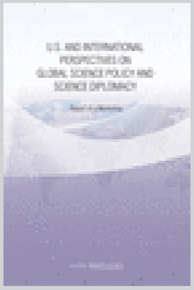

U.S. and International Perspectives on Global Science Policy and Science Diplomacy: Report of a Workshop

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U.S. AND INTERNATIONAL PERSPECTIVES ON GLOBAL SCIENCE POLICY AND SCIENCE DIPLOMACY

Report of a Workshop

Committee on Global Science Policy and Science Diplomacy

Development, Security, and Cooperation

Policy and Global Affairs

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Preface and Acknowledgments

The United States and other countries around the world face problems of an increasingly global nature that often require major contributions from science and engineering that one nation alone cannot provide. The advance of science and engineering is an increasingly global enterprise, and in many areas there is a natural commonality of interest among practitioners from diverse cultures.

In September 2010, the White House Office of Science and Technology Policy asked the National Academies to convene a workshop to explore effective ways to advance both U.S. goals and shared international goals through sound global science policy and science diplomacy, and to improve the mechanisms for carrying out these objectives.

To respond to this request, a committee was appointed by the National Academies to organize a workshop and write a report summarizing the workshop discussion. The committee convened the workshop in February 2011 in Washington, DC, to discuss the following challenges:

- How international scientific engagement can assist diplomacy, advance science, and help solve global problems; and
- What the U.S. government can do (in addition to what it already does) to help facilitate this engagement.

The committee, in developing the workshop agenda, focused the discussion on global science policy, i.e., on how the broad range of science, including basic science, can most effectively be pursued in a rapidly globalized science community, and the role of scientific cooperation in building positive relationships around the world. To keep the workshop discussion focused, the committee decided not to address in depth the specific issues of the role of science and technology in international development, national security, and global health. These elements were not completely excluded from the discussion, but the committee noted that they rightly are being addressed in many other venues.

The workshop offered an opportunity for dialogue between researchers, policy makers, and private-sector representatives. Special invitations were extended to experts in the international scientific community as well.

The report summarizes the views expressed by workshop participants, and while the committee is responsible for the overall quality and accuracy of the report as a record of what transpired at the workshop, the views contained in the report are not necessarily those of the committee or the National Academies.

The report has been reviewed in draft form by individuals chosen for their diverse perspectives and expertise in accordance with procedures approved by the National Academies' Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for quality and objectivity. The review comments and draft manuscript remain confidential to protect the integrity of the process.

The committee wishes to thank the following individuals for their review of this report: Thomas Casadevall, U.S. Geological Survey; James Langer, University of California, Santa Barbara; Willem Levelt, Max Planck Institute for Psycholinguistics; and John Wall, Cummins Inc. Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the content of the report, nor did they see the final draft before its release. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

Michael T. Clegg
Chair

Contents

APPENDIXES

Overview

At the request of the Executive Office of the President, Office of Science and Technology Policy, the National Academies held a workshop in Washington, DC, in February 2011, to assess effective ways to meet international challenges through sound science policy and science diplomacy. To gain U.S. and international perspectives on these issues, representatives from Brazil, Bangladesh, Egypt, Germany, Jamaica, Kazakhstan, Malaysia, Morocco, Rwanda, South Africa, and Syria attended the workshop, as well as two of the most recently named U.S. science envoys, Rita Colwell and Gebisa Ejeta.

Workshop participants discussed many of the characteristics of science, such as its common language and methods; the open, self-correcting nature of research; the universality of the most important questions; and its respect for evidence. These common aspects not only make science inherently international but also give science special capacities in advancing communication and cooperation.

Many workshop participants pointed out that, while advancing global science and science diplomacy are distinct, they are complementary, and making them each more effective often involves similar measures. Since the term *science diplomacy* has been used in various ways, many workshop participants pointed out the importance of clear and transparent motives for cooperation. *Diplomacy* is often understood to mean activity of governments rather than individuals. International scientific engagement, on the other hand, is often the work of individual scientists who seek to contribute to global understanding and human welfare. Therefore, some participants suggested it may sometimes be more accurate to use the term *global science cooperation* rather than *science diplomacy*. Other participants indicated that science diplomacy is, in many situations, a clear and useful concept, recounting remarkable historical cases of the effective use of international scientific cooperation in building positive governmental relationships and dealing with sensitive and urgent problems.

