Graduate Education

The Backbone of American Competitiveness and Innovation

COUNCIL OF GRADUATE SCHOOLS

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A report from the
Council of Graduate Schools
Advisory Committee on
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Executive Summary

It is tempting to be complacent about the future of American competitiveness. The United States is the world's largest economy and our higher education system is the envy of the world. As the home of Google, Genentech, and other path-breaking enterprises, we are known for our innovation and creativity. Our investments in scientific research have produced products and processes that have improved prosperity and national security.

But as our world flattens, we face new and growing competition. We can no longer take for granted America's continued leadership in innovation and competitiveness. We face the risk of losing the highly trained workforce that is essential to maintain our economic leadership. The warning signals are there. For example, as reported by the National Science Foundation (NSF),[i] the number of scientific papers published by Americans has fluctuated around a constant number over the past decade. Meanwhile the number of scientific papers published in other countries has grown by over 30 percent. U.S. scientific and technological leadership has until now been assured by the combination of graduate programs unparalleled in excellence and the steady supply of the world's most talented students. However, other countries are significantly increasing their investments in graduate education and attracting top students.

"We can no longer take for granted America's continued leadership in innovation and competitiveness."

This report—*Graduate Education: The Backbone of American Competitiveness and Innovation*—urges policymakers, business leaders, and higher education officials to unite together in making the investments necessary to enhance U.S. innovation and national security through stronger support for and attention to graduate education.

A highly trained workforce is essential to America's future economic competitiveness and national security. Graduate education, a vital part of the U.S. education system, must be strengthened as part of a national strategy on innovation and competitiveness. The work of graduate students contributes directly to our sustained economic growth and prosperity. Graduate students conduct groundbreaking research in universities, national laboratories, and private industry.

This report provides a framework of graduate education policies that will enhance U.S. competitiveness. It specifically addresses the role of graduate education in ensuring that the knowledge creators and innovators of tomorrow have the cultural awareness, skills, and expertise to compete effectively in a knowledge-based global economy. It provides an analysis of accomplishments, areas for improvement, and associated recommendations. The action agenda that follows is designed to strengthen U.S. competitiveness and innovation

through a renewed commitment to graduate education. The program includes the following:

Develop a highly skilled workforce by fostering collaboration among leaders in higher education, business, and government

The role of universities:

- Encourage graduate schools to urge their students to become citizen scholars by using their knowledge and skills in a real-world setting to gain scholarship and experience through service to the community, the state, the nation and the world
- Identify successful models that incorporate entrepreneurship across graduate curricula, as well as future directions for exploring the power of entrepreneurship in graduate education
- Provide more opportunities for doctoral students to evaluate the entire range of career options in various nonacademic settings, so that they can make sound career choices and successfully prepare for and pursue nonacademic careers
- Continue to expand innovative professional master's degrees in order to address pressing national needs in such critical fields as mathematics, science, engineering, social sciences, and humanities
- Continue to provide exposure to the array of roles and responsibilities graduate students face as part of the professoriate of the 21st century
- Broaden awareness of the risks associated with underfunding graduate education and the impact on innovation and national security.

The role of business leaders:

- Urge support for new federal legislation that authorizes funding for professional master's programs as an important component in building the nation's innovation infrastructure
- Engage in collaborative ventures with graduate schools
- Broaden awareness of the risks associated with underfunding graduate education and the impact on innovation and national security
- Adopt hiring practices that offer interdisciplinary thinkers a "home" to commercialize their abilities
- Expand career tracks that link promotion and advancement to risk-taking basic research, particularly among technical employees. Develop reward systems for team contributions and promote individuals who want to pursue interdisciplinary projects.

The role of policymakers:

- Provide support for students at both the master's and doctoral levels in science, technology, engineering, and mathematics (STEM) fields, including social sciences, as well as disciplines that foster global understanding of languages and culture
- Increase federal funds for graduate education programs by at least 10 percent at every agency
- Fashion graduate support and research programs to reward creativity and risk-taking as a key component of a U.S. strategy on innovation.

Expand participation of underrepresented groups in all fields, especially those essential to American competitiveness and national security

The role of universities:

- Develop more effective strategies to increase diversity in higher education, with particular attention to the programs that link national security and economic competitiveness
- Initiate new and expand existing scholarship programs to attract more underrepresented students into STEM fields
- Identify "best practices" in reducing attrition and shortening time required to receive a degree; this information should be promulgated throughout the graduate education community
- Develop personnel policies and provide resources to enable students, particularly women, to pursue challenging STEM careers while meeting family responsibilities.

The role of business leaders:

- Emphasize the contributions of a diverse workforce for economic competitiveness and national security.

The role of policymakers:

- Create incentives for students, particularly underrepresented groups, to pursue graduate education in STEM fields, social sciences, and humanities, through portable and competitive fellowships and traineeships, loan forgiveness, and other measures
- Create a program, funded by H-1B visa program revenues, to encourage U.S. domestic students to pursue graduate education in key areas of national need that are at the cutting-edge of new markets
- Identify strategies and funding mechanisms that will encourage more women and underrepresented groups in STEM fields to advance to leadership positions.

Create a vision for all U.S. students that careers in the STEM fields can be engaging, compelling, transparent and remunerative

The role of universities:

- Identify strategies to increase interest in STEM graduate education among U.S. students
- Enhance undergraduate and graduate programs by continuing to develop new pathways to STEM careers that link education outcomes to workforce needs.

The role of business leaders:

- Increase efforts to raise public awareness about the challenges to American competitiveness and security and the need for highly skilled workers in science, technology, social sciences, and humanities
- Acknowledge and publicize the contributions of STEM practitioners and their impact on our lives. Find ways to recognize individual scientists and engineers in the U.S. and international media
- Develop more effective partnerships with universities and state governments that will encourage the best and the brightest to continue in STEM careers.

The role of policymakers:

- Create policy incentives to encourage technical staff scientists and engineers to volunteer in local schools to promote STEM education and mentor students.

Produce a highly educated workforce with advanced skills and the flexibility to compete in an interdisciplinary environment at the frontier of knowledge creation

The role of universities:

- Build management structures that encourage inter-program as well as cross-program collaboration
- Develop budget structures that foster links between interdisciplinary research programs and graduate curricula.

The role of business leaders:

- Embrace job applicants who are graduates of innovative programs designed to respond to the needs of the 21st century workforce
- Enhance communication with graduate schools to clearly convey employer needs in the 21st century economy.

The role of policymakers:

- Expand models pioneered by NSF and the National Institutes of Health (NIH), such as the Integrative Graduate Education and Research Traineeship (IGERT) program and the interdisciplinary grant program at NIH, to address the impact of graduate education and research on advancing knowledge in cutting-edge fields in support of U.S. competitiveness
- Dedicate a percentage of federal research agency budgets to programs that focus on new frontiers in research

- Institute an R&D tax credit to encourage private investment in innovative research
- Provide tax credits to employers so that practicing scientists and engineers can participate in career-long learning and retrain for new job markets.

Attract and retain the best and brightest students from around the world

The role of universities:
- Continue to work with the federal government to make the visa process more efficient so that international students, scholars, and STEM workers can enter the United States in a timely and efficient manner
- Utilize alumni programs to maintain relationships with international graduates who return to their home countries.

The role of business leaders:
- Emphasize the contributions of highly skilled international workers to local, regional, and national economies.

