economic Advisers and the Congressional Budget Office should conduct a comprehensive analysis to examine how the United States compares with other nations as a location for innovation and related activities with a view to ensuring that the United States is one of the most attractive places in the world for long-term innovation-related investment. From a tax standpoint, that is not now the case.

Action D-4: Ensure ubiquitous broadband Internet access. Several nations are well ahead of the United States in providing broadband access for home, school, and business. That capability will do as much to drive innovation, the economy, and job creation in the 21st century as did access to the telephone, interstate highways, and air travel in the 20th century. Congress

[11] The current R&D tax credit expires in December 2005.

and the administration should take action—mainly in the regulatory arena and in spectrum management—to ensure widespread affordable broadband access in the near future.

CONCLUSION

The committee believes that its recommendations and the actions proposed to implement them merit serious consideration if we are to ensure that our nation continues to enjoy the jobs, security, and high standard of living that this and previous generations worked so hard to create. Although the committee was asked only to recommend actions that can be taken by the federal government, it is clear that related actions at the state and local levels are equally important for US prosperity, as are actions taken by each American family. The United States faces an enormous challenge because of the disadvantage it faces in labor cost. Science and technology provide the opportunity to overcome that disadvantage by creating scientists and engineers with the ability to create entire new industries—much as has been done in the past.

It is easy to be complacent about US competitiveness and pre-eminence in science and technology. We have led the world for decades, and we continue to do so in many research fields today. But the world is changing rapidly, and our advantages are no longer unique. Without a renewed effort to bolster the foundations of our competitiveness, we can expect to lose our privileged position. For the first time in generations, the nation's children could face poorer prospects than their parents and grandparents did. We owe our current prosperity, security, and good health to the investments of past generations, and we are obliged to renew those commitments in education, research, and innovation policies to ensure that the American people continue to benefit from the remarkable opportunities provided by the rapid development of the global economy and its not inconsiderable underpinning in science and technology.

SOME WORRISOME INDICATORS

- When asked in spring 2005 what is the most attractive place in the world in which to "lead a good life"[i], respondents in only one of the 16 countries polled (India) indicated the United States.
- For the cost of one chemist or one engineer in the United States, a company can hire about five chemists in China or 11 engineers in India. [ii]
- For the first time, the most capable high-energy particle accelerator on Earth will, beginning in 2007, reside outside the United States. [iii]
- The United States is today a net importer of *high-technology* products. Its share of global high-technology exports has fallen in the last 2 decades from 30% to 17%, and its trade balance in high-technology manufactured goods shifted from *plus* $33 billion in 1990 to a *negative* $24 billion in 2004. [iv]
- Chemical companies closed 70 facilities in the United States in 2004 and have tagged 40 more for shutdown. Of 120 chemical plants being built around the world with price tags of $1 billion or more, one is in the United States and 50 in China. [v]
- Fewer than one-third of US 4th grade and 8th grade students performed at or above a level called "proficient" in mathematics; "proficiency" was considered the ability to exhibit competence with challenging subject matter. Alarmingly, about one-third of the 4th graders and one-fifth of the 8th graders lacked the competence to perform basic mathematical computations. [vi]
- US 12th graders recently performed below the international average for 21 countries on a test of general knowledge in mathematics and science. In addition, an advanced mathematics assessment was administered to US students who were taking or had taken precalculus, calculus, or Advanced Placement calculus and to students in 15 other countries who were taking or had taken advanced mathematics courses. Eleven nations outperformed the United States, and four countries had scores similar to the US scores. No nation scored significantly below the United States. [vii]
- In 1999, only 41% of US 8th grade students received instruction from a mathematics teacher who specialized in mathematics, considerably lower than the international average of 71%. [viii]
- In one recent period, low-wage employers, such as Wal-Mart (now the nation's largest employer) and McDonald's, created 44% of the new jobs, while high-wage employers created only 29% of the new jobs. [ix]
- In 2003, only three American companies ranked among the top 10 recipients of patents granted by the United States Patent and Trademark Office. [x]
- In Germany, 36% of undergraduates receive their degrees in science and engineering. In China, the figure is 59%, and in Japan 66%. In the United States, the corresponding figure is 32%. [xi]
- The United States is said to have 10.5 million illegal immigrants, but under the law the number of visas set aside for "highly qualified foreign workers" dropped to 65, 000 a year from its 195,000 peak. [xii]
- In 2004, China graduated over 600,000 engineers, India 350,000, and America about 70,000.[xiii]
- In 2001 (the most recent year for which data are available), US industry spent more on tort litigation than on R&D. [xiv]