Discussions on science policy and science diplomacy over the two days of the workshop showed a considerable overlap:

Changing Research Environment

Many of the initial speakers at the workshop noted major changes in the way science and technology, including the large fraction of technology development and transfer done in the private sector, now proceed on a "global platform" rather than national platforms. An increasing number of technical advances, trained researchers and innovators, and research opportunities are found in other countries. U.S. research and education policies and practices, established many years ago, no longer reflect current realities and opportunities.

Preparing U.S. Researchers for International Science

There is an increasing role for science policy in dealing with science issues that are global by nature, such as climate change, biodiversity, food security, and energy. To respond to those challenges, many speakers and discussants noted, U.S. systems need to provide opportunities and incentives for U.S. researchers to be prepared to operate effectively in the international arena. This may include encouraging researchers to develop language and intercultural skills in preparation for and through international exchanges. It may also require sustained engagement to build personal and institutional relationships globally.

To encourage such engagement, some participants said that funding agencies should have flexible mechanisms that allow joint support for international projects, along with other innovations to reflect changing research opportunities. It is especially important to encourage sustained linkages between individual laboratories and with industry, both nationally and internationally.

Engaging Early Career Researchers

Workshop participants repeatedly recognized the importance of international research cooperation among early career scientists and engineers. Many noted that relationships built through such collaboration can last for decades to come and benefit scientific and technological progress.

Building Global Science Capacity

Effectively advancing science and its beneficial applications, several participants noted, involves actions by the United States and partners around the world, including:

- Developing research agendas that have a potential major effect on human welfare in developing countries;
- Bringing the talents of girls and women around the world into science and technology;
- Helping developing countries to be effective partners and to develop and retain scientific talent through national science and technology programs and the commitment of resources; and
- Recognizing and encouraging accomplishments in developing countries.

Learning from Industry

Given the increasing role of the private sector in the research arena, some workshop participants encouraged innovative public–private partnerships. They argued that governments in particular should try to leverage the experience of industry and apply the private sector's entrepreneurial and flexible spirit to governmental agencies. There is also a need for more university–industry partnerships nationally and internationally, they said, which can effectively contribute to educational training and technology transfer.

Responsible Science

Several participants pointed out that in a rapidly changing research environment involving unprecedented volumes of data and intense competitive pressure, continued work is needed to assure the necessary institutional basis for scientific cooperation. This particularly includes a common understanding of scientific integrity and responsibility.

Global Connectivity

Some discussants commented that growing global connectivity can dramatically accelerate cooperation and thereby expand the scale of scientific programs, highlighting the critical role of global connectivity for both developed and developing countries. Many pointed out that, while it is important to make efficient use of new information technologies and social media tools to implement new partnerships, they cannot replace face-to-face meetings.

Visa and Travel Restrictions

Many participants stated that visa and other travel policies need to encourage, not hinder, the initiation and continuation of scientific cooperation. They expressed concern that real and perceived visa problems can have serious repercussions, such as an increasing number of researchers looking for opportunities in other countries instead of the United States.

Application of Science Diplomacy

Workshop presentations, summaries of experiences, and discussions included many examples in which scientific cooperation or contact between technical experts had major value in building bridges and positive relationships in otherwise difficult international situations.

Several participants also acknowledged the capacity for cooperative activity in many U.S. government departments and technical agencies, as well as in private–public science partnerships, and emphasized that, to realize the benefits of science diplomacy on a large scale, institutional resources are necessary—such as staffing in both Washington, DC, and U.S. embassies. Other participants noted that science, when mobilized as a means of governmental diplomacy, should be carried out consistent with essential scientific methods, such as balanced consideration of all relevant evidence.

This report, structured according to the workshop agenda into a section on U.S. Policy for Global Science and one on Science for Diplomacy—Diplomacy for Science, presents the workshop discussions on these issues in more detail.