The role of policymakers:
- Continue to improve the visa process so that the pathway for international students, scholars, and STEM practitioners is made more efficient, allowing them to contribute to America's leadership and global competitiveness
- Create clear pathways to permanent residency for top international students and scholars by reforming immigration policies. For example, a proposed new visa category for doctoral students and scholars was included in various immigration bills last year
- Maintain "deemed export" policies that do not inappropriately constrain international students' ability to pursue graduate research.

Enhance the quality of graduate education through ongoing evaluation and research

The role of universities:
- Actively engage in the National Research Council's Assessment of Research Doctoral programs, a major national effort to develop benchmarks to ensure the quality of graduate education
- Continue to use information generated through the Council of Graduate Schools' Ph.D. Completion Project, which aims to assess completion rates in doctoral education and disseminate best practices to higher education officials.

The role of business leaders:
- Support risk-taking research programs that prepare individuals for employment in a knowledge-based global economy.

The role of policymakers:
- Use information from studies assessing the quality and accountability of graduate education.

America's success as the world's economic leader is rooted in our impressive graduate education system. Strengthened support in key fields at the graduate level is critical to maintaining our competitive edge and ensuring the security of all U.S. citizens. As MIT economist Lester Thurow wrote nearly 15 years ago, "in the 21st century, the education and skills of the workforce will end up being the dominant competitive weapon."[ii]

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i National Science Foundation, *Science and Engineering Indicators 2006*, *Appendix Tables*. Washington, DC.

ii Thurow, Lester. 1993. *Head to Head: The Coming Economic Battle Among Japan, Europe, and America*. St. Leonards, NSW: Allen & Unwin.

Overview

This report calls on policymakers, business leaders, and higher education officials to unite together in making the investments necessary to enhance U.S. innovation and national security in the 21st century. Graduate education prepares the knowledge creators and innovators of tomorrow with the skills, expertise, and cultural awareness needed to compete effectively in the knowledge-based global economy. The work of graduate students contributes directly to sustained economic growth, prosperity, and national security. Up to now, these contributions have been sustained by innovation and a dedication to excellence within each sector, and piecemeal collaborations between sectors. This report expresses the belief that while this approach has been effective in meeting the short-term goals of each sector, it is no longer adequate to meet the long-term challenges our nation faces in the 21st century global economy. Graduate education is a vital part of the U.S. education system, which must be nurtured and strengthened as part of a national strategy on innovation and competitiveness.

"Graduate education is a vital part of the U.S. education system…"

The risks to maintaining our competitive position in science, technology, engineering, and mathematics (STEM) have been widely noted. For example, as reported by the National Science Foundation (NSF),[1] the number of scientific papers published by Americans has fluctuated around a constant number over the past decade. Meanwhile the number of scientific papers published in other countries has grown by over 30 percent. U.S. scientific and technological leadership has until now been assured by the combination of graduate programs unparalleled in excellence and the steady supply of the world's most talented students. However, other countries are significantly increasing their investments in graduate education and attracting top students. To use Pulitzer Prize-winning journalist Thomas Friedman's phrase, this new competition promises to flatten the world in ways that we can only begin to imagine and with profound implications for our nation's economic future.

The STEM fields have received the lion's share of attention in recent years because of their immediate impact on U.S. competitiveness. But the social sciences, humanities, and arts are also critically important to our nation's long-term competitiveness and intellectual security: they are vital for innovation and problem solving within our communities, regions, and states, as well as nationally and globally. Some argue that national economic competitiveness in the future will depend on a "creative class" of knowledge workers who exhibit not just the mastery of a subject area, but the creative ability and drive to reshape the boundaries of knowledge and navigate between geocultural boundaries. As globalization makes geography matter less and technology matter more, those workers with "high concept" and "high touch" abilities will become increasingly valuable.[2]

U.S. graduate programs develop students with creative and problem solving skills and an ability to traverse through different cultures and communities in subjects as diverse as bioinformatics, physics, anthropology, and foreign languages. Today's employers highly value such intellectual skills. It is these skills that will enable the United States to remain competitive in the global economy. The nurturing of these traits in U.S. graduate programs will also enable us to protect our national security, whether from political forces, diseases, or natural disasters.

Recent reports have enumerated the multiple threats to future U.S. competitiveness and have proposed specific recommendations for improvement. *Innovate America* (2005), by the Council on Competitiveness, and *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (2005), from the National Academy of Sciences (NAS), include recommendations to strengthen U.S. graduate education, particularly in STEM fields. *Rising Above the Gathering Storm*, for example, recommends that we renew our efforts to make the United States an attractive place to study and perform research, so that we can continue to develop, recruit, and retain the best and brightest students, scientists, and engineers from both the United States and around the world.

"Many…have expressed serious concerns about the capacity of our nation to compete in the 21st century."

For decades, both American and international students have considered the United States the destination of choice for graduate study and subsequent employment, but there is evidence that this perception is changing. As other countries and regions around the world strengthen their efforts to recruit international students and retain their own top talent, international students are pursuing career options abroad after completing their U.S. graduate studies. In addition, even the best international students trained in the United States face increasing pressures to return to their home countries.

Reacting to these and other reports, many stakeholders have expressed serious concerns about the capacity of our nation to compete in the 21st century. The Council of Graduate Schools, representing more than 480 universities in the United States and Canada, first delineated the graduate education dimension of the challenge to America's competitiveness and innovation in a white paper released in 2005. Drawing on the original National Defense Education Act, *NDEA 21: A Renewed Commitment to Graduate Education* advanced guidelines to deal with this contemporary challenge and called for a comprehensive process involving leaders in private industry, government, and graduate education to generate a robust and fitting response.

The *Graduate Education and American Competitiveness Initiative*, launched in 2006, constitutes the next phase in this process. While the *NDEA 21* paper served as a springboard for some policy discussions in Congress, it focused primarily on the government's role, with limited attention to ways that universities and business leaders might contribute to ensuring the nation's competitive edge in the 21st century.

Policymakers have responded to concerns about America's competitiveness in the global economy. The America COMPETES Act (S.761), a bi-partisan initiative introduced in the U.S. Senate, would make major investments in education and innovation. This legislation recognizes the important role that graduate education plays in generating a knowledge economy and maintaining America's competitiveness. It includes support for graduate education at both the master's and doctoral levels.

Numerous proposals have also been introduced in the U.S. House of Representatives. Several of these address the role of graduate education in maintaining U.S. competitiveness and innovation, such as H.R. 363, which includes increased funding for interdisciplinary graduate education through NSF.

We are heartened by this response. But ultimate success in meeting the challenges we face depends upon two things: a strong partnership between graduate schools, corporations, and policymakers and a functioning graduate education policy network that will facilitate coordination across the three sectors to advance a prosperous future for our country.

This report, *Graduate Education: The Backbone of American Competitiveness and Innovation*, begins where the *NDEA 21* paper stopped, articulating a set of assumptions that support a policy framework addressing the role of graduate education in enhancing U.S. competitiveness. It describes current "best practices" that reflect efforts to act on these assumptions. Next, it moves to an inventory of deficits that exist in the current mix of activities in our graduate schools and in their partnerships with government and industry. Finally, it ends with a set of recommendations for future and ongoing partnerships.

The recommendations that emerge in this paper are directed to policymakers at all levels of government, as well as business and higher education leaders. They are the key stakeholders whose collaborative efforts will be needed to develop a policy network to address the critical issues in the area of American competitiveness and innovation.

