

Free Summary



Rising Above the Gathering Storm, Revisited: Rapidly Approaching Category 5

By Members of the 2005 "Rising Above the Gathering Storm" Committee; Prepared for the Presidents of the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine

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Executive Summary

In 2005, bipartisan requests from the United States House of Representatives and the United States Senate prompted the National Academies to conduct a study of America's competitiveness in the newly evolved global marketplace. An Academies committee comprised of twenty individuals of highly diverse professional backgrounds, supported by the staff of the Academies and many others, subsequently conducted a review of America's competitive position and released a report that has become popularly referred to as the "*Gathering Storm*" report after the first line in its title.

The Academies' review culminated in four overarching recommendations, underpinned by twenty specific implementing actions. Generally strong bipartisan support was granted these findings on Capitol Hill and in the White House and a number of the recommendations were eventually implemented. However, the preponderance of the enabling financial resources was provided in the American Recovery and Reinvestment Act ("Stimulus Legislation") which is presumed to be a one-time, albeit two-year, initiative. Similarly, the Authorizing Legislation to implement many of the *Gathering Storm* recommendations, known as the America COMPETES Act, was specified to expire after three years; i.e., in the 2010 fiscal year.

Although significant progress has been made as a result of the above legislation, the *Gathering Storm* effort once again finds itself at a tipping point. It is widely agreed that addressing America's competitiveness challenge is an undertaking that will require many years if not decades; however, the requisite federal funding of much of that effort is about to terminate. In order to sustain the progress that has begun it will be necessary to (1) reauthorize the America COMPETES Act, and (2) "institutionalize" funding and oversight of the *Gathering Storm* recommendations—

or others that accomplish the same purpose—such that funding and policy changes will routinely be considered in future years' legislative processes.

It would be impossible not to recognize the great difficulty of carrying out the *Gathering Storm* recommendations, such as doubling the research budget, in today's fiscal environment...with worthy demand after worthy demand confronting budgetary realities. However, it is emphasized that actions such as doubling the research budget are *investments* that will need to be made if the nation is to maintain the economic strength to provide for its citizens healthcare, social security, national security, and more. One seemingly relevant analogy is that a non-solution to making an over-weight aircraft flight-worthy is to remove an engine.

The original *Gathering Storm* competitiveness report focuses on the ability of America and Americans to compete for jobs in the evolving global economy. The possession of quality jobs is the foundation of a high quality life for the nation's citizenry.

The report paints a daunting outlook for America if it were to continue on the perilous path it has been following in recent decades with regard to sustained competitiveness.

The purpose of the present report is to assess changes in America's competitive posture in the five years that have elapsed since the *Gathering Storm* report was initially published and to assess the status of implementation of the National Academies' recommendations.

Robert Solow received a Nobel Prize in economics in part for his work that indicated that well over half of the growth in United States output per hour during the first half of the twentieth century could be attributed to advancements in knowledge, particularly technology.¹ This period was, of course, before the technology explosion that has been witnessed in recent decades. The National Academies *Gathering Storm* committee concluded that a primary driver of the future economy and concomitant creation of jobs will be *innovation*, largely derived from advances in science and engineering. While only four percent of the nation's work force is

¹ R.M. Solow, "Technical Change and the Aggregate Production Function." *Review of Economics and Statistics*, 39: 312-320, 1957.

composed of scientists and engineers, this group disproportionately creates jobs for the other 96 percent.²

When scientists discovered how to decipher the human genome it opened entire new opportunities in many fields including medicine. Similarly, when scientists and engineers discovered how to increase the capacity of integrated circuits by a factor of one million as they have in the past forty years, it enabled entrepreneurs to replace tape recorders with iPods, maps with GPS, pay phones with cell phones, two-dimensional X-rays with three-dimensional CT scans, paperbacks with electronic books, slide rules with computers, and much, much more.³ Further, the pace of creation of new knowledge appears by almost all measures to be accelerating.⁴