NOTES for SOME WORRISOME INDICATORS:

i Interview asked nearly 17,000 people the question: “Supposed a young person who wanted to leave this country asked you to recommend where to go to lead a good life – what country would you recommend ?” Except for respondents in India, Poland, and Canada, no more than one-tenth of the people in the other nations said they would recommend the United States. Canada and Australia won the popularity contest. Pew Global Attitudes Project, July 23, 2005.

ii The Web site http://www.payscale.com/about.asp tracks and compares pay scales in many countries. Ron Hira, of Rochester Institute of Technology, calculates average salaries for engineers in the United States and India as $70,000 and $13,580, respectively.

iii CERN, http://public.web.cern.ch/Public/Welcome.html.

iv For 2004, the dollar value of high-technology imports was $560 billion; the value of high-technology exports was $511 billion. See Appendix Table 6-01 of National Science Board’s Science and Engineering Indicators 2004.

v "No Longer The Lab Of The World: U.S. chemical plants are closing in droves as production heads abroad", BusinessWeek (May 2, 2005).

vi National Center for Education Statistics, Trends in International Mathematics and Science Study, 2003, http://nces.ed.gov/timss.

vii Data are from National Science Board. 2004. Science and Engineering Indicators 2004 (NSB 04-01). Arlington, VA: National Science Foundation. Chapter 1.

viii Data are from National Science Board. 2004. Science and Engineering Indicators 2004 (NSB 04-01). Arlington, VA: National Science Foundation. Chapter 1.

ix Roach, Steve. More Jobs, Worse Work. New York Times. July 22, 2004.

x US Patent and Trademark Office, Preliminary list of top patenting organizations. 2003, http://www.uspto.gov/web/offices/ac/ido/oeip/taf/top03cos.htm.

xi Data are from National Science Board. 2004. Science and Engineering Indicators 2004 (NSB 04-01). Arlington, VA: National Science Foundation, Appendix Table 2-33.

xii Colvin, Geoffrey. 2005. “America isn't ready”. Fortune Magazine, July 25. H-1B visas allow employers to have access to highly educated foreign professionals who have experience in specialized fields and who have at least a bachelor's degree or the equivalent. The cap does not apply to educational institutions. In November 2004, Congress created an exemption for 20,000 foreign nationals earning advanced degrees from US universities. See Immigration and Nationality Act Section 101(a)(15)(h)(1)(b).

xiii Geoffrey Colvin. 2005. “America isn't ready”. Fortune Magazine, July 25.

xiv US research and development spending in 2001 was $273.6 billion, of which industry performed $194 billion, and funded about $184 billion. (National Science Board Science and Engineering Indicators 2004). One estimate of tort litigation costs in the United States was $205 billion in 2001. (Leonard, Jeremy A. 2003. How Structural Costs Imposed on U.S. Manufacturers Harm Workers and Threaten Competitiveness. Prepared for the Manufacturing Institute of the National Association of Manufacturers. http://www.nam.org/s_nam/bin.asp?CID=216&DID=227525&DOC=FILE.PDF.

Appendix B: Senate Letter to National Academy of Sciences

United States Senate

WASHINGTON, DC 20510

May 27, 2005

Dr. Bruce Alberts
President
National Academy of Sciences
2101 Constitution Avenue
Washington, DC 20418

Dear Dr. Alberts:

The Energy Subcommittee of the Senate Energy and Natural Resources Committee has been given the latitude by Chairman Pete Domenici to hold a series of hearings to identify specific steps our government should take to ensure the preeminence of America's scientific and technological enterprise.