Key Assumptions

Graduate Education's Role in Enhancing U.S. Competitiveness and Innovation

1 **A highly skilled workforce operating at the frontiers of knowledge creation and professional practice is key to America's competitiveness and national security. Universities, governments, and private industry each play an essential role in providing the expertise and resources necessary to achieve this objective.**

2 **The expanded participation of U.S. citizens, particularly from under-represented minority groups, should be a priority in fields that are essential to our nation's success. Development of STEM careers should be emphasized.**

3 **Interdisciplinary research preparation and education are central to future competitiveness, because knowledge creation and innovation frequently occur at the interface of disciplines.**

4 **U.S. graduate schools must be able to attract the best and brightest students from around the world.**

5 **The quality of graduate programs drives the success of America's higher education system. Efforts to evaluate and improve all aspects of the quality of the U.S. graduate education enterprise must be advanced and supported in order to foster innovation.**

A Graduate Education Policy Framework

We believe that there is general agreement on five assumptions that provide the framework for the United States to move forward. Adopting this framework will require universities, industry, and governments to engage in effective partnerships to promote future intellectual global leadership.

Although key stakeholders can point to considerable accomplishments that resonate with these assumptions, there is clearly room for improvement. We now consider each assumption individually.

1 A highly skilled workforce operating at the frontiers of knowledge creation and professional practice is key to America's competitiveness and national security. Universities, governments, and private industry each play an essential role in providing the expertise and resources necessary to achieve this objective.

What Are Some of the Promising Practices to Date?

Innovative Collaborations

Many U.S. graduate schools offer creative and innovative programs, often in collaboration and consultation with industry and government, that are specifically designed to produce the workforce we need. The workforce of the future must include people trained at the graduate level for they will be the knowledge creators and innovators of tomorrow. These future leaders must not only possess technical competence, but must also be adept at addressing social and cultural issues confronting all of us in the global economy. Linkages between graduate schools, corporations, and governments have taken many forms and involved various levels of cooperation.

In some settings, new graduate programs have been developed in response to the needs of local and regional employers. At North Carolina State University, a one-year professional Master's of Science in Analytics degree was developed to provide industry with graduates who possess both strong analytical skills and an understanding of how analytics tools are applied to solve complex problems. Two of the leading suppliers of analytics software tools and solutions, who are located in the Triangle region of North Carolina, were involved in planning the degree program. Additionally, many of the state's largest employers in other areas, ranging from banking to pharmaceuticals to information technology, are applying advanced

analytics to their operation and should welcome these graduates.

A number of research universities are collaborating with automobile, oil, gas, and electric power companies to search for new technologies to stabilize greenhouse gas emissions, as one element of addressing the consequences of global warming. At Princeton University, researchers are working on the Carbon Mitigation Initiative to develop safe, effective, and affordable ways that individuals and companies can reduce global carbon dioxide emissions. The Massachusetts Institute of Technology's Energy Laboratory joined forces with six companies to launch an industrial consortium called the Carbon Sequestration Initiative to support research on carbon sequestration, a potentially important approach to reducing greenhouse gas emissions. At Stanford University, the Global Climate and Energy Project brings together academic and industry experts to collaborate on fundamental, precommercial technology research. This long-term effort aims to develop a global energy system with low greenhouse gas emissions.

Corporations and universities are also working together to ensure that the United States is adequately prepared to deal with the nation's rapid change from a manufacturing to a service economy. This shift is creating a need for college graduates who have the knowledge and skills to address both technical and business issues in this changing environment. A new academic discipline and research area called "services science" is emerging to fill this need. Services science integrates a variety of disciplines (including engineering, information technology, social sciences, and management) to focus education and research on services. IBM is providing leadership in this area and supporting a number of such initiatives at institutions around the world. At the University of California at Berkeley, IBM is supporting a new curriculum initiative called Services Science, Management and Engineering, which is designed to prepare graduate students for careers in this emerging multidisciplinary field.

"A heightened commitment to socially relevant research may even improve the quality of graduate learning."

Creating Citizen Scholars

One of the most compelling challenges faced by research universities in the 21st century is the obligation to serve society. A 2004 NAS report called for increased commitment to interdisciplinary, socially relevant research, recognizing that today's social challenges require research solutions that challenge traditional disciplines and university structures.[3] Increased commitment to socially relevant research and to the articulation of its public benefits may not only help to leverage academe's intellectual capital to the benefit of society; it might also attract more talented U.S. students who currently choose nonacademic paths to give back to their communities and society. A heightened commitment to socially relevant research may even improve the quality of graduate learning. In the words of Benjamin Franklin, "Tell me and I forget, teach me and I may remember, involve me and I will learn."

One model for advancing socially relevant research is the intellectual entrepreneurship (IE) program pioneered at the University of Texas at Austin. Students in the program are educated to become citizen scholars by using their skills and knowledge in a real-world setting and preparing for a career in all sectors of the economy. This program differs from typical community outreach and professional development initiatives in that it emphasizes cross-disciplinary scholarship and learning. The success of the IE program at the Austin campus derives from a critical group of

faculty members who view themselves as citizen scholars—researchers who break the traditional boundaries between disciplines as well as between theoretical knowledge and the broader world.

Another innovative example is the Transformative Graduate Education (TGE) initiative introduced by the Graduate School at Virginia Tech. TGE is comprised of three overlapping components: professional development, faculty development, and the "Citizen Scholar Experience" (CSE). The CSE program provides students an opportunity to engage in public scholarship—scholarship in service to the community, the state, the nation, and the world. Community-based collaborative projects, leadership training, and global seminars prepare students to serve in varying capacities. Together, "these three components enhance the preparation of and better equip graduate students with the knowledge and skills needed for meaningful and relevant contributions in the 21st century."[4]

The advancement of public scholarship also lies behind an innovative consortium of higher education institutions committed to public scholarship through partnerships with community organizations. The *Imagining America: Artists and Scholars in Public Life* program combines the various missions of higher education, those of research, teaching, service, and public engagement. Through such initiatives, universities and colleges recognize that the work their students do in the social sciences, arts, and humanities impacts public life in a positive and meaningful way.

Similarly, the doctoral program at the University of Washington's Simpson Center Institute for the Public Humanities offers doctoral students a chance to work across disciplines as well as with the community to develop public projects in the humanities. The in-depth, weeklong course instills in students a sense of how their knowledge of the humanities can be used to contribute to civic, community-sponsored, and cultural projects of diverse sizes and purposes.

Fostering Entrepreneurship

The focus on entrepreneurship at both undergraduate and graduate levels has been gaining momentum. Entrepreneurship programs at the graduate level facilitate the knowledge creation and innovation vital to expanding America's economic prosperity. There are many outstanding examples of how structured entrepreneurship activities are now enhancing the preparation of graduate students.

Georgia Tech's Enterprise Innovation Institute and Advanced Technology Development Center (ATDC) help local and regional enterprises become more competitive through the use of science, technology, and innovation. For example, the school provides "programs that help...entrepreneurs launch and build successful companies."[5] One such company is Vivonetics, a nanotech startup company cofounded by a Georgia Tech researcher. Vivonetics was awarded a federal grant to develop and commercialize a molecular beacon used to detect and diagnose cancer and other diseases. The ATDC also works to improve the competitiveness of established companies.

"Entrepreneurship programs at the graduate level facilitate the knowledge creation and innovation vital to expanding America's economic prosperity."

Google and Genentech are two prominent examples of startup companies that emerged from the research of graduate students and faculty. In 1998, Google founders Larry Page and Sergey Brin, graduate students in computer science at Stanford University, developed a new approach to online

searches that took root in a dorm room and quickly spread to information seekers around the world. Google is now considered the world's largest search engine, easy to use, free, fast, and effective.