Importantly, *leverage* is at work here. It is not simply the scientist, engineer and entrepreneur who benefit from progress in the laboratory or design center; it is also the factory worker who builds items such as those cited above, the advertiser who promotes them, the truck driver who delivers them, the salesperson who sells them, and the maintenance person who repairs them—not to mention the benefits realized by the user. Further, each job directly created in the chain of manufacturing activity generates, on average, another 2.5 jobs in such unrelated endeavors as operating restaurants, grocery stores, barber shops, filling stations and banks.⁵ Progress enabling products such as those mentioned above in the information fields is built upon the work of a few individuals who decades ago were investigating something called solid state physics—none of whom probably ever thought about CT scans, GPS or iPods—the latter of which can enable one to hold 160,000 books in one's pocket—any more than one today can predict the breakthroughs a half century hence.⁶

² National Science Board, *Science and Engineering Indicators 2010*. Arlington, VA: National Science Foundation (NSB 10-01), Figure 3-3.

³ In 1971, the Intel 4004 Processor had 2300 transistors. See: http://download.intel.com/pressroom/kits/events/moores_law_40th/MLTimeline.pdf. In 2009, Intel released the Xeon® 'Nehalem-EX' Processor with 2.3 billion transistors. See: <http://www.intel.com/pressroom/archive/releases/2009/20090526comp.htm>.

⁴ Beyond Discovery: The Path from Discovery to Human Benefit is a series of articles that explore the origins of various technological and medical advances (www.beyonddiscovery.org/).

⁵ J. Bivens, Updated Employment Multipliers for the U.S. Economy (2003), Economic Policy Institute Working Paper, August 2003. Available at: http://www.epi.org/page/-/old/workingpapers/epi_wp_268.pdf.

⁶ For a 64 gigabyte iPod, holding books with an average file size of 400 kilobytes.

The *Gathering Storm* report assessed America's position with respect to each of the principal ingredients of innovation and competitiveness—Knowledge Capital, Human Capital and the existence of a creative “Ecosystem.” Numerous significant findings resulted—for example, with regard to Knowledge Capital it was noted that federal government funding of R&D as a fraction of GDP has *declined* by 60 percent in 40 years.⁷ With regard to Human Capital, it was observed that over two-thirds of the engineers who receive PhD's from United States universities are not United States citizens.⁸ And with regard to the Creative Ecosystem it was found that United States firms spend over twice as much on litigation as on research.⁹ However, the most pervasive concern was considered to be the state of United States K-12 education, which on average is a laggard among industrial economies—while costing more per student than any other OECD country.¹⁰

So where *does* America stand relative to its position of five years ago when the *Gathering Storm* report was prepared? The unanimous view of the committee members participating in the preparation of this report is that our nation's outlook has worsened. While progress has been made in certain areas—for example, launching the Advanced Research Projects Agency-Energy—the latitude to fix the problems being confronted has been severely diminished by the growth of the national debt over this period from \$8 trillion to \$13 trillion.¹¹

Further, in spite of sometimes heroic efforts and occasional very bright spots, our overall public school system—or more accurately 14,000 systems—has shown little sign of improvement, particularly in mathematics and science.¹² Finally, many other nations *have* been markedly progressing, thereby affecting America's relative ability to compete effectively for new factories, research laboratories, administrative

⁷ Federal R&D was 1.92 percent of GDP in 1964 and 0.76 percent of GDP in 2004. See: <http://www.nsf.gov/statistics/nsf10314/pdf/tab13.pdf>.

⁸ National Science Foundation, Division of Science Resources Statistics, *Survey of Earned Doctorates*. See <http://www.nsf.gov/statistics/nsf09311/pdf/tab3.pdf>.

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¹⁰ NSB, 2010, Appendix Tables 1-9, 1-10, and 1-11; and Organization for Economic Cooperation and Development, *Education at a Glance 2009: OECD Indicators*; Table B-1. See: http://www.oecd.org/document/24/0,3343,en_2649_39263238_43586328_1_1_1_37455,00.html.

¹¹ See Table 7.1, Federal Debt at the End of the Year: 1940:2015 at: <http://www.whitehouse.gov/omb/budget/Historicals/> (accessed August 23, 2010).

