THE RESEARCH MISSION IN HIGHER EDUCATION

AGB ASSOCIATION OF GOVERNING BOARDS OF UNIVERSITIES AND COLLEGES

The Guardians Initiative™

Reclaiming the Public Trust

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Whether for fundamental understanding or more immediate application, the sort of creativity, discovery, and innovation employed in an academic setting subsequently feeds advances in medicine, materials, transportation, energy, food supply, communication, human behavior, computing, robotics, and more.

THE RESEARCH MISSION IN HIGHER EDUCATION

Introduction

It can be argued that America's historical and continuing leadership in scientific and technological advancement is the result, at least in part, of an innovative form of partnership between higher education, government, and business. The uncommon partnership has resulted not only in the scientific and technological advancements that have emerged from the labs of our nation's research universities, it has also whetted an appetite for discovery, innovation, and creativity among students in all of American higher education and within the broader American culture. With so many big questions looming—in areas of energy, water, medicine, climate, security, job creation, and cosmology, to offer a few examples—our nation's ability to respond and continue to lead will depend on maintaining and even enhancing that partnership.

Positioning our nation's colleges and universities to be valuable partners in the creation and application of new knowledge has led to the invention of academic science, a relatively recent and marvelous addition. In its modern form—dating back a mere 75 years in this country—academic science is the result of an American experiment first to direct government support and then corporate investment into our richest centers for creativity, our colleges and universities. It produced a new subcategory of educational institutions, so-called research universities, which grew vigorously out of the fertile soil of the tradition of liberal learning. At the same time, it expanded the scope of humanistic studies in all our institutions of higher education, fostering new conversations ranging from rationalism to ethics to culture to pedagogical practice.

The benefits of academic science in America for the whole world have been technological, educational, and cultural. The impact of the products of academic science is nearly inestimable, although there have been recent efforts to quantify it. From 2003 to 2012 the U.S. Congress commissioned the National Academies to recall the United States' achievements and assess the ability of our nation to continue to innovate and compete within the global knowledge-based economy of the future. Three reports emerged from these assessments: *Rising above* *the Gathering Storm: Energizing and Employing America for a Brighter Economic Future;*[1] *Rising above the Gathering Storm Revisited: Rapidly Approaching Category 5;*[2] and *Research Universities and the Future of America.*[3] In each of these reports, the authors make clear their view that the United States, the envy of the world for its creativity and its system of higher education, is at risk of relinquishing its leadership in science and technology to other nations, leading to the erosion of American prosperity and well-being and threatening national security.

From an educational perspective, science, engineering, and technological disciplines have provided expanded platforms upon which to pursue discovery and excite creativity. Of highest value only when shared or applied for a broader purpose, the sciences are inherently generous disciplines aimed at improving and preserving quality of life. For these reasons and to help thwart the risk that some may be forgetting the boldness and benefits of continuing this wildly successful national experiment and partnership, we attempt here to remind us all of the purposes and promises of academic science.

A Brief History of Science in the Academy

From the beginnings of formal higher education, traceable to the 1088 founding of the University of Bologna, the sciences were included among the seven liberal arts: grammar, rhetoric, and logic (composing the *trivium*) and geometry, arithmetic, music, and astronomy (composing the *quadrivium*). But a reasonable starting point for mapping the evolution of the involvement of American colleges and universities in science in general, and in science in the public interest in particular, is the early 19th century. Of the several American colleges and universities in existence then, only the U.S. Military Academy at West Point (established in 1802) undertook the teaching of science and technology in its curriculum. Around the world, French, German, and Russian institutions had begun teaching science and technology, but American institutions had patterned themselves more traditionally after the English liberal arts ideal and largely disdained even the prospect of considering the pursuit of science as an appropriate endeavor for higher education. The original mission of the colonial colleges was "animated with the desire to provide learned ministers, learned laymen . . . with a love of higher education for its own sake."[4] Jeremiah Day, the ninth president of Yale College (1817–46) and a teacher of mathematics as an element of "natural philosophy," was an outspoken advocate for classical liberal arts education. The *Yale Report of 1828*[5] famously asserted that the college curriculum should focus on foundational and fundamental materials only, suggesting derisively that Isaac Newton himself would be a poor teacher of scientific fundamentals, having spent excessive time and effort on scientific advancement! "Indeed we doubt, whether elementary principles are always taught to the best advantage, by those whose researches have carried them so far beyond these simpler truths, that they come back to them with reluctance and distaste." Even by the 1850s, when science was established as an academic discipline at such institutions as Harvard and Yale, those enrolled for scientific studies were frowned upon. For example, students who enrolled in Yale's Sheffield Scientific School were not permitted to attend chapel with students enrolled in the "regular" academic disciplines.[6]