1

U.S. Policy for Global Science

The public and private sectors and federal administrations from both major political parties have repeatedly recognized advantages that science brings to international relations. Scientific and technological advances are critical for addressing many major global challenges, while the apolitical focus of science on evidence allows positive interactions even in the presence of policy differences. This perspective is reflected most recently in the Obama administration's emphasis on and support for science, technology, and innovation in many of its foreign and domestic policies. Efforts are under way to revitalize global science and technology cooperation, to address challenges that impede such cooperation, and to reach out to other countries through efforts such as the science envoy program.[1] However, the administration is interested in what more can and should be done to further encourage international scientific engagement and collaboration to address challenges that face the United States and the world.

In this report, the term global science is used to describe the advancement of science as a common, global process.

HISTORICAL AND STRUCTURAL CONTEXT

Employing a universal language that connects its participants, science crosses national borders and brings people together, and has done so for centuries. Particularly in recent decades, large numbers of scientists have moved to settings that enable unencumbered scientific discovery

[1]For more information on the Science Envoy Program, visit www.america.gov/science_envoys.html; www.state.gov/g/oes/rls/fs/2010/136220.htm; or www.state.gov/r/pa/prs/ps/2011/03/157830.htm. All accessed April 4, 2011.

and exchange. Offering such opportunities, the United States has been an attractive choice for many of the brightest minds around the world. In fact, today about a quarter of the Nobel laureates living in the United States were born overseas, as Ralph Cicerone, president of the National Academy of Sciences, said in his welcoming remarks.

C. D. Mote Jr., of the University of Maryland, summarized major changes of the twentieth and early twenty-first centuries related to science. Following the Vannevar Bush report *Science: The Endless Frontier,* delivered to President Truman in 1945, the U.S. "national innovation environment"[2] was created through a partnership between government, industry, and universities delineating responsibilities for national health, welfare, and security. With the substantial changes the world experienced after the cold war, this partnership, while remarkably successful for decades, no longer corresponds to the realities that emerged in the 1990s.

The cold war period (1945–1990), Mote argued, was characterized throughout the world by a paradigm of "isolation and control" of information and innovation for national security and commercialization purposes. This paradigm has been replaced by one of "partnerships and engagement" to most effectively accelerate innovation, discovery in science, and creation of the technologies shaping the twenty-first century. However, many U.S. policies, such as export controls or travel, visa, and employment restrictions for foreign visitors, were put in place many years ago and reflect the isolation and control perspective of the past and are not adaptive in a rapidly changing world.

Businesses and industry no longer operate on a national platform but on a global platform, not for a lack of national interest, but because new economic realities dominate the identification of science and technology investments likely to be most effective. Similarly, Mote said, governments face concerns of an increasingly global nature that are rooted in science and technology and that require partnerships between and among governments: currency valuation, interest rates, climate change,

[2]Major elements of the U.S. national innovation environment were laid out in *Science: The Endless Frontier* (1945). This was not stipulated in law to be the "national innovation environment" and was not adopted formally by the nation. However, the policy recommendations of *Science: The Endless Frontier* were followed closely by the nation. What followed in the cold war period was a consequence of the assignment of responsibilities in that report and the nation's adherence to its guidance.

Mote first formulated the ideas outlined in this section for the National Academies' report *S&T Strategies of Six Countries: Implications for the United States* (2010).

pandemics, diseases, food supply and safety, terrorism, and nuclear proliferation and security, to name a few.

For the government–industry–university triad to operate effectively in a global innovation environment, the world's principal research universities must also operate on the global platform, said Mote. Though much research involves international cooperation, most universities have not yet adopted a global vision and function, a step that industry took more than a decade ago.

Recognizing the opportunities, risks, and complexities of partnerships between governments, industries, and universities, Mote explained that science policy can facilitate advances in science and technology through promoting an environment of partnerships and engagement and through increasing the effectiveness of interactions within the global innovation platform.