¹² National Center for Education Statistics, Numbers and Types of Public Elementary and Secondary Local Education Agencies, From the Common Core of Data: School Year 2007–08. See: <http://nces.ed.gov/pubs2010/2010306.pdf> (accessed August 23, 2010).

centers—and *jobs*. While this progress by other nations is to be both encouraged and welcomed, so too is the notion that Americans wish to continue to be among those peoples who do prosper.

The only promising avenue for achieving this latter outcome, in the view of the *Gathering Storm* committee and many others, is through *innovation*. Fortunately, this nation has in the past demonstrated considerable prowess in this regard. Unfortunately, it has increasingly placed shackles on that prowess such that, if not relieved, the nation's ability to provide financially and personally rewarding jobs for its own citizens can be expected to decline at an accelerating pace. The recommendations made five years ago, the highest priority of which was strengthening the public school system and investing in basic scientific research, appears to be as appropriate today as then.

The *Gathering Storm* Committee's overall conclusion is that in spite of the efforts of both those in government and the private sector, the outlook for America to compete for quality jobs has further deteriorated over the past five years.

The *Gathering Storm* increasingly appears to be a Category 5.

A Few Factoids

Thirty years ago, ten percent of California's general fund went to higher education and three percent to prisons. Today, nearly eleven percent goes to prisons and eight percent to higher education.¹

China is now second in the world in its publication of biomedical research articles, having recently surpassed Japan, the United Kingdom, Germany, Italy, France, Canada and Spain.²

The United States now ranks 22nd among the world's nations in the density of broadband Internet penetration and 72nd in the density of mobile telephony subscriptions.³

In 2009, 51 percent of *United States* patents were awarded to non-United States companies.⁴

The World Economic Forum ranks the United States 48th in quality of mathematics and science education.⁵

Of Wal-Mart's 6,000 suppliers, 5,000 are in China.⁶

There are sixteen energy companies in the world with larger reserves than the largest United States company.⁷

IBM's once promising PC business is now owned by a Chinese company.⁸

The legendary Bell Laboratories is now owned by a French company.⁹

Hon Hai Precision Industry Co. (computer manufacturing) employs more people than the worldwide employment of Apple, Dell, Microsoft, Intel and Sony combined.¹⁰

No new nuclear plants and no new petroleum refineries have been built in the United States in a third of a century, a period characterized by intermittent energy-related crises.¹¹

Only four of the top ten companies receiving United States patents last year were United States companies.¹²

United States consumers spend significantly more on potato chips than the government devotes to energy R&D.¹³

The world's largest airport is now in China.¹⁴

In 2000 the number of foreign students studying the physical sciences and engineering in United States graduate schools for the first time surpassed the number of United States students.¹⁵

Federal funding of research in the physical sciences as a fraction of GDP fell by 54 percent in the 25 years after 1970. The decline in engineering funding was 51 percent.¹⁶

GE has now located the majority of its R&D personnel outside the United States.¹⁷

Manufacturing employment in the U.S. computer industry is now lower than when the first personal computer was built in 1975.¹⁸

In the 2009 rankings of the Information Technology and Innovation Foundation the U.S. was in sixth place in global innovation-based competitiveness, but ranked 40th in the rate of change over the past decade.¹⁹

China has now replaced the United States as the world's number one *high-technology* exporter.²⁰

In 1998 China produced about 20,000 research articles, but by 2006 the output had reached 83,000 . . . overtaking Japan, Germany and the U.K.²¹

Eight of the ten global companies with the largest R&D budgets have established R&D facilities in China, India or both.²²

During a recent period during which two high-rise buildings were constructed in Los Angeles, over 5,000 were built in Shanghai.²³

In a survey of global firms planning to build new R&D facilities, 77 percent say they will build in China or India.²⁴

China has a \$196 billion positive trade balance. The United States' balance is negative \$379 billion.²⁵

Sixty-nine percent of United States public school students in fifth through eighth grade are taught mathematics by a teacher without a degree or certificate in mathematics.²⁶

Ninety-three percent of United States public school students in fifth through eighth grade are taught the physical sciences by a teacher without a degree or certificate in the physical sciences.²⁷

