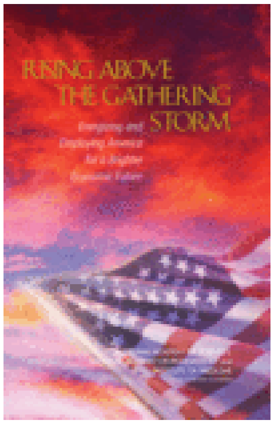
Free Executive Summary



Rising Above The Gathering Storm: Energizing and Employing America for a Brighter Economic Future

Committee on Prospering in the Global Economy of the 21st Century:An Agenda for American Science and Technology, National Academy of Sciences, National Academy of Engineering, Institute of Medicine

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In a world where advanced knowledge is widespread and low-cost labor is readily available, U.S. advantages in the marketplace and in science and technology have begun to erode. A comprehensive and coordinated federal effort is urgently needed to bolster U.S. competitiveness and pre-eminence in these areas. This congressionally requested report by a pre-eminent committee makes four recommendations along with 20 implementation actions that federal policy-makers should take to create high-quality jobs and focus new science and technology efforts on meeting the nation's needs, especially in the area of clean, affordable energy: 1) Increase America's talent pool by vastly improving K-12 mathematics and science education; 2) Sustain and strengthen the nation's commitment to long-term basic research;3) Develop, recruit, and retain top students, scientists, and engineers from both the U.S. and abroad; and4) Ensure that the United States is the premier place in the world for innovation. Some actions will involve changing existing laws, while others will require financial support that would come from reallocating existing budgets or increasing them.

Executive Summary

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 even before the information-technology revolution have shown that as much as 85% of measured growth in US income per capita was due to technological change.[1]

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,

[1]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 unexplained portion, referred to alternatively as the "residual" or "the measure of ignorance," has been widely attributed to the effects of technological change.

India, or dozens of other nations whose economies are growing. This has been aptly referred to as "the Death of Distance."

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 Representative Sherwood Boehlert and Representative 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 policymakers 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. 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 first gathering to report release) limited the ability of the committee to conduct an exhaustive analysis. Even if unlimited time were available, definitive analyses on many issues are not possible given the uncertainties involved.[2]

This report reflects the consensus views and judgment of the committee members. Although the committee consists of leaders in academe, industry, and government—including 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 e-mail and telephone with other experts, and an unusually large panel of reviewers.

[2]Since the prepublication version of the report was released in October, certain changes have been made to correct editorial and factual errors, add relevant examples and indicators, and ensure consistency among sections of the report. Although modifications have been made to the text, the recommendations remain unchanged, except for a few corrections, which have been footnoted.

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 technological building blocks critical to 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 the 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.

The committee found that multinational companies use such criteria[3] as the following in determining where to locate their facilities and the jobs that result:

- Cost of labor (professional and general workforce).
- Availability and cost of capital.
- Availability and quality of research and innovation talent.
- Availability of qualified workforce.
- Taxation environment.
- Indirect costs (litigation, employee benefits such as healthcare, pensions, vacations).
- Quality of research universities.
- Convenience of transportation and communication (including language).
- Fraction of national research and development supported by government.

[3]D. H. Dalton, M. G. Serapio, Jr., and P. G. Yoshida. *Globalizing Industrial Research and Development*. Washington, DC: US Department of Commerce, Technology Administration, Office of Technology Policy, 1999; Grant Gross. "CEOs Defend Moving Jobs Offshore at Tech Summit." *InfoWorld*, October 9, 2003; Bruce Mehlman. 2003. Offshore Outsourcing and the Future of American Competitiveness"; Bruce Einhorn et al. "High Tech in China: Is It a Threat to Silicon Valley?" *Business Week* online, October 28, 2002; B. Callan, S. Costigan, and K. Keller. *Exporting U.S. High Tech: Facts and Fiction About the Globalization of Industrial R&D*. New York: Council on Foreign Relations, 1997.

- Legal-judicial system (business integrity, property rights, contract sanctity, patent protection).
- Current and potential growth of domestic market.
- Attractiveness as place to live for employees.
- Effectiveness of national economic system.

Although the US economy is doing well today, current trends in each of those criteria indicate that the United States may not fare as well in the future without government intervention. 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.

The committee notes that the nation is unlikely to receive some sudden "wakeup" call; rather, the problem is one that is likely to evidence itself gradually over a surprisingly short period.