The National Academies could provide critical assistance in this effort by assembling some of the best minds in the scientific and technical community to identify the most urgent challenges the United States faces in maintaining leadership in key areas of science and technology. Specifically, we would appreciate a report from the National Academies by September 2005 that addresses the following:

- Is it essential for the United States to be at the forefront of research in broad areas of science and engineering? How does this leadership translate into concrete benefits as evidenced by the competitiveness of American businesses and an ability to meet key goals such as strengthening national security and homeland security, improving health, protecting the environment, and reducing dependence on imported oil?

  What specific steps are needed to ensure that the United States maintains its leadership in science and engineering to enable us to successfully compete, prosper, and be secure in the global community of the 21st century? How can we determine whether total federal research investment is adequate, whether it is properly balanced among research disciplines (considering both traditional research areas and new multidisciplinary fields such as nanotechnology), and between basic and applied research?

- How do we ensure that the United States remains at the epicenter of the ongoing revolution in research and innovation that is driving 21st century economies? How can we assure investors that America is the preferred site for investments in new or expanded businesses that create the best jobs and provide the best services?

- How can we ensure that critical discoveries across all the scientific disciplines are predominantly American and exploited first by firms producing and hiring in America? How can we best encourage domestic firms to invest in invention and innovation to meet new global competition and how can public research investments best supplement these private sector investments?

- What specific steps are needed to develop a well-educated workforce able to successfully embrace the rapid pace of technological change?

Your answers to these questions will help Congress design effective programs to ensure that America remains at the forefront of scientific capability, thereby enhancing our ability to shape and improve our nation's future.

We look forward to reviewing the results of your efforts.

Sincerely,

Lamar Alexander
Chairman
Energy Subcommittee

Jeff Bingaman
Ranking Member
Committee on Energy and
Natural Resources

Appendix C: House Letter to National Academy of Sciences

U.S. HOUSE OF REPRESENTATIVES

COMMITTEE ON SCIENCE

SUITE 2320 RAYBURN HOUSE OFFICE BUILDING
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TTY: (202) 226–4410
http://www.house.gov/science/welcome.htm

June 30, 2005

Dr. Bruce Alberts
President
National Academy of Sciences
2101 Constitution Avenue
Washington, DC 20418

Dear Dr. Alberts,

We understand that the National Academies, in response to a request from Senators Alexander and Bingaman, are in the early stages of developing a study related to the urgent challenges facing the United States in maintaining leadership in key areas of science and technology. Because the Science Committee considers ensuring the strength and vitality of the Nation's scientific and technology enterprise an important part of its broad oversight responsibility, we are writing to endorse the request for this study and to encourage the National Academies to carry it forward expeditiously.

In addition, we would like to suggest some specific questions we hope to see addressed by the study:

- What skills will be required by the future U.S. science and engineering workforce in order for it to command a salary premium over foreign scientists and engineers? Are alternative degree programs needed, such as professional science masters degrees, to meet the needs of industry and to lead to attractive career paths for students?

- Are changes needed in the current graduate education system, such as: a different mix in graduate support among fellowships, traineeships, and research assistantships; more research faculty positions and fewer postdocs and graduate students in traditional graduate programs?

- Should a greater proportion of federal research funding be allocated to high-risk, exploratory research and should funding priorities among broad fields of science and engineering be readjusted?

- What policies and programs will help ensure the rapid flow of research results into the marketplace and promote the commercialization of research in a way that leads to the creation of good jobs for Americans?

The committee looks forwards to reviewing the results of this effort, and hopes that a draft response will be available by September 30, 2005. We hope that the new and innovative ideas you produce as the result of this effort will be able to translate into policies that will enhance U.S. prosperity in the 21st century. If you have any questions, please contact Dan Byers of the Majority Staff or Jim Wilson of the Minority Staff.

Sincerely,

SHERWOOD BOEHLERT
Chairman

BART GORDON
Ranking Member