Nevertheless, a vision for academic science and the benefits that it could yield was advancing through private and government forces. In 1824, Stephen Van Rensselaer III, a supporter of higher education, established a center for technological research that would later become Rensselaer Polytechnic Institute. In 1862, the Morrill Land-Grant Acts required that states, in exchange for the transfer of federally held lands, offer education in agriculture and the so-called mechanics arts. Echoes of the "Agriculture and Mechanical" (A&M) title are retained in the names of several public universities today. The establishment of more academic centers for science and technology soon followed. In 1865, the first students arrived at the Massachusetts Institute of Technology (MIT), and the Stevens Institute of Technology opened in 1870. In his 1876 inaugural address as the first president of Johns Hopkins University, Daniel Coit Gilman declared that "all sciences are worthy of promotion"[7] and set about to make Johns Hopkins the first American university patterned after the German graduate education model. In the ensuing years, more academic institutes for science would open and universities would come to support academic science education and research. By the close of World War II, it had become clear that the pursuit of science would be vital to the health of our people as well as to our nation's economy and security. It was during this period that the concept of the modern research university was born.

A key proponent of the role that colleges and universities could play in the pursuit of America's scientific agenda was Vannevar Bush, a brilliant inventor and engineer with an extraordinary reputation and an extensive list of accomplishments, including the cofounding of the Raytheon Company and an appointment to the faculty of MIT. Beginning in 1941 he chaired the U.S. Office of Scientific Research and Development (OSRD), a position he held until 1951, thus becoming our nation's first science adviser to the president of the United States. It was in this capacity in 1945 that he published *Science: The Endless Frontier*,[8] a report to President Harry Truman urging expanded government support for science and advocating the key role that America's colleges and universities could play in the pursuit of America's scientific agenda. As a result, the National Institutes of Health (NIH) was established in 1947, and the National Science Foundation (NSF) awarded its first research grants in 1952. Military offices for scientific research established programs to support academic pursuit of nonclassified research. Although this support has declined somewhat through the years, the federal government still represents the largest source of academic research support.[9] Other nations—for example, Japan and the former Union of Soviet Socialist Republics (USSR)—chose not to invest in higher education as part of their scientific policies, opting instead to open additional government-controlled national laboratories and even build science cities (Tsukuba Science City in Japan and multiple cities in the USSR). The decision to engage institutions of higher education as partners in the pursuit of a national science agenda turned out to reap enormous benefits for society and helped position the United States as the world leader in scientific discovery and technological innovation.

Academic Research Defined

Academic research has contributed across a continuum from very basic, such as discovery and theoretical work on the nature of our universe or human biology, to more directed and applied research in such areas as medicine, artificial intelligence, and agriculture. Whether for fundamental understanding or more immediate application, the sort of creativity, discovery, and innovation employed in an academic setting subsequently feeds advances in medicine, materials, transportation, energy, food supply, communication, human behavior, computing, robotics, and more. Research toward the more basic end of the academic science continuum (as compared with applied research) does not necessarily or even usually generate findings that have immediate applications, though. Basic research is also dependent upon published findings. Researchers around the world, in the most frequently cited basic science publications, refer to American authors more often than those from any other country—at about twice the rate as the runner-up, China.[10] On the more applied side, there are nearly as many patents held by inventors from the United States as by those of all other nations combined.[11] (However, since 2010, China's patent application rate has soared past that of the United States and the rest of the world.[12]) Although much of the academic contribution to those statistics began with very fundamental ideas, there are decades of follow-up data that demonstrate clear links between basic discovery and societal productivity and well-being. In fact, 80 percent of cited research articles published between 1976 and 2015 have been shown to link forward to issued patents. The same study reveals that during that same time period, most patents (more than 60 percent) link back to prior published research.[13] It is little wonder that so many common advances in new technology—electronic, medical, agricultural, and others—owe their origins to American academic innovation.[14,15]