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 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 course 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, on a one-to-one basis, of $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 the physical and life sciences, mathematics, computer sciences, or engineering *with teacher certification*. The models for this action are the UTeach and California Teach program.

Action A-2: Strengthen the skills of 250,000 teachers through training and education programs at summer institutes, in master's programs, and in Advanced Placement (AP) and International Baccalaureate (IB) training programs. 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 the skills and state-of-the-art knowledge of 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 one model for this action.

• *Science and mathematics master's programs:* Provide grants to research universities to offer, over 5 years, 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 action is the University of Pennsylvania Science Teacher 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 science and mathematics. Assuming satisfactory performance, teachers may receive incentive payments of $1,800 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 a world-class standard:* 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 action is the Project Lead the Way pre-engineering courseware.

Action A-3: Enlarge the pipeline of students who are prepared to enter college and graduate with a degree in science, engineering, or mathematics by increasing the number of students who pass 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 who take at least one AP or IB mathematics or science exam to 1.5 million, and set a goal of tripling the number who pass those tests to 700,000.[4] Student incentives for success would include 50% examination fee rebates and $100 mini-scholarships for each passing score on an AP or IB science or mathematics examination.

Although it is not included among the implementation actions, the committee also finds attractive the expansion of two 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

[4]This sentence was incorrectly phrased in the original October 12, 2005, edition of the executive summary and has now been corrected.

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% each year over the next 7 years through reallocation of existing funds[5] or, if necessary, through the investment of new funds. Special attention should go to the physical sciences, engineering, 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 or the social sciences. A balanced research portfolio in all fields of science and engineering research is critical to US prosperity. **Increasingly, the most significant new scientific and engineering advances are formed to cut across several disciplines.** This investment should be evaluated regularly to realign the research portfolio to satisfy emerging needs and promises—unsuccessful projects and venues of research should be replaced with research projects and venues that have greater potential.

Action B-2: Provide new research grants of $500,000 each annually, payable over 5 years, to 200 of the nation's 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 (NASA)—to underwrite new research opportunities at universities and government laboratories.

Action B-3: Institute a National Coordination Office for Advanced Research Instrumentation and Facilities to manage a fund of $500 million in incremental funds 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

[5]The funds may come from anywhere in government, not just other research funds.

the facilities, instrumentation, 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 of the type that often suffers in today's increasingly risk-averse environment.

Action B-5: Create in the Department of Energy an organization like the Defense Advanced Research Projects Agency (DARPA) called the Advanced Research Projects Agency-Energy (ARPA-E).[6] 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 and do so in a timely manner. 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 approximately 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 spinoff benefits, including aiding in the education of the next generation of 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 and any appropriate actions taken.

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

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

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 bachelor's degrees in the physical sciences, the life sciences, engineering, and mathematics 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 a stipend of $30,000[7] annually directly to students, who would choose where to pursue graduate studies instead of being required to follow faculty research grants, and up to $20,000 annually for tuition and fees.

Action 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. These incentives would promote career-long learning to keep the workforce productive in an environment 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

[7] An incorrect number was provided for the graduate student stipend in the original October 12, 2005, edition of the executive summary.

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 US-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 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.[8]

Action C-7: Reform the current system of "deemed exports." 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[9] regulations on the education and fundamental research work of international students and scholars should be limited by removing from the deemed-exports technology list all technology items (information and equipment) 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.

[8]Since the report was released, the committee has learned that the Consolidated Appropriations Act of 2005, signed into law on December 8, 2004, exempts individuals that have received a master's or higher education degree from a US university from the statutory cap (up to 20,000). The bill also raised the H-1B fee and allocated funds to train American workers. The committee believes that this provision is sufficient to respond to its recommendation—even though the 10,000 additional visas recommended is specifically for science and engineering doctoral candidates from US universities, which is a narrower subgroup.

[9]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." 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.

INCENTIVES FOR INNOVATION

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 based on innovation by such actions as modernizing the patent system, realigning tax policies to encourage innovation, and ensuring affordable broadband access.***

Implementation Actions

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 US Patent and Trademark Office with 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 that 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,[10] and it should be increased from 20 to 40% of the qualifying increase so that the US tax credit is competitive with those of other countries. The credit should be extended to companies that have consistently spent large amounts on research and development so that they will

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

not be subject to the current de facto penalties for having previously invested in research and development.