In 1976, venture capitalist Robert Swanson and bioscientist Herbert Boyer, a specialist in the technology known as "gene-splicing" at the University of California at San Francisco and a co-developer of recombinant DNA, founded Genentech. This company, which has continued to collaborate with the university since Dr. Boyer's retirement in 1991, exemplifies how researchers in higher education institutions and companies work cooperatively to achieve the scientific progress that contributes to advancing science, spawning new industries, and improving people's lives.

"The federal government continues to be the prime funder of academic research and development as well as the major supporter of graduate students."

Strengthening Professional Practice

The professional master's degree is a promising new initiative that is shaping graduate education in direct response to changing workforce needs in the business, nonprofit, and government sectors. In the social sciences and humanities, efforts are underway to professionalize master's programs to produce graduates with both field expertise and business skills. These social science and humanities programs include technical and professional writing, cultural resources management, conflict resolution, and health communication. In the STEM fields, the Professional Science Master's (PSM) combines advanced study with professional and interdisciplinary training. The two-year PSM degree includes four basic components: advanced science or mathematics courses which comprise approximately two-thirds of requirements; "plus" courses in business principles and other professional skills, such as written and oral communication, intellectual property, and entrepreneurship; a summer internship in a targeted employment sector; and a capstone project often done as part of an interdisciplinary team.

PSM programs are specifically designed to meet the needs of local, nonacademic employers with input from advisory boards representing the employment sector. These boards ensure that PSM programs reflect workplace needs and produce a pool of talented employees who require little or no transition time or additional training. The combination of advanced science or math, interdisciplinary exposure, and professional business skills creates highly adaptable graduates interested in innovation. As such, the PSM can serve as a model for professional stand-alone master's degrees in a wide range of fields. The Council of Graduate Schools, with support from the Alfred P. Sloan Foundation, is currently the center of an initiative to institutionalize the PSM degree as a regular feature of graduate education. Through a project funded by the Ford Foundation, CGS also actively promotes innovative professional master's programs in the humanities and social sciences.

Federal Government's Unique Role

The federal government continues to be the prime funder of academic research and development as well as the major supporter of graduate students. In fiscal year 2005, the federal government accounted for 64 percent of the $45.8 billion that universities and colleges spent on R&D activities.[6] Major investments from NIH and from various NSF programs, such as the Graduate Research Fellowship Program and the IGERT Program, support graduate education. Other federal agencies

and departments have programs that provide critical assistance to graduate students: these include the Departments of Energy, Education, Defense, Homeland Security, and State, as well as the National Oceanic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration, and the Environmental Protection Agency.

At the Department of Education, the Graduate Assistance in Areas of National Need program funds fellowships through higher education institutions for graduate studies in such areas as biology, chemistry, computer and information sciences, engineering, mathematics, nursing, and physics. The smaller Jacob K. Javits Fellowship program provides fellowships directly to graduate students and supports studies in the social sciences, arts, and humanities.

The Department of Energy's Office of Science sponsors fundamental research programs in the sciences including nanoscale science, climate change, genomics, life sciences, high energy physics, and advanced scientific computing. This office supports research at more than 300 colleges and universities nationwide. In 2006, the department funded the work of approximately 3,200 graduate students at institutions of higher education around the nation.[7]

The Department of State provides grants for both U.S. and foreign students pursuing graduate studies under the auspices of the Fulbright Student Program. The National Defense Education Program was established two years ago at the Department of Defense; it supports graduate fellowships for students entering STEM fields who commit to national service after completing their program. Other than the creation of the National Defense Education Program, there has not been a significant increase in funding for any of these programs in several years.

State Governments' Significant Contributions

Many states are seeking ways to improve higher education outcomes and productivity, despite the pressures of budgetary constraints and global competition. As a result, universities are maximizing their resources by developing partnerships, both within their own institutions and with others.

One creative, collaborative approach to setting goals for a state's public higher education system has been developed in Kentucky. The state has reframed its higher education agenda from a traditional competition between institutions to a shared one, directed at meeting statewide needs. State rather than institutional interests drive the agenda, with an overarching goal of increasing the number of college and graduate students who are prepared for future jobs.

"Some states…have issued reports calling for recognition of the value of graduate education."

Another collaborative approach is the Keystone Innovation Zone initiative in Pennsylvania, which awards grants for partnerships between communities and higher education institutions to generate job growth through technology transfer and entrepreneurship. Under this program, universities have partnered with economic development organizations, businesses, banks, foundations, and other organizations in their region.

Some states, while not yet targeting new funding for graduate program development, have issued reports calling for recognition of the value of graduate education in promoting innovation and prosperity. These include Alabama, California, Florida, Massachusetts, and Virginia.

Some partnerships link all three stakeholders—universities, corporations, and state government—together. The Center for Information Technology Research in the Interest of Society (CITRIS) at the University of California provides a "best practice" example. CITRIS is a multidisciplinary institute that uses information technology research to develop solutions to social problems. At CITRIS, more than 300 faculty and thousands of students from various departments at four University of California campuses (Berkeley, Davis, Merced, and Santa Cruz) collaborate with industrial researchers from over 60 corporations. They work on developing cutting-edge solutions to environmental and sustainable energy problems and on health care delivery, electronic security, and economic productivity. Research findings range from those that are industry-specific to those with national relevance. After four years of operation, CITRIS has built a foundation to support and deliver long-term program growth while expanding its reach to new research areas, including services science and energy and environmental monitoring; it is also growing its cadre of industrial partners.

The Private Sector's Essential Contribution

Increasingly university fundraising campaigns are turning to the private sector—specifically corporations, foundations, and individuals—and targeting graduate education as a critical area for contributions. For example, Stanford University is embarking on the largest fundraising campaign ever attempted in higher education. One of three key areas that will be addressed through the "Stanford Challenge" campaign is the enhancement of "the education of future leaders by … strengthening graduate programs."[8] The university is also raising funds to enhance interdisciplinary graduate opportunities, expand access to leadership training, and remove institutional barriers to encourage collaboration among departments.

"Increasingly university fundraising campaigns are…targeting graduate education as a critical area for contributions."

What Remains To Be Done?

- **Universities need to expand innovative collaborations with the private sector, building on best practices illustrated above.** Such collaboration must be integral to disciplinary and interdisciplinary research activity. University policies and practices should be reviewed to ensure that any barriers to creative partnerships are based upon principle and not bureaucratic traditions.

- **Universities should establish more programs to promote public scholarship and train citizen scholars, thereby changing the way people think about graduate education and the public good it can deliver.** This change in thinking is important, especially in the sciences, if we are to attract a more diverse pool of domestic students. It is also important to develop a broad-based appreciation for those disciplines that foster global understanding of language and culture so that our nation can meet the challenges of the 21st century.

- **Universities, corporate leaders, and government stakeholders must embrace the concept of the graduate student as intellectual entrepreneur.** Research and advanced problem solving are inherently entrepreneurial activities, and it is clear that entrepreneurship is a driving force in preparing the innovators of tomorrow. America's future hinges on our

capacity to generate visionary and risk-taking entrepreneurs, such as those who founded Google and Genentech.

- **All stakeholders need to expand the support for professional master's programs in key fields.** Traditionally a master's degree has been the major pathway to professional practice in the United States. In scientific fields, a master's degree has been viewed as a degree awarded "en route" to a doctorate. Instead, it should be seen as a passport to a productive and meaningful scientific career. Graduates from professional master's programs could potentially ameliorate state and regional workforce issues.