Of the Big Three American automakers, one is now owned by a firm in Italy (after having been previously sold by a German firm), and another is 60 percent owned by the United States government.²⁸

The United States ranks 27th among developed nations in the proportion of college students receiving undergraduate degrees in science or engineering.²⁹

Forty-nine percent of United States adults do not know how long it takes for the Earth to revolve around the Sun.³⁰

The United States graduates more visual arts and performing arts majors than engineers.³¹

The total *annual* federal investment in research in mathematics, the physical sciences and engineering is now equal to the *increase* in United States healthcare costs every nine weeks.³²

Bethlehem Steel marked its 100th birthday by declaring bankruptcy.³³

The United States ranks 20th in high school completion rate among industrialized nations and 16th in college completion rate.³⁴

In less than 15 years, China has moved from 14th place to second place in published research articles (behind the United States).³⁵

China's real annual GDP growth over the past thirty years has been 10 percent.³⁶

According to OECD data the United States ranks 24th among thirty wealthy countries in life expectancy at birth.³⁷

For the next 5-7 years the United States, due to budget limitations, will only be able to send astronauts to the Space Station by purchasing rides on Russian rockets.³⁸

The average American K-12 student spends four hours a day in front of a TV.³⁹

China's Tsinghua and Peking Universities are the two largest suppliers of students who receive PhD's—in the United States.⁴⁰

Sixty-eight percent of U.S. state prison inmates are high school drop-outs or otherwise did not qualify for a diploma.⁴¹

The United States has fallen from first to eleventh place in the OECD in the fraction 25-34 year olds that has graduated high school. The older portion of the U.S. workforce ranks first among OECD populations of the same age.⁴²

When MIT put its course materials on the worldwide web, over half of the users were outside the United States.⁴³

Six of the ten best-selling vehicles in the United States are now foreign models.⁴⁴

Since 1995 the United States share of world shipments of photovoltaics has fallen from over 40 percent to well under 10 percent—while the overall market has grown by nearly a factor of one hundred.⁴⁵

Among manufacturers of photovoltaics, wind turbines and advanced batteries, the top ten global firms by market capitalization include two, one and one United States firms, respectively. The other firms are from China, Denmark, France, Germany, India, Spain, Taiwan and the U.K.⁴⁶

An American company recently opened the world's largest private solar R&D facility . . . in Xian, China.⁴⁷

By 2008, public spending in the United States on energy R&D had declined to less than half what it was three decades ago in real purchasing power. By 2005, private investment had declined to less than one-third of the total.⁴⁸

A single Japanese automobile model constitutes about half of the U.S. hybrid market.⁴⁹

Last year Mitsubishi introduced the world's first mass-produced all-electric car.⁵⁰

A Japanese company produces over 75 percent of the world's nickel-metal hydride batteries used in vehicles.⁵¹

Japan has 1524 miles of high speed rail; France has 1163; and China just passed 742 miles. The United States has 225. China has 5612 miles now under construction and one plant produces 200 trains each year capable of operating at 217 mph. The United States has none under construction.⁵²

Roughly half of America's outstanding public debt is now foreign-owned—with China the largest holder.⁵³

The increase in cost of higher education in America has substantially surpassed the growth in family income in recent decades. United States current and former students have amassed \$633 billion in student loan debt.⁵⁴

There are 60 new nuclear power plants currently being built in the world. One of these is in the United States.⁵⁵

In 2008, 770,000 people worked in the United States correction sector, a number which is projected to grow. During the same year there were 880,000 workers in the entire United States automobile manufacturing sector.⁵⁶

Between 1996 and 1999, 157 new drugs were approved in the United States. In a corresponding period ten years later the number dropped to 74.⁵⁷

All the National Academies *Gathering Storm* committee's recommendations could have been fully implemented with the sum America spends on cigarettes each year—with \$60 billion left over.⁵⁸

Youths between the ages of 8 and 18 average seven-and-a-half hours a day in front of video games, television and computers—often multi-tasking.⁵⁹

In 2007 China became second only to the United States in the estimated number of people engaged in scientific and engineering research and development.⁶⁰