Action D-3: Provide tax incentives for US-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 and special tax provisions providing 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 and the jobs resulting from that 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 can be expected to 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 and the administration should take action—mainly in the regulatory arena and in spectrum management—to ensure widespread affordable broadband access in the very 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 disparity it faces in labor costs. Science and technology provide the opportunity to overcome that disparity 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 preeminence 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. Some will argue that this is a problem for market forces to resolve—but that is exactly the concern. Market forces are *already at work* moving jobs to countries with less costly, often better educated, highly motivated workforces and friendlier tax policies.

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 COMPETITIVENESS INDICATORS

US Economy

- The United States is today a net importer of *high-technology* products. Its trade balance in high-technology manufactured goods shifted from *plus* \$54 billion in 1990 to *negative* \$50 billion in 2001.[1]
- 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.[2]
- The United States is one of the few countries in which industry plays a major role in providing healthcare for its employees and their families. Starbucks spends more on healthcare than on coffee. General Motors spends more on healthcare than on steel.[3]
- US scheduled airlines currently outsource portions of their aircraft maintenance to China and El Salvador.[4]
- IBM recently sold its personal computer business to an entity in China.[5]
- Ford and General Motors both have junk bond ratings.[6]
- It has been estimated that within a decade nearly 80% of the world's middle-income consumers would live in nations outside the currently industrialized world. China alone could have 595 million middle-income consumers and 82 million upper-middle-income consumers. The total population of the United States is currently 300 million[7] and it is projected to be 315 million in a decade.
- Some economists estimate that about half of US economic growth since World War II has been the result of technological innovation.[8]
- In 2005, American investors put more new money in foreign stock funds than in domestic stock portfolios.[9]

Comparative Economics

- Chemical companies closed 70 facilities in the United States in 2004 and 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 are in China. No new refineries have been built in the United States since 1976.[10]
- The United States is said to have 7 million illegal immigrants,[11] but under the law the number of visas set aside for "highly qualified foreign workers," many of whom contribute significantly to the nation's innovations, dropped to 65,000 a year from its 195,000 peak.[12]
- When asked in spring 2005 what is the most attractive place in the world in which to "lead a good life", respondents in only 1 (India) of the 16 countries polled indicated the United States.[13]

- A company can hire nine factory workers in Mexico for the cost of one in America. A company can hire eight young professional engineers in India for the cost of one in America.[14]
- The share of leading-edge semiconductor manufacturing capacity owned or partly owned by US companies today is half what it was as recently as 2001.[15]
- During 2004, China overtook the United States to become the leading exporter of information-technology products, according to the Organisation for Economic Co-operation and Development (OECD).[16]
- The United States ranks only 12th among OECD countries in the number of broadband connections per 100 inhabitants.[17]

K–12 Education

- 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 even basic mathematical computations.[18]
- In 1999, 68% of US 8th-grade students received instruction from a mathematics teacher who did not hold a degree or certification in mathematics.[19]
- In 2000, 93% of students in grades 5–9 were taught physical science by a teacher lacking a major or certification in the physical sciences (chemistry, geology, general science, or physics).[20]
- In 1995 (the most recent data available), US 12th graders performed below the international average for 21 countries on a test of general knowledge in mathematics and science.[21]
- US 15-year-olds ranked 24th out of 40 countries that participated in a 2003 administration of the Program for International Student Assessment (PISA) examination, which assessed students' ability to apply mathematical concepts to real-world problems.[22]
- According to a recent survey, 86% of US voters believe that the United States must increase the number of workers with a background in science and mathematics or America's ability to compete in the global economy will be diminished.[23]
- American youth spend more time watching television[24] than in school.[25]
- Because the United States does not have a set of national curricula, changing K–12 education is challenging, given that there are almost 15,000

school systems in the United States and the average district has only about six schools.[26]