It is important to bear in mind, however, that the pursuit of academic science follows paths that are different from those pursued by corporate research efforts or research activities intended for the development of military technology, even though the results of academic research do contribute to industrial vitality and national security. One notable distinction of academic research is that it is intended to incorporate a strong teaching component along with scientific productivity. The lead faculty member in a study or project, the "principal investigator," might partner with other faculty colleagues, but a large portion of the work is performed by students: undergraduates, graduate students, and postdocs. Including this teaching component as an essential element of how research is performed on our college and university campuses, one can expect and even feel frustrated at times by the inefficiency of the academic research enterprise. In addition to the necessary inefficiency that attends the creative process, there is the added inefficiency of student researchers, who are acquiring research skills even as they are exercising them. These students are short-term apprentices, many of whom go on to successful careers in business, industry, and government as well as the academy. Thus the benefits of academic research throughout its continuum, from most basic to more applied, need to be measured not only in terms of patents and profits but also in terms of how they fuel the creative genius that is, arguably, America's most significant and ongoing contribution to science and technology around the world.

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Another characteristic of academic research that sets it apart from industrial or military research is that it is open research. The methods of discovery and results are expected to be open and available. There can be no trade secrets such as those that might be developed in a corporate laboratory, and for the most part, academic researchers do not engage in classified studies. "Publish or perish" is actually part of the genius of a national system of scientific discovery that ensures that the teaching and sharing of ideas—the very core of any university mission—are enhanced, not hindered, by the pursuit of science within the academy. Still, it should be noted that critics of open publication worry about America's tendency to "give away" technology. In the 1980s, for example, the development and production of optical disc memory and light-emitting diode (LED) flat panel display technology transferred from their U.S. origins into the hands of developers and producers overseas. While the benefits from refinement and production of some technology might have been exported, America's demonstrated capacity for creativity and innovation has remained undiminished and unmatched. The United States remains the envy of the world for its ability to create, innovate, and discover.

Appreciation of the value of academic freedom for creativity, innovation, and discovery in America does not go unnoticed around the world. In the 1980s, American engineering schools were invited—at times even courted—to establish technology campuses around the world. In recent years, the invitation has broadened to establish campuses that host liberal arts studies. It appears that other parts of the world have taken note of the American genius of pursuing discovery and innovation within the context of the creativity and curiosity of campuses committed to liberal learning. It is also interesting to note the relationship between higher education and democracy. A fascinating study by researchers at the London School of Economics of 14,870 colleges and universities in 73 nations shows a very strong correlation between the growth of higher education and the growth of democratic ideals.[16]

Opportunities for All of Higher Education

When governing board members consider the advancing frontier of science and the position of their respective institutions both to benefit from and contribute to it, it can be difficult to reflect thoughtfully and formulate coherent positions from which to guide their institutions. Some may even dismiss the conversation as moot if their institution isn't classified as a research university. But consider this: In the U.S., only 6.1 percent of 4,324 institutions—266—have a Carnegie classification as "High Research Activity" or "Very High Research Activity," and those institutions educate nearly one-third of all students enrolled in colleges and universities.[17] However, federal research support went to nearly 1,000 academic institutions in fiscal year 2016,[18] demonstrating that many more of our faculty and students are formally engaged in academic research than would be indicated by Carnegie classification alone. Furthermore, since it is the liberal arts tradition that is foundational to the creativity that underpins and inspires science and technology education and research, a conversation about creativity, innovation, and discovery is appropriate at all our institutions of higher education. What can make this conversation challenging is that the utilitarian aspect of research has of late been so successful in delivering useful technology that it has dominated, and perhaps even warped, the definition of science, often thrusting academic science and the fundamentals of the creative

