

Scientific and Technological Innovation Challenges for the 21st Century

For society and government, developments in science and technology present great opportunities to improve the quality of life, the performance of the economy and the government, and the relationship of government to its citizens. Advances in science and technology in the United States have historically been fueled by combined public and private sector research and development investments of about \$284 billion annually. These investments, along with the nation's strong research and development infrastructure and intellectual property protections, have long ensured the United States a leadership position in the development and commercialization of scientific advances and have helped nurture entrepreneurship and dissemination of information on new technologies. The benefits of applying technological innovation, such as information technology, in the United States, have not only resulted in many positive outcomes but have also presented many new challenges, concerns, and vulnerabilities.

The following challenges and illustrative questions provide a framework for thinking about these issues in the future.

As the pace of innovation has quickened over the past 30 years, competition in the global economy has also accelerated and other nations are increasingly gaining in their ability to commercialize technological advances, educate highly skilled technical workforces, and offer world-class research opportunities to the best and brightest minds. These strides in global scientific and technological innovation are beginning to challenge the United States' preeminent position.

▶ *How can the federal government develop a more coordinated and targeted approach to setting the U.S. research agenda that also ensures the best return on investment? For example, can the current patchwork of federal investments in scientific research provided by multiple agencies and programs be integrated or better coordinated to more effectively and efficiently identify and prioritize critical emerging technologies?*

▶ *Are different kinds of federal incentives needed to encourage greater private sector collaboration and nurture interdisciplinary research and development approaches that can enhance U.S. competitiveness and productivity? For*

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example, does the current research tax credit actually stimulate private sector research spending that would not have occurred otherwise? Are the types of research being done by businesses that claim most of the tax credit enhancing U.S. competitiveness and productivity?

▶ *Can existing program structures and funding processes maintain the nation's position as a critical collaborator in jointly funded international scientific research and ensure that the United States can continue to attract global investments in new technologies? For example, how can the U.S. nanotechnology research and development effort effectively collaborate with global nanotechnology research and development efforts without compromising the nation's intellectual property or competitiveness?*

Compounding these external challenges are domestic demographic and educational changes that have reduced the size and quality of the U.S. scientific workforce, such as the lagging performance of U.S. students in science, math, and engineering; the large numbers of U.S. scientists reaching retirement age; and reduced numbers of foreign-born scientists and researchers coming to the United States because of heightened security concerns and opportunities in other nations.

▶ *How can the United States better develop a world-class technical and scientific domestic workforce that is not as dependent on large inflows of international students and researchers? For example, are different educational tools or targeted funding strategies needed to enhance U.S. student achievements in math and the sciences?*

▶ *Do current workforce retraining programs provide adequate incentives to help the United States develop lifelong learning strategies and proactive training programs that will meet the needs of a rapidly changing technological environment? For example, should the federal government consider providing training tax credits to employers or individuals so that U.S. workers can obtain the training they need to stay current in a knowledge-based economy?*

Information technology advancements have contributed to substantial gains in U.S. productivity, opened the workforce to people who were previously barred because of physical disabilities or geographic distances, and have begun to alter the way citizens

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interact with their government. However, interconnectivity has also raised the potential for unauthorized access to personal and confidential data and created new vulnerabilities to the nation's critical operations and the infrastructures they support.

▶ *How can the federal government effectively utilize advanced technologies to further enhance homeland security while also protecting the privacy of U.S. citizens? For example, should the federal government encourage states to use biometric technologies that could help ensure that drivers licenses are issued only to authorized and authenticated individuals?*

▶ *What cybersecurity technologies can be applied to protect critical infrastructures from attack given current threat assessments and what implementation challenges, such as effective information sharing among key public and private stakeholders, will have to be addressed?*

Similarly, despite many successes in the exploration of space, the loss of life, unsuccessful missions, and unforeseen cost overruns have recently increased the level of concern over the benefits of such exploration, particularly with regard to human space flight activities. Since its inception, the National Aeronautics and Space Administration (NASA) has undertaken programs that have greatly advanced scientific and technological knowledge. However, a painful symbol of the difficult environment in which NASA must perform its mission, as well as the risks associated with human space exploration, is the recent loss of Shuttle Columbia and its crew. The complexities NASA faces in returning the remaining three shuttles to flight so that construction can resume on the International Space Station and the debate over the potential cost and the federal government's role in implementing the administration's vision for space exploration are emblematic of the challenges the nation will need to resolve in the years ahead.

▶ *What objectives are both appropriate and affordable for the U.S. space program? For example, can all existing programs continue to be effectively implemented at current resource levels and without substantial involvement by the private sector?*