Higher Education

- In South Korea, 38% of all undergraduates receive their degrees in natural science or engineering. In France, the figure is 47%, in China, 50%, and in Singapore, 67%. In the United States, the corresponding figure is 15%.[27]
- Some 34% of doctoral degrees in natural sciences (including the physical, biological, earth, ocean, and atmospheric sciences) and 56% of engineering PhDs in the United States are awarded to foreign-born students.[28]
- In the US science and technology workforce in 2000, 38% of PhDs were foreign-born.[29]
- Estimates of the number of engineers, computer scientists, and information-technology students who obtain 2-, 3-, or 4-year degrees vary. One estimate is that in 2004, China graduated about 350,000 engineers, computer scientists, and information technologists with 4-year degrees, while the United States graduated about 140,000. China also graduated about 290,000 with 3-year degrees in these same fields, while the US graduated about 85,000 with 2- or 3-year degrees.[30] Over the past 3 years alone, both China[31] and India[32] have doubled their production of 3- and 4-year degrees in these fields, while the United States[33] production of engineers is stagnant and the rate of production of computer scientists and information technologists doubled.
- About one-third of US students intending to major in engineering switch majors before graduating.[34]
- There were almost twice as many US physics bachelor's degrees awarded in 1956, the last graduating class before Sputnik, than in 2004.[35]
- More S&P 500 CEOs obtained their undergraduate degrees in engineering than in any other field.[36]

Research

- In 2001 (the most recent year for which data are available), US industry spent more on tort litigation than on research and development.[37]
- In 2005, only four American companies ranked among the top 10 corporate recipients of patents granted by the *United States* Patent and Trademark Office.[38]
- Beginning in 2007, the most capable high-energy particle accelerator on Earth will, for the first time, reside outside the United States.[39]

- Federal funding of research in the physical sciences, as a percentage of gross domestic product (GDP), was 45% less in fiscal year (FY) 2004 than in FY 1976.[40] The amount invested annually by the US federal government in research in the physical sciences, mathematics, and engineering combined equals the annual increase in US healthcare costs incurred every 20 days.[41]

PERSPECTIVES

- "If you can solve the education problem, you don't have to do anything else. If you don't solve it, nothing else is going to matter all that much." —Alan Greenspan, outgoing Federal Reserve Board chairman[42]
- "We go where the smart people are. Now our business operations are two-thirds in the U.S. and one-third overseas. But that ratio will flip over the next ten years." —Intel Corporation spokesman Howard High[43]
- "If we don't step up to the challenge of finding and supporting the best teachers, we'll undermine everything else we are trying to do to improve our schools." —Louis V. Gerstner, Jr., Former Chairman, IBM[44]
- "If you want good manufacturing jobs, one thing you could do is graduate more engineers. We had more sports exercise majors graduate than electrical engineering grads last year." —Jeffrey R. Immelt, Chairman and Chief Executive Office, General Electric[45]
- "If I take the revenue in January and look again in December of that year 90% of my December revenue comes from products which were not there in January." —Craig Barrett, Chairman of Intel Corporation[46]
- "When I compare our high schools to what I see when I'm traveling abroad, I am terrified for our workforce of tomorrow." —Bill Gates, Chairman and Chief Software Architect of Microsoft Corporation[47]
- "Where once nations measured their strength by the size of their armies and arsenals, in the world of the future knowledge will matter most." —President Bill Clinton[48]
- "Science and technology have never been more essential to the defense of the nation and the health of our economy." —President George W. Bush[49]

NOTES FOR *SOME COMPETITIVENESS INDICATORS AND PERSPECTIVES*

[1]For 2001, the dollar value of high-technology imports was $561 billion; the value of high-technology exports was $511 billion. See National Science Board. *Science and Engineering Indicators 2004*. NSB 04-01. Arlington, VA: National Science Foundation, 2004. Appendix Table 6-01. Page A6-5 provides the export numbers for 1990 and 2001 and page A6-6 has the import numbers.

[2]S. Roach. *More Jobs, Worse Work*. New York Times, July 22, 2004.

[3]C. Noon. "Starbuck's Schultz Bemoans Health Care Costs." *Forbes.com,* September 19, 2005. Available at: http://www.forbes.com/; R. Scherer. "Rising Benefits Burden." *Christian Science Monitor,* June 9, 2005. Available at: http://www.csmonitor.com/.

[4]S. K. Goo. *Airlines Outsource Upkeep*. Washington Post, August 21, 2005. Available at: http://www.washingtonpost.com/wp-dyn/content/article/2005/08/20/AR2005082000979.html; S. K. Goo. *Two-Way Traffic in Airplane Repair*. Washington Post, June 1, 2004. Available at: http://www.washingtonpost.com/.

[5]M. Kanellos. "IBM Sells PC Group to Lenovo." *News.com,* December 8, 2004. Available at: http://news.com.com/IBM+sells+PC+group+to+Lenovo/2100-1042_3-5482284.html.