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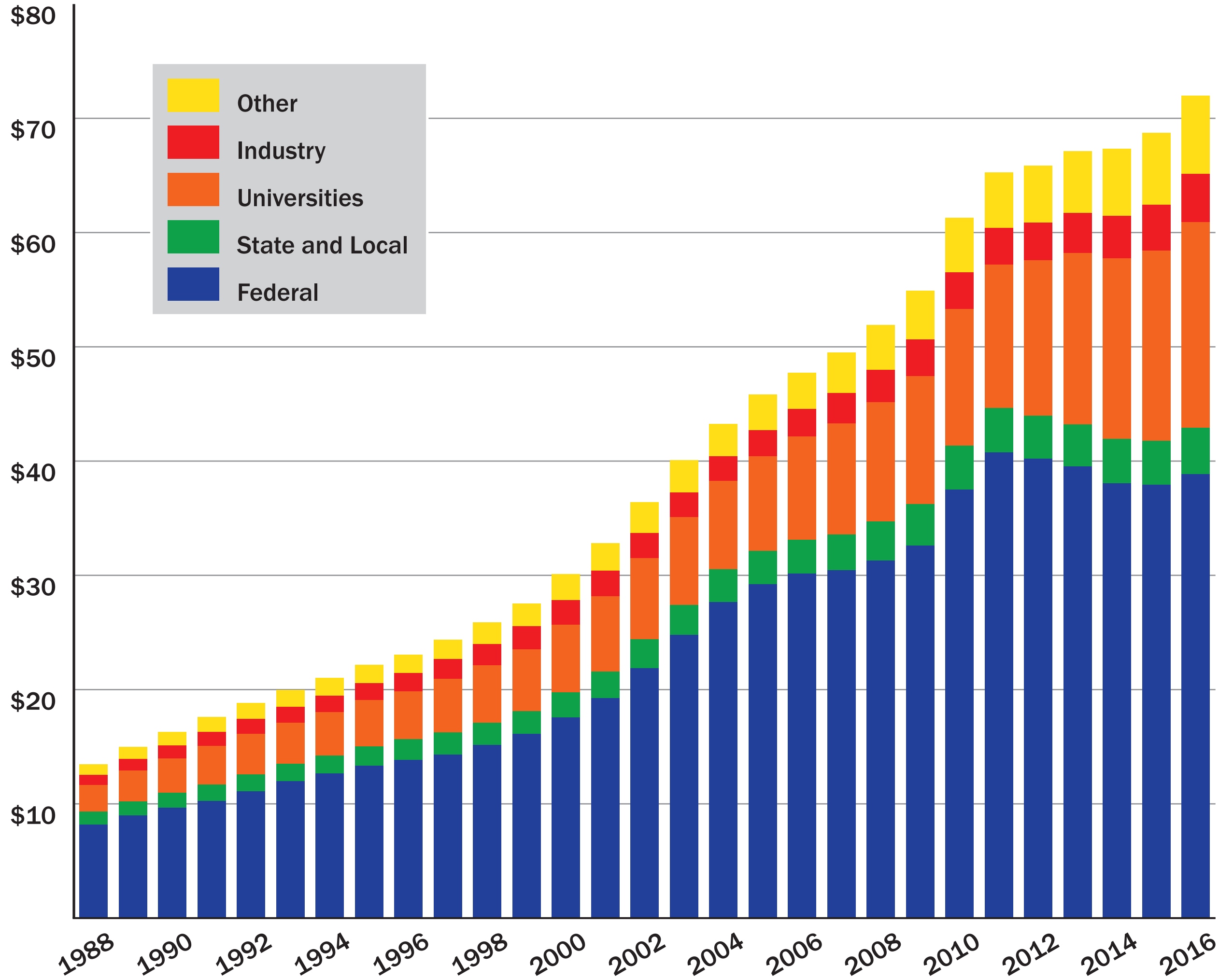
University R&D Funding by Source

Expenditures in billions, FY 2017 dollars



Source: National Science Foundation/National Center for Science and Engineering Statistics, *Higher Education R&D series,* based on national survey data.

processes of innovation and discovery beyond our scope of vision when we think and talk about science.