In January 2010, China's BGI made the biggest purchase of genome sequencing equipment ever.⁶¹

In May 2010, a supercomputer produced in China was ranked the world's second-fastest.⁶²

Almost one-third of U.S. manufacturing companies responding to a recent survey say they are suffering from some level of skills shortages.⁶³

According to the ACT College Readiness report, 78 percent of high school graduates did not meet the readiness benchmark levels for one or more entry-level college courses in mathematics, science, reading and English.⁶⁴

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Rapidly Approaching Category 5

By Members of the 2005 “Rising Above the Gathering Storm” Committee

Prepared for the Presidents of the

National Academy of Sciences

National Academy of Engineering

Institute of Medicine

NATIONAL ACADEMY OF SCIENCES,
NATIONAL ACADEMY OF ENGINEERING, *AND*
INSTITUTE OF MEDICINE
OF THE NATIONAL ACADEMIES

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THE NATIONAL ACADEMIES

Advisers to the Nation on Science, Engineering, and Medicine

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2005 “RISING ABOVE THE GATHERING STORM” COMMITTEE MEMBERS PARTICIPATING IN “THE GATHERING STORM, REVISITED”¹

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CRAIG BARRETT [NAE] is retired chairman and CEO of Intel Corporation.

GAIL CASSELL [IOM] is vice president for scientific affairs and a Distinguished Lilly Research Scholar for Infectious Diseases at Eli Lilly and Company. She is the former president of the American Society for Microbiology and former member of the Food and Drug Administration Science Board and Advisory Committees to the Director of the National Institutes of Health and the Center for Disease Control.

NANCY GRASMICK is the Maryland state superintendent of schools.

CHARLES HOLLIDAY JR. [NAE] is the retired chairman of the Board and CEO of DuPont.

SHIRLEY ANN JACKSON [NAE] is president of Rensselaer Polytechnic Institute. She is a past president of the American Association for the Advancement of Science and was chairman of the U.S. Nuclear Regulatory Commission.

ANITA K. JONES [NAE] is University Professor Emerita at the University of Virginia. She served as director of defense research and engineering at the U.S. Department of Defense and was vice-chair of the National Science Board.

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C. D. (DAN) MOTE JR. [NAE] is president emeritus of the University of Maryland and the Glenn L. Martin Institute Professor of Engineering.

¹Additional members of the 2005 Committee:

STEVEN CHU [NAS], a Nobel Laureate in physics, is currently serving as U.S. Secretary of Energy.

ROBERT GATES, former president of Texas A&M University, is currently serving as U.S. Secretary of Defense.

JOSHUA LEDERBERG [NAS], recipient of the Nobel Prize in physiology/medicine, passed away on February 2, 2008.

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RICHARD N. ZARE [NAS] is the Marguerite Blake Wilbur Professor of Natural Science at Stanford University. He was chair of the National Science Board from 1996 to 1998.

“Gentlemen, we have run out of money. It is time to start thinking.”

Sir Ernest Rutherford, Nobel Laureate (Physics)

Foreword

We are pleased to present this report authored by members of the committee that produced the 2005 report, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*.¹ We requested this new report to get the perspective of the original committee on progress and change since the 2005 report.

BACKGROUND

Rising Above the Gathering Storm was prepared in response to a request by a bipartisan group of Senators and Members of Congress who asked the National Academies 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?*²

These questions were posed in the context of rapid and deep changes in the global economy, investment patterns, advancing science and technology, and the global redistribution of skilled workforces, education, and innovation-driven industries. Moreover, there was widespread unease about long-term trends in U.S. investments in research, develop-

¹ NAS/NAE/IOM, *Rising above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, National Academies Press, 2007. The initial report release was in 2005, with the final, edited book issued in 2007.

² Letters from Senators Jeff Bingaman and Lamar Alexander, dated May 27, 2005, and Congressmen Sherwood Boehlert and Bart Gordon, to NAS President Bruce Alberts.