- **Despite the fiscal challenges facing federal policymakers, the federal government must continue to play a major role in building the infrastructure for and supporting graduate education and research.** Notwithstanding the federal programs highlighted above, in the absence of a clear federal commitment to make appropriate strategic investments to develop the innovation talent pool more broadly, it is unlikely that our competitive future and national security will be assured.

- **Innovations should be undertaken in every state to bring their higher education systems into full partnership with corporations and other key sectors to prepare the highly skilled workforce needed for the 21st century economy.** While states must continue to support undergraduate education, universities must be more active in informing legislators about the value of graduate education and its importance in promoting innovation and prosperity.

- **Given the constraints on federal and state budgets, the private sector should respond to universities' requests for support for innovative graduate programs.** This will require closer collaboration between graduate schools, corporations, foundations, and individuals.

2 The expanded participation of U.S. citizens, particularly from underrepresented minority groups, should be a priority in fields that are essential to our nation's success. Development of STEM careers should be emphasized.

What Are Some of the Promising Practices to Date?

The combined effects of changing U.S. demographics and global competition make it imperative that more U.S. citizens, particularly underrepresented minorities and women, be encouraged to pursue graduate education in all fields, especially those essential to our economic and national security. At the doctoral level, an increased effort must be made to expand the number of U.S. citizens earning degrees in key fields. NSF data show that in 1966 U.S. citizens earned 79 percent of the doctoral degrees in the STEM fields, but in 2005, they earned just 53 percent.[9] Within the STEM disciplines, there are vast differences by citizenship status, with temporary residents earning more than half of the doctorates in engineering, physics and computer science in 2005 (though only 6 percent of those in psychology). If the United States is to maintain its competitive edge, it is imperative that U.S. citizens from all population groups, including those who traditionally have not been highly represented, such as minorities and women, pursue STEM graduate degrees in greater numbers.

There are many exemplary programs at colleges and universities that provide models for diversifying the STEM pipeline by attracting more

students into graduate education. Among the most prominent is the Meyerhoff Scholars program at the University of Maryland, Baltimore County (UMBC). This program aims to increase the number of underrepresented students, primarily African-Americans, who pursue graduate degrees in science and engineering. While "most programs directed to minority students look at remediation and deficits…,"[10] according to UMBC President Freeman Hrabowski, the Meyerhoff Program focuses on bright and capable African-American students who aspire to become leaders in science and engineering research. Analysis of student survey and interview data has shown that each component of the program is critical to its success, including study groups, a summer bridge program, adequate financial support, and the availability of mentors and internships. Since 1993, there have been more than 450 graduates and about 60 percent have pursued advanced degrees. Currently, over 260 Meyerhoff Scholars are enrolled at the Baltimore County campus.

"The United States must find ways to nurture a broader and more diverse talent pool to be successful in the knowledge-based economy."

The Leadership Alliance, a consortium of more than 30 preeminent research and teaching academic institutions in the United States, is dedicated to expanding the participation of underserved and underrepresented minorities in master's and doctoral programs and, ultimately, research professions in the academic, public, and private sectors. The Leadership Alliance Summer Research Early Identification Program is a mentoring program offered to undergraduates at participating Alliance institutions. The program gives underserved and underrepresented students the opportunity to work for eight to ten weeks under the guidance of a faculty or research mentor. It also encourages students from traditionally underrepresented groups to consider research careers in the sciences, social sciences, and humanities.

NSF has developed four programs aimed at increasing the number of minorities participating in research and education in STEM fields: Alliances for Graduate Education and the Professoriate, the Louis Stokes Alliances for Minority Participation, the Centers for Research Excellence in Science and Technology, and the Historically Black Colleges and Universities Undergraduate Program. The objectives of the Alliances for Graduate Education and the Professoriate are "to create and implement innovative models for recruiting, mentoring, and retaining minority students in doctoral programs and to develop effective strategies for identifying and supporting underrepresented minorities who want to pursue academic careers."[11] Nationally there are approximately 30 alliances, involving more than 100 universities and colleges. The Louis Stokes Alliances program is a multidisciplinary program created to increase the quality and quantity of students receiving baccalaureate degrees in STEM fields who are qualified for either doctoral study or professional practice in STEM fields supported by NSF. The program is increasingly emphasizing student progress from baccalaureate degrees to graduate study.

The Ronald E. McNair Post Baccalaureate Achievement program is funded under Title IV of the Higher Education Act of 1965. Administered by the Department of Education, the program awards grants to more than 150 higher education institutions in the United States

and Puerto Rico. The McNair Program is designed to encourage low-income and minority undergraduate students with strong academic potential to pursue doctoral degrees and become college or university teachers.

The proportion of women choosing to pursue science and engineering careers has increased significantly over the past decade. Women continue to be underrepresented in the workforce, however, constituting about 25 percent of the total STEM workforce and less than 21 percent of the science and engineering faculty in four-year colleges and universities.[12] Women from minority groups are severely underrepresented, constituting only about two percent of science and engineering faculty in four-year colleges and universities. The goal of NSF's ADVANCE program is to increase the representation and advancement of women in academic science and engineering careers. Through these programs, NSF supports new approaches aimed at improving the environment for women in U.S. higher education institutions and promoting their participation in the highest ranks of academic leadership.

MentorNet, an award-winning nonprofit online mentoring network, addresses the retention and success primarily of women and other underrepresented groups in engineering, science, and mathematics. Since 1997, MentorNet has provided students from some of the world's top colleges and universities with an individual mentor from industry and academia, and facilitates their communication through e-mail. The MentorNet Community also fosters communications with others from around the world interested in improving diversity in engineering and science.

What Remains To Be Done?

- **Shortcomings in student financial support need to be documented and addressed.** At both the master's and doctoral levels, financial support that meets students' needs is often lacking. Research by the Council of Graduate Schools is currently attempting to document the scope of this gap, but there is no debate about its existence.

- **The structure of state and university graduate student support must be rebuilt to address gaps in student funding resulting from disparate funding mechanisms.** The support furnished by universities is typically provided through a network of different funding mechanisms, with different timelines, which may leave students without financial support for periods of time. Since state-funded stipends (typically teaching assistantships) are one of the major funding mechanisms, the recent budget constraints in many states have negatively affected graduate student aid.

- **The United States must find ways to nurture a broader and more diverse talent pool to be successful in the knowledge-based economy.** Efforts to plug the gaps between the number of underrepresented students and women who choose STEM programs in graduate schools and their current representation in the relevant population must be continued and expanded. Moreover, there are gaps in the number of students eligible to proceed to the next level of training at every stage along the STEM education pathway.

- **Universities and corporations must communicate to students the benefits and value associated with a STEM career, despite the financial obligations that may be incurred.** Many students who achieve undergraduate degrees in STEM majors leave the STEM fields at significant rates when they pursue a graduate degree. For domestic students, anecdotal evidence suggests that neither faculty nor industry has communicated the intellectual excitement or career potential for those who persist in advanced STEM studies.

3 Interdisciplinary research preparation and education are central to future competitiveness, because knowledge creation and innovation frequently occur at the interface of disciplines.

What Are Some of the Promising Practices to Date?

Advances in knowledge, together with an awareness of how modern society functions, have led researchers to tackle complex problems that a single academic discipline can no longer solve. For example, Hurricane Katrina drew national attention to the need for a much greater level of strategic collaboration not only between states, the federal government, and universities, but also across communities of knowledge within universities. Fortunately, many successful interdisciplinary graduate programs are providing innovative solutions to pressing societal problems. Increasingly, universities are partnering with corporations and government agencies to respond to the challenges that face our nation. Successful interdisciplinary graduate programs often emerge from these partnerships, which are typically housed in a research institute within the university.