[6]See http://www.nytimes.com/.

[7]In China, P. A. Laudicina. *World Out of Balance: Navigating Global Risks to Seize Competitive Advantage*. New York: McGraw-Hill, 2005. P. 76. For the United States, see US Census Bureau. "US Population Clock." Available at: http://www.census.gov. For current population and for the projected population, see Population Projections Program, Population Division, US Census Bureau. "Population Projections of the United States by Age, Sex, Race, Hispanic Origin, and Nativity: 1999 to 2100." Washington, DC, January 13, 2000. Available at: http://www.census.gov/population/www/projections/natsum-T3.html.

[8]M. J. Boskin and L. J. Lau. Capital, Technology, and Economic Growth. In N. Rosenberg, R. Landau, and D. C. Mowery, eds. *Technology and the Wealth of Nations*. Stanford, CA: Stanford University Press, 1992.

[9]P. J. Lim. *Looking Ahead Means Looking Abroad*. New York Times, January 8, 2006.

[10]M. Arndt. "No Longer the Lab of the World: U.S. Chemical Plants are Closing in Droves as Production Heads Abroad." *BusinessWeek,* May 2, 2005. Available at: http://www.businessweek.com/ and http://www.usnews.com/usnews/.

[11]As of 2000, the unauthorized resident population in the United States was 7 million. See US Citizenship and Immigration Services. "Executive Summary: Estimates of the Unauthorized Immigrant Population Residing in the United States: 1990 to 2000." January 31, 2003. Available at: http://uscis.gov/graphics/shared/statistics/publications/2000ExecSumm.pdf.

[12]Section 214(g) of the Immigration and Nationality Act sets an annual limit on the number of aliens that can receive H-1B status in a fiscal year. For FY 2000 the limit was set at 115,000. The American Competitiveness in the Twenty-First Century Act increased the annual limit to 195,000 for 2001, 2002, and 2003. After that date the cap reverts back to 65,000. 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). See US Citizenship and Immigration Services. "USCIS Announces Update Regarding New H-1B Exemptions." July 12, 2005. Available at: http://uscis.gov/ and US Citizenship and Immigration Services. "Questions and Answers: Changes to the H-1B Program." November 21, 2000. Available at: http://uscis.gov.

[13]Pew Research Center. "U.S. Image Up Slightly, But Still Negative, American Character Gets Mixed Reviews." Washington, DC: Pew Global Attitudes Project, 2005. Available at: http://pewglobal.org/reports/display.php?ReportID=247.

The interview asked nearly 17,000 people the question: "Suppose 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.

[14]US Bureau of Labor Statistics. "International Comparisons of Hourly Compensation Costs for Production Workers in Manufacturing, 2004." November 18, 2005. Available at: ftp://ftp.bls.gov/.

[15]Semiconductor Industry Association. "Choosing to Compete." December 12, 2005. Available at: http://www.sia-online.org/.

[16]Organisation for Economic Co-operation and Development. "China Overtakes U.S. as World's Leading Exporter of Information Technology Goods." December 12, 2005. Available at: http://www.oecd.org/. The main categories included in OECD's definition of ICT (information and communications technology) goods are electronic components, computers and related equipment, audio and video equipment, and telecommunication equipment.

[17]Organisation for Economic Co-operation and Development. "OECD Broadband Statistics, June 2005." October 20, 2005. Available at: http://www.oecd.org/.

[18]National Center for Education Statistics. 2006. "The Nation's Report Card: Mathematics 2005." Available at: http://nces.ed.gov/nationsreportcard/pdf/main2005/2006453.pdf.

[19]National Science Board. *Science and Engineering Indicators 2004*. NSB 04-01. Arlington, VA: National Science Foundation, 2004. Chapter 1.

[20]National Center for Education Statistics. Schools and Staffing Survey, 2004. "Qualifications of the Public School Teacher Workforce: Prevalence of Out-of-Field Teaching 1987-88 to 1999-2000 (Revised)." 2004. P. 10. Available at: http://nces.ed.gov/pubs2002/2002603.pdf.

[21]National Center for Education Statistics. "Highlights from TIMSS." 2004. Available at: http://nces.ed.gov/pubs99/1999081.pdf.