PREFACE

ment and higher education, and special and deepening concern about the competitiveness of U.S. businesses and the state of the primary and secondary education attained by vast numbers of our children. *Rising Above the Gathering Storm* was drafted by a group of 20 distinguished Americans including then current or former corporate CEOs; university presidents; scientists, including three Nobel Laureates; philanthropists, former government officials; and education leaders.³ Norman R. Augustine, retired CEO of Lockheed Martin and former Under Secretary of the Army, chaired the committee. A vast relevant literature was reviewed, updated, and summarized; a diverse group of 66 stakeholders was convened to help frame and contextualize the issues; and the committee formed consensus on its recommendations. Peers drawn from many relevant backgrounds and experiences reviewed the report prior to its release.

The original report informed the debate in Congress and within two presidential administrations, and, together with other reviews of America's competitive position and innovation environment, led to the passage with strong bipartisan support of the America COMPETES Act of 2007⁴ that has formed the basis for debating and structuring federal policy and budgets, and prompted a great deal of activity at local, state, and regional levels as well.

THE CURRENT REVIEW

In the five years that have passed since *Rising Above the Gathering Storm* was issued, much has changed in our nation and world. Despite the many positive responses to the initial report, including congressional hearings and legislative proposals, America's competitive position in the world now faces even greater challenges, exacerbated by the economic turmoil of the last few years and by the rapid and persistent worldwide advance of education, knowledge, innovation, investment, and industrial infrastructure. Indeed the governments of many other countries in Europe and Asia have themselves acknowledged and aggressively pursued many of the key recommendations of *Rising Above the Gathering Storm*, often more vigorously than has the U.S. We also sense that in the face of so many other daunting near-term challenges, U.S. government and industry are letting the crucial strategic issues of U.S. competitiveness slip below the surface.

³ The Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology was authorized under the auspices of the NAS/NAE/IOM Committee on Science, Engineering, and Public Policy (COSEPUP). Its overall charge was to address cross-cutting issues in science and technology policy that affect the health of the national research enterprise.

⁴ America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science Act, Public Law 110-69, August 9, 2007.

For these reasons, we believed that the nation would be well served by an update of the global context and events since the original report. We therefore asked Mr. Augustine, assisted by National Academies staff, to prepare a first draft of this update document and then work with the available members of the original committee to refine it. Each of the available members of the committee generously agreed to do so as a matter of national service. The resulting report was then anonymously peer reviewed by ten individuals with a wide range relevant expertise and experience. The results of this process are reported herein and have the unanimous support of the available members of the 2005 committee.⁵

As presidents of the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, we are pleased to convey this report to interested readers. We believe that it will serve to inform the public and policy makers, rekindle and advance an urgent national dialogue, and stimulate further strong and sustained bipartisan effort to ensure the future competitiveness, innovation capacity, economic vitality, and job creation in the opening decades of this century.

Ralph J. Cicerone
President, National
Academy of Sciences

Charles M. Vest
President, National
Academy of Engineering

Harvey V. Fineberg
President, Institute
of Medicine

⁵ One member, Joshua Lederberg, is now deceased. Steven Chu is currently serving as U.S. Secretary of Energy and Robert Gates is currently serving as U.S. Secretary of Defense and therefore they could not participate.

PREFACE

During the summer of 2005, the National Academy of Sciences, the National Academy of Engineering and the Institute of Medicine undertook a study of America's evolving competitiveness in the global economy. The study resulted in a 500-page volume that became known as the "*Gathering Storm*" report. It focused upon the ability of Americans to compete for employment in a job market that increasingly knows no geographic boundaries.

The Executive Summary of the original report began, "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." But the report concluded that, "Without a renewed effort to bolster the foundations of our competitiveness, we can expect to lose our privileged position." Contained in the initial report were twenty specific actions that were intended to help assure that America could in fact remain competitive.

Five years have passed since the initial report was prepared, a period in which a great deal has changed...and a great deal has not changed. The recommendations included several actions that relate specifically to the physical sciences and engineering. Reflecting evolving federal budget priorities, the present report also briefly considers the biological sciences, which after a period of growth have begun to see their funding erode. This document, unanimously approved by participating members of the original *Gathering Storm* committee, revisits and updates the earlier findings.

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