In considering this latter point, ponder the thoughts of two very creative people, Chuck Vest and Madeleine L'Engle, on this unfortunate myopia that narrows the definition of science. Vest was the president of MIT from 1990 to 2004. In a 1995 speech to the National Press Club he said, "Industry's nearly total R&D focus on rapidly commercializing products, when combined with growing constraints on support of university research, could devastate our national innovation system. It could well leave us without a shared, evolving base of new scientific knowledge and new technology. We must not . . . foreclose on [the future of Americans] by failing to invest in their education and in the research that will be the basis of their progress."[19]

Given the slow erosion of our definition of science over recent decades, it is not surprising that our federal government now seems unsure of its continuing commitment to that enormously successful partnership it struck with American colleges and universities following those early recommendations by Bush. Federal funding for research has waned in recent years. Industrially sponsored research has grown to make up only part of that shortfall, the rest falling on universities to procure, largely through foundation support and philanthropy. (Although welcome, private foundation and philanthropic support sometimes comes with constraints that direct and narrow the range of research opportunities.) It is now the case, nevertheless, that many nations, including South Korea, Taiwan, Australia, Japan, and Germany, commit larger percentages of their gross domestic product (GDP) toward research than does the United States, and China is quickly closing the gap.[21] Many more nations exceed the United States in the percentage of GDP committed specifically to academic research.[22] Although America now has more potential for international research collaborations than ever before (indeed multinational partnerships have become extremely productive), our leadership position does seem to be at risk. Just as there is a message to be sent from our governing board members to our institutions of higher education, there is also a message that they need to help transmit to our federal government, reminding our elected and appointed officials of the importance of continuing to invest in that successful bargain struck years ago that

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Vest's mention of "our national innovation system" is a brilliant broadening of the definition of academic science. A similar warning was offered 30 years earlier by L'Engle, the author of the classic children's story *A Wrinkle in Time*, which was subsequently produced as a science fantasy adventure film. She wrote that she was inspired to write this science fantasy after studying Albert Einstein's work on space-time. In accepting the 1963 Newbery Medal, she warned, "Because of the very nature of the world today our children receive in school a heavy load of scientific and analytical subjects so that . . . they must be guided into creativity." Both of these distinguished individuals would have us be more intentional about the basics of science—creativity, innovation, and discovery—not only its products.[20]

Examples of Innovations from University Research

- Artificial blood transfusion
- Artificial heart
- Blood preservation
- Bone marrow transplant
- Cancer biomarkers
- Cardiac pacemaker
- CT scan
- Cochlear implant
- CPAP
- Crystallographic electron microscopy
- Digital cryptography
- e-Ink
- Electronic computing
- Fluoride toothpaste
- Genetic disease diagnosis and therapy
- Google
- GPS
- Graphene
- Heart-lung bypass machine
- Hybrid grasses
- Hypertext
- Laser and maser technology
- Laser cataract surgery
- Light emitting diodes
- Liquid crystal display
- Lithium–ion batteries
- Magnetic core memory
- Modern oil prospecting
- MRI scan
- Nicotine patch
- Nuclear power
- Oil refining
- pH sensor
- Pharmaceuticals
  - Antibiotics
  - Anticoagulants
  - Flu vaccines
  - Hepatitis B vaccine
  - Polio vaccines
  - Vitamin D
- Plasma screens
- Polaroid film
- Programming/coding languages
- Richter scale
- Rocket fuel
- Seat belts
- Silica gel
- Solar power
- Internet
- Spreadsheet
- Touchscreens
- Web browsers
- Wetsuit
- Wind tunnels
- Wireless local area networks

www.onlineuniversities.com/blog/2012/08/100-important-innovations-that-came-from-university-research/

has placed our researchers in a position to be strong contributors and leading collaborators.

As universities search for a clear vision of the future of their role in creativity generally, and in science in particular, Americans themselves have mixed feelings concerning science and technology. We are eager for the next scientific advancement—from the next generation of cell phones to the emergence of autonomous vehicles. We are eager for the advancement of medical science as well. With regard to the latter, the advice often given to administrators and faculty researchers by concerned trustees is, "Please hurry up!" But at the same time there are fears associated with scientific advancement and the resulting technology. Such fears range from ethical and privacy concerns about genetic engineering to workforce concerns about the impact of robotics and automation. Technology intended to facilitate communication—from texting to social media and beyond—seems to be more effective at transferring information than it is at building understanding. The "precautionary principle" that guides some scientific ethics, especially among our European colleagues, urges us not to hurry up but rather to slow down. The good news amid this confusion is that there is a realization that technology is not inherently good or bad but requires stewardship by wise and creative minds—the very products of our college and university system. Again, there is an opportunity for science to be discussed in higher education at all institutions, not just at research universities.