CHANGING PATTERNS OF MOBILITY

Charles Vest, president of the National Academy of Engineering, opened the session on changing patterns of mobility with a reflection on the changing nature of what many call brain drain. For most of the twentieth century, the world experienced a pattern of brain drain with the brightest minds moving to countries that offered the best possible education and environments to pursue careers in science and technology. For decades, the United States was among the most appealing countries for the best researchers from around the world. In the shifting global environment this started to change. Countries such as India and China have been able to reverse the brain drain to some extent and attract scientists and engineers to return to research and technology facilities in their home countries. Other countries and regions also have created more attractive and stronger education and research environments for their scientists and engineers.

> *Engineering is a social exercise. To work in teams, you have to know the people you're working with—you need to know each other's strengths and weaknesses, and you need to understand each other's culture. This is especially true when working together from a distance . . . so when you are on teleconferences or exchanging emails you have personal relationships to build on.*
>
> John Wall, Vice President and Chief Technical Officer, Cummins Inc.

According to Vest, these conditions resulted in what is called brain circulation: Many scientists and engineers no longer spend their careers in one or two countries but in many different countries. This is changing again. In a global innovation environment and with technological advances in the cyber infrastructure, the next era could be one of brain integration, allowing experts to work increasingly across boundaries, on global problems, often without having to leave their laboratories.

During the ensuing discussion, several participants noted that to maximize advances in science and technology that benefit the global community, governments should create an environment that inspires and engages top talents from around the world, offers opportunities for leveraging international collaboration, and provides researchers with access to research facilities.

Movement of Scientists Hampered by Visa and Travel Restrictions

Many participants, both from the United States and from other countries, voiced concern that, particularly during the last 10 years, the United States responded to national and global security concerns with visa and immigration processes that have made it more difficult for some scientists and engineers to study, conduct research, work, or even attend meetings and conferences in this country. Visa restrictions that prevent foreign researchers from returning to the United States for certain periods of time also impose limitations on effective cooperation of benefit to the United States and the home countries of those requesting a visa. As many workshop participants pointed out, this can have serious repercussions in the short and long term, when more of the brightest young and senior researchers turn away from opportunities in the United States to those offered by other countries. Representatives of government agencies noted that U.S. government researchers also face travel restrictions imposed by government policies that limit direct interaction with research developments around the world, and that the lack of communication among U.S. government technical agencies sometimes hinders effective domestic and international coordination.

Personal Relationships in an Age of Virtual Innovations

Many workshop participants noted that rapidly advancing communication technologies offer new opportunities for effective relations through virtual meetings and collaborations and that these interactions often take place in different ways within different age groups. It also was pointed out that even though new social media play an unprecedented role, especially in connecting young people, face-to-face interactions remain critical for building long-term relationships among scientists and engineers from very different backgrounds. Several participants therefore stressed that restrictions imposed on travel and visas, which limit direct personal interaction, remain a problem.

Educating and Empowering a New Generation of Scientists

Rita Colwell, professor at the University of Maryland and recently appointed science envoy, highlighted that it is important for the U.S. science system to prepare young researchers for a career in today's globally interconnected science environment. This requires a multidisciplinary approach to their education, in which foreign language and intercultural skills can be of major importance. This interdisciplinary education would be further strengthened by expanded student exchanges. However, Colwell noted that spending several years in a foreign laboratory may not be the most appropriate model, since most U.S. researchers feel the need to remain in the United States to pursue their academic career. An alternative is linkages of U.S. and foreign laboratories that allow students and researchers to spend a few weeks at a time over the span of several years in a laboratory overseas for joint research, to exchange results, draft papers, and publish with their counterparts. This can be an effective way of building international understanding and cooperation. Yet, this approach requires funding agencies to have the flexibility to provide shared funding for work in laboratories in the United States and overseas.