"…interdisciplinary graduate programs are providing innovative solutions…"

For example, the University of Colorado at Boulder has been using the institute concept to conduct interdisciplinary, collaborative research. Currently, it has seven research institutes, including two joint institutes with federal agencies. The Cooperative Institute for Research in Environmental Sciences was established in 1967 as a partnership between NOAA and the university. Building on the success of this model, other higher education institutions have developed 12 subsequent joint institutes with NOAA. The second venture, the Joint Institute for Laboratory Astrophysics, is the result of a partnership between the University and the National Institute of Standards and Technology.

The scope of research undertaken by these institutes is vast. Often conducted with industrial partners, the projects address real-world problems, such as the discovery of the causes of the Antarctic ozone hole or the pioneering work on ultrafast lasers capable of manipulating matter at room temperatures.

Another example of the interdisciplinary research institute is the Beckman Institute for Advanced Science and Technology at the University of Illinois at Urbana-Champaign. Its mission is to "foster interdisciplinary work of the highest quality, transcending many of the limitations inherent in traditional university organizations and structures. The Institute was founded on the premise that reducing the barriers between traditional scientific and technological disciplines can yield research advances that more conventional approaches cannot."[13] We need this kind of effort to keep the United States at the top of the competitiveness ladder.

Cross-disciplinary programs at universities sometimes include partnerships with industry. One innovative program is the Ohio State University College of Engineering collaboration with the Honda Motor Company. Representatives of the university and Honda oversee the nonprofit Transportation Research Center. Surplus funds are used to support

the partnership's research and public service activities as well as provide funding for community outreach and teaching projects. Students also have the opportunity to interact with Honda's research and development staff and are able to see the real-world applications of their research.

The Materials Research Science and Engineering Centers (MRSEC) illustrate NSF's commitment to excellence in interdisciplinary research and education. MRSEC is a network of centers located at 29 major academic research institutions throughout the United States. Over the last decade, NSF has supported high quality interdisciplinary and multidisciplinary materials research and education at the centers, while addressing science and engineering problems of importance to society. MRSEC fosters active collaboration between academia and other sectors, which enables researchers to address complex and broad-ranging problems that require the scale and range of disciplines provided by a campus-based center. By collaborating with other institutions and sectors, these centers stimulate interdisciplinary education and the development of human resources, including support for underrepresented groups, beyond the host institution. Cooperative programs involving minority and nonminority institutions are strongly encouraged.

One of the most innovative federal programs developed to foster interdisciplinary research is NSF'S IGERT program. The program is organized around an interdisciplinary theme that provides a framework for integrating research and education and for promoting collaborative efforts within and across departments and institutions. These programs educate Ph.D. scientists and engineers in a specific discipline, who are also capable of operating in an interdisciplinary environment and possess skills to become leaders in academic or nonacademic environments. The programs contribute to the students' professional development, equipping them to understand and integrate scientific, technical, business, social, ethical, and policy issues to confront future challenges.

Another innovative federal program is the Interdisciplinary Research Awards established by NIH. These awards are designed to enable scientists to conduct interdisciplinary research by lowering organizational barriers that may impede such work. The awards include funding for the "training of scientists in interdisciplinary strategies; creation of specialized centers to help scientists forge new and more advanced disciplines from existing ones; supplement existing awards which encourage interdisciplinary depth for an ongoing project; planning of forward-looking conferences to catalyze collaboration among the life and physical sciences."[14] The awards also aim to change NIH policies and procedures, particularly those affecting how leadership of collaborative efforts is recognized, by promoting multiple principal investigators, rather than a single project investigator.

Finally, the PSM program, described above as a best practice in strengthening professional practice, is a promising example of interdisciplinary efforts as well. At Middle Tennessee State University, three PSM programs in biostatistics, biotechnology, and bioinformatics train students across disciplines, while ensuring they have basic scientific and mathematical expertise. Enrollment in these programs has nearly doubled in just one year. PSM graduates from the university have cross-disciplinary skills ranging from mathematics, to management and administration, to statistical analysis. Local and regional businesses, nonprofits, and governments collaborate with the university to establish internships to further develop the students' skills.

What Remains To Be Done?

- **The United States must increase the number of graduate education programs that reflect the interdisciplinary dynamism characteristic of the most innovative research centers, while sustaining the quality of core disciplines.** Financial supporters and universities must build systems that support interdisciplinary program growth and effective cross-program collaborations.

- **To meet the requirements of the 21st century, universities and federal funders must reform the administrative and reward systems to recognize the growing importance of interdisciplinary research.** Many university policies regarding the funding, staffing, and hiring for interdisciplinary activities, and some federal funding requirements, unintentionally encourage and reward only single discipline studies.

- **In the new knowledge-based economy, the need for graduates with interdisciplinary skills requires that businesses, governments, and nonprofits collaborate with universities to develop and expand professional master's programs.** These innovative programs can be adapted to different schools and regions and show clear advantages for all sectors.

- **In this interdisciplinary environment, it is essential that the three sectors collaborate to produce the future knowledge creators and innovators needed to solve increasingly complex societal problems.** The future workforce will be comprised of individuals working across disciplines to address specific technical, social, cultural, and economic issues confronting the nation in the 21st century.

4 U.S. graduate schools must be able to attract the best and brightest students from around the world.

What Are Some of the Promising Practices to Date?

The United States had long been regarded as an attractive setting in which to study and conduct research. However, in the aftermath of the 2001 terrorist attacks, the number of international students enrolling in U.S. graduate programs declined. Despite the efforts of the higher education community, a perception evolved that the United States was no longer welcoming international graduate students. Evidence of this changing perception includes a three-year decline of first-time enrollments after 9/11. However, the most recent enrollment data from the Council of Graduate Schools finds that total enrollment of international graduate students in its U.S. member institutions has made a modest recovery, increasing one percent from 2005 to 2006.[15] Since the number of international students enrolling in U.S. graduate schools, particularly in STEM fields, continues to increase—by 2005, they represented 41.2 percent of all doctorates awarded in these fields—these students are vitally important.

The United States was able to reverse the decline in international enrollment primarily because of U.S. government policy changes streamlining the visa process, the outreach efforts of graduate schools, and the growth of the pool itself. Yet global competition for the most highly qualified students is increasing rapidly. In early 2006, the United Kingdom announced a new immigration policy to attract international students and highly skilled workers. The European Union, China, India, and other countries are also enhancing their higher education systems to attract talented students to their universities. One clear sign that U.S. graduate schools have been successful is the adoption of American-style graduate education by countries and regions that are looking to graduate education as a tool for economic development.

Overall, foreign-born workers make up over a quarter of the STEM workforce in the United States. Studies conducted at Georgia State University find that foreign-born scientists have made exceptional contributions, based on indicators such as election to the National Academy of Sciences, author citations, and recognition as authors of "hot papers" and "citation classics."[16] A report from Duke University's Master of

Engineering Management Program and the University of California–Berkeley's School of Information found that "foreign nationals residing in the United States were named as inventors or co-inventors in 24.2 percent of international patent application files from the United States."[17] An example of this phenomenon is the 2007 Grainger Challenge Prize for Sustainability, which was awarded to a Bangladesh-born researcher who earned his U.S. citizenship, received his doctorate in the United States, and devoted many years to developing a water filtration system to eliminate arsenic in drinking water. This chemist, working at George Mason University, developed a system that is affordable, reliable, and will help millions of people around the world have safe drinking water.