[22]National Center for Education Statistics. "International Outcomes of Learning in Mathematics Literacy and Problem Solving: PISA 2003 Results from the U.S. Perspective." 2005. Pp. 15 and 29. Available at: http://nces.ed.gov/pubs2005/2005003.pdf.

[23]The Business Roundtable. "Innovation and U.S. Competitiveness: Addressing the Talent Gap. Public Opinion Research." January 12, 2006. Available at: http://www.businessroundtable.org/pdf/20060112Two-pager.pdf.

[24]American Academy of Pediatrics. "Television—How it Affects Children." Available at: http://www.aap.org/. The American Academy of Pediatrics reports, "Children in the United States watch about four hours of TV every day"; this works out to be 1,460 hours per year.

[25]National Center for Education Statistics. 2005. "The Condition of Education." Table 26-2, Average Number of Instructional Hours per Year Spent in Public School, by Age or Grade of Student and Country: 2000 and 2001. Available at: http://nces.ed.gov/. NCES reports that in 2000 US 15-year-olds spent 990 hours in school, during the same year 4th graders spent 1,040 hours.

[26]National Center for Education Statistic. "Public Elementary and Secondary Students, Staff, Schools, and School Districts: School Year 2003-04." 2006. Available at: http://nces.ed.gov/.

[27]Analysis conducted by the Association of American Universities. 2006. "National Defense Education and Innovation Initiative." Based on data in National Science Board. *Science and Engineering Indicators 2004*. NSB 04-01. Arlington, VA: National Science Foundation, 2004. Appendix Table 2-33. For countries with both short and long degrees, the ratios are calculated with both short and long degrees as the numerator.

[28]National Science Board. *Science and Engineering Indicators 2004*. NSB 04-01. Arlington, VA: National Science Foundation, 2004. Chapter 2, Figure 2-23.

[29]National Science Board. A companion to *Science and Engineering Indicators 2004*. NSB 04-01. Arlington, VA: National Science Foundation, 2004.

[30]G. Gereffi and V. Wadhwa. 2005. "Framing the Engineering Outsourcing Debate: Placing the United States on a Level Playing Field with China and India." Available at: http://memp.pratt.duke.edu/downloads/duke_outsourcing_2005.pdf.

[31]Ministry of Science and Technology (MOST). *Chinese Statistical Yearbook 2004*. People's Republic of China: National Bureau of Statistics of China, 2004. Chapter 21, Table 21-11. Available at: http://www.stats.gov.cn/english/statisticaldata/yearlydata/yb2004-e/indexeh.htm. The extent to which engineering degrees from China are comparable to those from the United States is uncertain.

[32]National Association of Software and Service Companies. *Strategic Review 2005*. National Association of Software and Service Companies, India, 2005. Chapter 6, Sustaining the India Advantage. Available at: http://www.nasscom.org/strategic2005.asp.

[33]National Center for Education Statistics. *Digest of Education Statistics 2004*. Washington, DC: Institute of Education Sciences, Department of Education, 2004. Table 250. Available at: http://nces.ed.gov/.

[34]M. Boylan. Assessing Changes in Student Interest in Engineering Careers Over the Last Decade. CASEE, National Academy of Engineering, 2004. Available at: http://www.nae.edu/; C. Adelman. *Women and Men on the Engineering Path: A Model for Analysis of Undergraduate Careers*. Washington, DC: US Department of Education, 1998. Available at: http://www.ed.gov. According to this Department of Education analysis, the majority of students who switch from engineering majors complete a major in business or other non-science and engineering fields.

[35]National Center for Education Statistics. *Digest of Education Statistics 2004*. Washington, DC: Institute of Education Sciences, Department of Education, 2004. Table 250. Available at: http://nces.ed.gov/.

[36]S. Stuart. "2004 CEO Study: A Statistical Snapshot of Leading CEOs." 2005. Available at: http://content.spencerstuart.com/sswebsite/pdf/lib/Statistical_Snapshot_of_Leading_CEOs_relB3.pdf#search='ceo%20educational%20background'.

[37]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*. NSB 04-01. Arlington, VA: National Science Foundation, 2004. One estimate of tort litigation costs in the United States was $205 billion in 2001.

J. A. Leonard. 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. Available at: http://www.nam.org/.

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[40]American Association for the Advancement of Science. "Trends in Federal Research by Discipline, FY 1976-2004." October 2004. Available at: http://www.aaas.org/.