Ominous signs begin to emerge when we apply a limited definition of science or begin to value it only for its near-term utility, thus risking an imbalance in the necessary continuum of academic science from basic to more applied. For example, we have had university campuses proposing to discontinue their liberal arts programs in favor of curricula with high-demand career paths. In recent years state legislatures have entertained serious proposals to drop all reference to knowledge creation and research in states' educational missions[23] and, in another instance, to implement differentiated tuition, charging students more to earn degrees in the liberal arts.[24] Although this latter plan promised to make it less expensive to study science, it also suffered from too narrow an understanding of the role of creativity, innovation, and discovery in the broader definition of science.

Conclusion and a Charge to Our Governing Board Members

From the beginnings of formal higher education at the University of Bologna in 1088, the sciences were included among the seven liberal arts: grammar, rhetoric, and logic (composing the *trivium*) and geometry, arithmetic, music, and astronomy (the *quadrivium*), and history has shown a necessary interdependence between the sciences, social sciences, and humanities. The past century has witnessed an explosion in scientific understanding and technological advancement. But the brightness of that explosion must not blind us in our judgment in guiding our colleges and universities forward—neither to overly emphasize the sciences nor to eschew them.

A fair question for governing boards to ask of virtually any institution of higher education is, "What are we doing to foster creativity, innovation, and discovery on our campus, and how are we judging our effectiveness?" One would expect that this question would be answered in a variety of acceptable ways to ensure that both the curricular and extracurricular opportunities for our students are designed and implemented with the intent to instill and grow a sense of creative curiosity. Those institutions that bear the "research university" designation have the added obligation to show evidence regarding how the science that they perform contributes not only scientific achievement but also provides a teaching "laboratory" in which the campus community can foster creativity, innovation, and discovery—that is, true academic research.

Those same wise trustees must also ask good questions of our government officials, asking, for example, about their continuing or waning commitment to the 75-year-old partnership that has so benefited our nation and the world. It may require some remedial education of those who imagine that federal support for academic research is a "favor" bequeathed upon certain elite universities as part of the educational business model of those institutions. (To be fair, there are those within the university community who, perhaps unaware of the history of the long-standing government/university partnership in science, have come to perceive federal research support as an entitlement rather than a partnership investment.) For those government officials and leaders open to considering possibilities for changes in regulation and appropriation to guide the partnership to better health, recent prescriptions have been offered by such august bodies as the Association of American Universities and the American Academy of Arts and Sciences.[25,26]

Thirdly, our board members should have good questions at hand to ask donors and alumni about the reasons they continue to support their schools. Donor numbers and donation levels are valid indications that our institutions are valued, but they do not indicate *why* they are valued. When offered the opportunity to respond to probing questions about purpose, supporters of our institutions often respond with answers that go beyond such utilitarian reasons as career preparation. They recognize the value of academic preparation in employing their intellect in imaginative and satisfying ways. And they recognize that creativity, innovation, and discovery—the foundational elements of academic science—must remain part of the core of our academic purpose involving all the components of higher education.

The promise of that unique partnership proposed to Truman by Bush 75 years ago has surely exceeded all expectations. It is hard to believe that even Bush could have imagined the benefits to our nation's economy, defense, food security, transportation, communications, education, and health care owing to the deliberate engagement of our universities in the pursuit of these national and global priorities. But there is great risk in failing to preserve this partnership. This warning is echoed in *Research Universities and the Future of America*: "It is essential that we as a nation reaffirm and revitalize the unique partnership that has long existed among research universities, the federal government, the states, and philanthropy and strengthen its links with business and industry." Armed with a greater awareness of the history, past contributions, and future potential of academic research, creativity, and discovery, we trust that leaders in higher education will be better prepared to engage responsibly within the boardroom and persuasively beyond it to help ensure our continuing leadership for the benefit of our nation and the world.

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1133 20TH STREET NW, SUITE 300, WASHINGTON, DC 20036
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