Many stakeholders agree that international students are an asset and that without them training and research would suffer. Maintaining our leadership in research and innovation rests in part on these highly qualified international students in U.S. graduate programs. In order for the United States to continue its leadership in a competitive global economy, it must not only continue to cultivate domestic talent, but also to attract and retain the best and the brightest from around the world. However, the return of foreign students to their home countries also has positive effects as these highly educated professionals can serve as ambassadors for the United States by supporting democratic principles and building bridges for collaboration.

What Remains To Be Done?

- **The United States must continue to adopt policies that encourage international students to pursue graduate study in our country.** While the Council of Graduate Schools' research indicates evidence of modest recovery from the post-9/11 decline, it is unlikely that the United States will ever return to the days when we could assume that the most talented students worldwide would automatically select U.S. graduate schools as their first choice. Continued improvement in visa processing for international students and scholars, including visa categories and duration, will be needed.

- **The United States should use visa policies as mechanisms to actively attract talented international students to U.S. graduate programs.** Other countries use visa policies for strategic recruitment of international talent. In the United States, by contrast, all international applicants to graduate schools must indicate a commitment to return to their home country as a basic qualifying criterion for visa approval.

- **Collaborations with international students who have returned to their home countries after being educated in U.S. graduate institutions should be fostered.** U.S. policies should encourage extended collaboration and research with leaders and scholars who have completed their graduate training in the United States.

- **U.S. policy should not overly restrict graduate students' access to unclassified fundamental research.** There has been discussion of revised deemed export policies that would restrict international students' access to laboratories, even for unclassified fundamental research. While these policies to date have not been implemented, the specter of such policies can have a chilling effect on students who now have viable alternative options for pursuing advanced study.

5 The quality of graduate programs drives the success of America's higher education system. Efforts to evaluate and improve all aspects of the quality of the U.S. graduate education enterprise must be advanced and supported in order to foster innovation.

What Are Some of the Promising Practices to Date?

Quality graduate education is the essential ingredient in our country's leadership in research and innovation, and U.S. graduate programs must be sustained and enhanced. But, there is no assurance that what has worked in the past to make the United States a leader in innovation and graduate education quality will continue to serve us in the future. The content, skills, frameworks, and delivery of many graduate programs will continue to evolve to accommodate changes in the knowledge base, work demands, and technology. These changes will be assessed within the broader context of accountability in higher education. Universities are devoting more attention and resources to assessing graduate programs in terms of the extent to which they meet hard metrics of success. Quality is currently being encouraged and assessed in two highly visible national projects: the Council of Graduate Schools' Ph.D. Completion Project and the National Research Council's Assessment of Doctoral Programs.

"Universities and governments need to implement policies and practices proven to improve completion rates."

The Ph.D. Completion Project—a collaboration between the Council of Graduate Schools, Pfizer Inc., and the Ford Foundation—has provided funding to 21 major U.S. and Canadian research universities and is working with an additional 24 university partners. The project will assess the completion rates of doctoral students across a wide array of fields, create and implement interventions designed to increase completion, and evaluate the impact of these interventions. The project aims to produce the most comprehensive and useful data yet available on attrition rates for doctoral studies and completion of Ph.D. programs. The information is important since previous studies suggest that, while the majority of students who enter doctoral programs have the academic ability to complete the degree, on average only 50 to 60 percent of those who enter doctoral programs in the United States complete their degrees.[18] The Ph.D. Completion Project is one of the concrete ways in which our nation's universities are strategically working to ensure that we do not continue to waste this precious talent.

The Assessment of Research Doctoral Programs, a partnership between the National Research Council and more than 200 doctoral-training institutions in the United States, seeks to help universities use benchmarking to improve the quality of graduate programs, provide information to potential students and the public on doctoral programs nationwide, and improve our national research capacity. Previous assessments in 1983 and 1995 have provided important indicators of the quality of U.S. doctoral programs. Final data from the current assessment will be available in late 2007.

In addition to such internal assessments of the quality of graduate programs, other projects focus on how well doctoral students are being prepared for teaching careers. The Council of Graduate Schools' program on Preparing Future Faculty (PFF) is being conducted in partnership with the National Science Foundation, Pew Charitable Trusts, Atlantic Philanthropies, and the Association of American Colleges and Universities. PFF programs provide doctoral students, as well as some master's and postdoctoral students, with opportunities to observe and experience faculty responsibilities at a variety of academic institutions. One of the goals is to make research and teaching careers and graduate education more attractive by raising the caliber

of undergraduate teaching. By partnering research universities with nearby four-year and community colleges (many of whom serve populations that have been traditionally underrepresented in the graduate enterprise), PFF establishes new pathways to the graduate degree. Since its inception, PFF has served as a model of institutional partnership for numerous professional development programs. Today, PFF programs are active in more than 45 doctoral degree-granting institutions and nearly 300 partner institutions in the United States; the initiative has become a well-recognized national movement.

The quality of U.S. graduate education also depends on indicators that are less tangible than measurements of hard quantitative metrics. True quality hinges on the extent to which programs cultivate graduates with traits that are more difficult to measure, such as creativity and risk-taking. These qualities are key to advancing innovative basic research and must be integral parts of a national competitiveness strategy. A number of models illustrate these qualities, including NSF's IGERT program, NIH's interdisciplinary grant program, and the entrepreneurship activities described above.

What Remains To Be Done?

- **Universities and governments need to implement policies and practices proven to improve completion rates.** While information on key metrics of quality are currently being collected in graduate schools across the country, the capacity of graduate schools to implement effective strategies for improving and developing political support is less clear. Current efforts, such as the Ph.D. Completion Project, are yielding critical information about how institutions and funders can change policy and practices to increase completion. However, the political and organizational will to implement such sustainable policies remains untested.

- **Efforts are needed to ensure that long-term, creative, risk-taking research is a core part of the graduate curriculum.** Educating graduate students to be intellectual risk-takers, however, defies easy measurement. As companies focus increasingly on research with short-term returns on investment, the graduate school community has taken on more of the longer-term basic research. This kind of risk-taking is crucial to the success of the enterprise and key to American competitiveness.

An Action Agenda

to Strengthen U.S. Competitiveness and Innovation Through a Renewed Commitment to Graduate Education

The previous discussion and analysis identified current strengths and opportunities for improvement for the key stakeholders. The action agenda that follows offers a path forward to strengthen and revitalize U.S. competitiveness and innovation.

Develop a highly skilled workforce by fostering collaboration among leaders in higher education, business, and government

The role of universities:

- Encourage graduate schools to urge their students to become citizen scholars by using their skills and knowledge in a real-world setting to gain scholarship and experience through service to the community, the state, the nation and the world
- Identify successful models that incorporate entrepreneurship across graduate curricula, as well as future directions for exploring the power of entrepreneurship in graduate education
- Provide more opportunities for doctoral students to evaluate the entire range of career options in various nonacademic settings, so that they can make sound career choices and successfully prepare for and pursue nonacademic careers
- Continue to expand innovative professional master's degrees in order to address pressing national needs in such critical fields as mathematics, science, engineering, social sciences, and humanities
- Continue to provide exposure to the array of roles and responsibilities graduate students face as part of the professoriate of the 21st century
- Broaden awareness of the risks associated with underfunding graduate education and the impact on innovation and national security.