[41]Centers for Medicare and Medicaid Services. "National Heath Expenditures." 2005. Available at: http://www.cms.hhs.gov/NationalHealthExpendData/downloads/tables.pdf.

[42]US Department of Education, Office of the Secretary. *Meeting the Challenge of a Changing World: Strengthening Education for the 21st Century*. Washington, DC: US Department of Education, 2006.

[43]K. Wallace. "America's Brain Drain Crisis Why Our Best Scientists Are Disappearing, and What's Really at Stake." *Readers Digest,* December 2005.

[44]L. V. Gerstner, Jr. *Teaching at Risk: A Call to Action*. New York: City University of New York, 2004. Available at: www.theteachingcommission.org.

[45]Remarks by J. R. Immelt to Economic Club of Washington as reported in Neil Irwin. *US Needs More Engineers, GE Chief Says*. Washington Post, January 23, 2006.

[46]C. Barrett. Comments at public briefing on the release of Rising Above the Gathering Storm report. October 12, 2005. Available at: http://www.nationalacademies.org/morenews/20051012.html.

[47]B. Gates. Speech to the National Education Summit on High Schools. February 26, 2005. Available at: http://www.gatesfoundation.org/MediaCenter/Speeches/BillgSpeeches/BGSpeechNGA-050226.htm.

[48]W. J. Clinton. Commencement address at Morgan State University in Baltimore, Maryland. In *1997 Public Papers of the Presidents of the United States, Books I and II*. Washington, DC: Government Printing Office, May 18, 1997. Available at: http://www.gpoaccess.gov/pubpapers/wjclinton.html.

[49]Remarks by President George W. Bush in meeting with high-tech leaders. March 28, 2001. Available at: http://www.whitehouse.gov/.

RISING ABOVE THE GATHERING STORM

Energizing and Employing America for a Brighter Economic Future

Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology

Committee on Science, Engineering, and Public Policy

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Preface

Ninety-nine percent of the discoveries are made by one percent of the scientists.

Julius Axelrod, Nobel Laureate[1]

The prosperity the United States enjoys today is due in no small part to investments the nation has made in research and development at universities, corporations, and national laboratories over the last 50 years. Recently, however, corporate, government, and national scientific and technical leaders have expressed concern that pressures on the science and technology enterprise could seriously erode this past success and jeopardize future US prosperity. Reflecting this trend is the movement overseas not only of manufacturing jobs but also of jobs in administration, finance, engineering, and research.

The councils of the National Academy of Sciences and the National Academy of Engineering, at their annual joint meeting in February 2005, discussed these tensions and examined the position of the United States in today's global knowledge-discovery enterprise. Participants expressed concern that a weakening of science and technology in the United States would inevitably degrade its social and economic conditions and in particular erode the ability of its citizens to compete for high-quality jobs.

On the basis of the urgency expressed by the councils, the National Academies' Committee on Science, Engineering, and Public Policy

[1]*Proceedings of the American Philosophical Society*, Vol. 149, No. 2, June 2005.

(COSEPUP) was charged with organizing a planning meeting, which took place May 11, 2005. One of the speakers at the meeting was Senator Lamar Alexander, the former secretary of education and former president of the University of Tennessee.

Senator Alexander indicated that the Energy Subcommittee of the Senate Energy and Natural Resources Committee, which he chairs, had been given the authority by the full committee's chair, Senator Pete Domenici, to hold a series of hearings to identify specific steps that the federal government should take to ensure the preeminence of America's science and technology enterprise. Senator Alexander asked the National Academies to provide assistance in this effort by selecting a committee of experts from the scientific and technical community to assess the current situation and, where appropriate, make recommendations. The committee would be asked to identify urgent challenges and determine specific steps to ensure that the United States maintains its leadership in science and engineering to compete successfully, prosper, and be secure in the 21st century.

On May 12, 2005, the day after the planning meeting, three members of the House of Representatives who have jurisdiction over science and technology policy and funding announced that a conference would be held in fall 2005 on science, technology, innovation, and manufacturing. Appearing at a Capitol Hill press briefing to discuss the conference were representatives Frank Wolf, Sherwood Boehlert, and Vern Ehlers. Representative Boehlert said of the conference: "It can help forge a national consensus on what is needed to retain US leadership in innovation. A summit like this, with the right leaders, under the aegis of the federal government, can bring renewed attention to science and technology concerns so that we can remain the nation that the world looks to for the newest ideas and the most skilled people."