The role of business leaders:

- Urge support for new federal legislation that authorizes funding for professional master's programs as an important component in building the nation's innovation infrastructure
- Engage in collaborative ventures with graduate schools
- Broaden awareness of the risks associated with underfunding graduate education and the impact on innovation and national security
- Adopt hiring practices that offer interdisciplinary thinkers a "home" to commercialize their abilities
- Expand career tracks that link promotion and advancement to risk-taking basic research, particularly among technical employees. Develop reward systems for team contributions and promote individuals who want to pursue interdisciplinary projects.

The role of policymakers:

- Provide support for students at both the master's and doctoral levels in the STEM fields, including social sciences, as well as disciplines that foster global understanding of languages and culture

- Increase federal funds for graduate education programs by at least 10 percent at every agency
- Fashion graduate support and research programs to reward creativity and risk-taking as a key component of a U.S. strategy on innovation.

Expand participation of underrepresented groups in all fields, especially those essential to American competitiveness and national security

The role of universities:

- Develop more effective strategies to increase diversity in higher education, with particular attention to the programs that link national security and economic competitiveness
- Initiate new and expand existing scholarship programs to attract more underrepresented students into STEM fields
- Identify "best practices" in reducing attrition and shortening time required to receive a degree; this information should be promulgated throughout the graduate education community
- Develop personnel policies and provide resources to enable students, particularly women, to pursue challenging STEM careers while meeting family responsibilities.

The role of business leaders:

- Emphasize the contributions of a diverse workforce for economic competitiveness and national security.

The role of policymakers:

- Create incentives for students, particularly underrepresented groups, to pursue graduate education in the STEM fields, social sciences, and humanities, through portable and competitive fellowships and traineeships, loan forgiveness, and other measures
- Create a program, funded by H-1B visa program revenues, to encourage U.S. domestic students to pursue graduate education in key areas of national need that are at the cutting-edge of new markets
- Identify strategies and funding mechanisms that will encourage more women and underrepresented groups in STEM fields to advance to leadership positions.

"U.S. graduate programs must be sustained and enhanced."

Create a vision for all U.S. students that careers in the STEM fields can be engaging, compelling, transparent and remunerative

The role of universities:

- Identify strategies to increase interest in STEM graduate education among U.S. students
- Enhance undergraduate and graduate programs by continuing to develop new pathways to STEM careers that link education outcomes to workforce needs.

The role of business leaders:

- Increase efforts to raise public awareness about the challenges to American competitiveness and security and the need for highly skilled workers in science, technology, social sciences, and humanities
- Acknowledge and publicize the contributions of STEM practitioners and their impact on our lives. Find ways to recognize individual scientists and engineers in the U.S. and international media
- Develop more effective partnerships with universities and state governments that will encourage the best and the brightest to continue in STEM careers.

The role of policymakers:

- Create policy incentives to encourage technical staff scientists and engineers to volunteer in local schools to promote STEM education and mentor students.

Produce a highly educated workforce with advanced skills and the flexibility to compete in an interdisciplinary environment at the frontier of knowledge creation

The role of universities:

- Build management structures that encourage inter-program as well as cross-program collaboration
- Develop budget structures that foster links between interdisciplinary research programs and graduate curricula.

The role of business leaders:

- Embrace job applicants who are graduates of innovative programs designed to respond to the needs of the 21st century workforce
- Enhance communication with graduate schools to clearly convey employer needs in the 21st century economy.

The role of policymakers:

- Expand models pioneered by NSF and NIH, such as the IGERT and interdisciplinary grant programs, to address the impact of graduate education and research on advancing knowledge in cutting-edge fields in support of U.S. competitiveness
- Dedicate a percentage of federal research agency budgets to programs that focus on new frontiers in research
- Institute an R&D tax credit to encourage private investment in innovative research
- Provide tax credits to employers so that practicing scientists and engineers can participate in career-long learning and retrain for new job markets.

Attract and retain the best and brightest students from around the world

The role of universities:

- Continue to work with the federal government to make the visa process more efficient so that international students, scholars, and STEM workers can enter the United States in a timely and efficient manner
- Utilize alumni programs to maintain relationships with international graduates who return to their home countries.

The role of business leaders:

- Emphasize the contributions of highly skilled international workers to local, regional, and national economies.

The role of policymakers:

- Continue to improve the visa process so that the pathway for international students, scholars, and STEM practitioners is made more efficient, allowing them to contribute to America's leadership and global competitiveness
- Create clear pathways to permanent residency for top international students and scholars by reforming immigration policies. For example, a proposed new visa category for doctoral students and scholars was included in various immigration bills last year
- Maintain "deemed export" policies that do not inappropriately constrain international students' ability to pursue graduate research.

Enhance the quality of graduate education through ongoing evaluation and research

The role of universities:

- Actively engage in the National Research

Council's Assessment of Research Doctoral programs, a major national effort to develop benchmarks to ensure the quality of graduate education

- Continue to use information generated through the Council of Graduate Schools' Ph.D. Completion Project, which aims to assess doctoral studies' completion rates and disseminate best practices to higher education officials.

The role of business leaders:

- Support risk-taking research programs that prepare individuals for employment in a knowledge-based global economy.

The role of policymakers:

- Use information from studies assessing the quality and accountability of graduate education.

Conclusion

For much of the 20th century, the United States enjoyed the benefits of being the world's leader in research and innovation, resulting in economic progress and unprecedented security for its citizens. However, America's future success in this regard is not guaranteed. This issue has been highlighted in recent reports warning that our economic leadership is eroding and our primacy in global competitiveness is threatened. The consensus is that strengthening graduate education—the backbone of American competitiveness and innovation—is key to a prosperous and secure future.

The highly skilled, creative workforce of tomorrow is developed through our graduate programs. Graduate students become our scientists, researchers, experts, and innovators in a wide variety of fields. Graduate programs are where they acquire innovative research and leadership skills. This report enumerates the key assumptions underlying this vision of the future, assesses the many positive activities underway that contribute to a prosperous future, highlights gaps that need to be addressed, and concludes with six broad recommendations for action and the necessary roles for each stakeholder.

"Our graduate schools are key to developing the best and brightest domestic and globally recruited talent."

Nearly 15 years ago, in his best-selling book *Head to Head*, MIT economist Lester Thurow said that "in the 21st century, the education and skills of the workforce will end up being the dominant competitive weapon."[19] His words have never been more relevant than they are today. The U.S. economy remains critically dependent on the talent and knowledge of the available workforce, particularly in the technical areas. It is up to our leaders in graduate schools, business, and government not only to innovate within their own environment, but also to develop strategies to scale up those innovations in the nation as a whole. Our graduate schools are key to developing the best and brightest domestic and globally recruited talent. To that end, we provide this paper as a foundation for policymakers, business leaders, and higher education officials to engage in an ongoing partnership that ensures the continued competitiveness and security of our nation.

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About the Council of Graduate Schools

The Council of Graduate Schools (CGS) is an organization of more than 480 institutions of higher education in the United States and Canada engaged in graduate education, research, and the preparation of candidates for advanced degrees. CGS member institutions award more than 90 percent of the doctoral degrees and over 75 percent of the master's degrees in the United States. The organization's mission is to improve and advance graduate education, which it accomplishes through advocacy in the federal policy arena, research, and the development and dissemination of best practices. This CGS report, *Graduate Education: The Backbone of American Competitiveness and Innovation*, was released at the 2007 Legislative Forum on April 26, 2007 in Washington, DC.

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