In describing the rationale for the conference, Representative Wolf recalled meeting with a group of scientists and asking them how well the United States was doing in science and innovation. None of the scientists, he reported, said that the nation was doing "okay." About 40% said that we were "in a stall," and the remaining 60% said that we were "in decline." He asked a similar question of the executive board of a prominent high-technology association, which reported that in its view the United States was "in decline."

Later, the National Academies received a bipartisan letter addressing the subject of America's competitiveness from Senators Lamar Alexander and Jeff Bingaman. The letter, dated May 27, 2005, requested that the National Academies conduct a formal study on the issue to assist in congressional deliberations. That was followed by a bipartisan letter from Representatives Sherwood Boehlert and Bart Gordon, of the House Committee on

Science, which expanded on the Senate request. In response, the National Academies initiated a study with its own funds.

To undertake the study, COSEPUP established the Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology. The committee members included presidents of major universities, Nobel laureates, CEOs of Fortune 100 corporations, and former presidential appointees. They were asked to investigate the following questions:

- What are the top 10 actions, in priority order, that federal policymakers 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 implementation strategy, with several concrete steps, could be used to implement each of those actions?

This study and report were carried out with an unusual degree of urgency—only a matter of weeks elapsed from the committee's initial gathering to release of its report. The process followed the regular procedures for an independent National Research Council study, including review of the report, in this case, by 37 experts. The report relies on customary reference to the scientific literature and on consensus views and judgments of the committee members.

The committee began by assembling the recommendations of 13 issue papers summarizing past studies of topics related to the present study. It then convened five focus groups consisting of 66 experts in K–12 education, higher education, research, innovation and workforce issues, and national and homeland security and asked each group to recommend three actions it considered to be necessary for the nation to compete, prosper, and be secure in the 21st century. The committee used those suggestions and its own judgment to make its recommendations. The key thematic issues underlying these discussions were the nation's need to create jobs and need for affordable, clean, and reliable energy.

In this report, a description of the key elements of American prosperity in the 21st century is followed by an overview of how science and technology are critical to that prosperity. The report then evaluates how the United States is doing in science and technology and provides recommendations for improving our nation's prosperity. Finally, it posits the status of prosperity if the United States maintains a narrow lead (the current situation), falls behind, or emerges as the leader in a few selected fields of science and technology.

We strayed from our charge in that we present not 10 actions but 4 recommendations and 20 specific actions to implement them. The committee members deeply believe in the fundamental linkage of all the recommendations and their integrity as a coordinated set of policy actions. To emphasize one or neglect another, the members decided, would substantially weaken what should be viewed as a coherent set of high-priority actions to create jobs and enhance the nation's energy supply in an era of globalization. For example, there is little benefit in producing more researchers if there are no funds to support their research.

The committee thanks the focus-group members, who took precious personal time in midsummer to donate the expertise that would permit a highly focused, detailed examination of a question of extraordinary complexity and importance. We thank the staff of the National Academies. They quickly mobilized the knowledge resources and practical skills needed to complete this study in a rapid, thorough manner.

Norman R. Augustine
Chair, Committee on Prospering in the Global Economy of the 21st Century

CRAIG BARRETT

NANCY GRASMICK

GAIL CASSELL

CHARLES HOLLIDAY, JR.

STEVEN CHU

SHIRLEY ANN JACKSON

ROBERT GATES

ANITA K. JONES

JOSHUA LEDERBERG

ROBERT C. RICHARDSON

RICHARD LEVIN

P. ROY VAGELOS

C. D. (DAN) MOTE, JR.

CHARLES M. VEST

CHERRY MURRAY

GEORGE M. WHITESIDES

PETER O'DONNELL, JR.

RICHARD N. ZARE

LEE R. RAYMOND

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This report has been reviewed in draft form by persons chosen for their diverse perspectives and technical expertise in accordance with procedures approved by the National Research Council's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making the published report as sound as possible and to ensure that the report meets institutional standards of objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process.

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Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations, nor did they see the final draft of the report before its release. The review of this report was overseen by Floyd Bloom, Robert Frosch, and M. R. C. Greenwood, appointed by the Report Review Committee, who were responsible for making certain that an independent examination of the report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of the report rests entirely with the author committee and the institution.

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