> *Funding agencies should encourage joint funding with labs overseas that allows for student and researcher exchanges through linkages of labs.*
>
> Rita Colwell, Distinguished University Professor, University of Maryland, and U.S. Science Envoy

> *Working around the world for young scientists and engineers must become just like working around the country has been for earlier generations.*
>
> C. D. Mote, Glenn L. Martin Institute Professor of Engineering, University of Maryland

Gebisa Ejeta, professor at Purdue University and recently appointed science envoy, emphasized the importance of strengthening science education, particularly at the tertiary level, in many developing countries to build a local science culture that increases the respect for scientists and for the benefits to society that result from their work. Marvadeen Singh-Wilmot, professor at the University of the West Indies, Jamaica, added that good science education is critical for children around the world, as it shows them a way to create, innovate, and build, and thus exposes them to interesting and exciting career possibilities. Several U.S. and foreign participants stressed that investments in science education in the United States and around the world are a critical step to build a science culture in a society that is beneficial to each country and the world at large.

Engaging Early Career Researchers Around the World

Both domestic and foreign workshop participants pointed out the importance of enabling early career researchers around the world to connect, collaborate, and establish relationships that have the potential to last for decades to come. Bringing early career researchers together, many noted, not only benefits scientific and technological progress, but for many of these young scientists and engineers, such connections lead to engaging with experts in other fields and to reaching out to society broadly. The idea of a science program similar to the U.S. Peace Corps was raised in the discussion; however, several workshop participants suggested that there are existing programs with such aims that merit support, some of which are described in Box 1-1.

Other Questions and Ideas

In addition to the points already addressed, the following questions were raised during this session's discussion:

- How will the changing demographics around the world affect mobility patterns, and what implications does this have for the United States and other countries?
- How can different sectors take advantage of an aging population of highly skilled but retired scientists and engineers?
- What can governments do to help the private sector employ the large and still-growing number of young unemployed college graduates, particularly in countries in the Middle East and North Africa?

BOX 1-1
Selected International Programs for Early Career Researchers

Young Scientist Ambassador Program (YSAP)
"This program will promote the efforts of…Young Scientists to bridge the international scientific gap by facilitating cultural, scientific, intellectual, or educational interactions. The ambassadorship must be *non-traditional*; that is, interaction must occur between two countries that are at different stages of scientific development, or between two countries that historically have had minimal scientific contact." (www.chem.ufl.edu/~miller/YSAP/)

Young Scientists Volunteer Program (YSVP)
The Young Scientist Volunteer Program (YSVP) aims to bridge and close the gap between the scientific communities in developed and developing countries. Scientists are volunteering to identify barriers to and challenges for progress in developing countries; to form a list of existing helpful resources (made available by embassies, UNICEF, science academies, available visiting positions for undergraduate and graduate students and faculty, and so on); and to build a marketplace for volunteering opportunities.

Kavli Frontiers of Science Symposia
"Kavli Frontiers of Science symposia bring together outstanding young scientists to discuss exciting advances and opportunities in a broad range of disciplines. The format encourages both one-on-one conversations and informal group discussions in which young participants continue to communicate about insights gained from formal presentations and the excitement of learning about cutting-edge research in other fields. By doing so, Frontiers helps to remove communication barriers between fields and encourages collaborations among some of the world's best and brightest young scientists. Annual Kavli Frontiers symposia are held for young scientists in the U.S. and bilateral symposia have included young researchers in the U.K., Germany, France, Japan, China, Indonesia, and India." (www.nasonline.org/site/PageServer?pagename=FRONTIERS_main)

Frontiers of Engineering Program
"The Frontiers of Engineering program brings together…a group of engineering leaders from industry, academe, and government labs to discuss pioneering technical work and leading-edge research in various engineering fields and industry sectors. The goal of the meetings is to introduce these outstanding engineers (ages 30-45) to each other, and through this interaction facilitate collaboration in engineering, the transfer of new techniques

continued

BOX 1-1 Continued

and approaches across fields, and establishment of contacts among the next generation of engineering leaders." Frontiers of Engineering symposia are held annually in the United States, and bilateral symposia engage young engineers from Germany, Japan, India, and China. A multilateral symposium with the European Union started in 2010. (http://www.naefrontiers.org)

Germany's Young Academy of Sciences
"The *Junge Akademie (Young Academy)* was founded in the year 2000 as an academy for the new generation of scientists and scholars. It is a joint project of the *Berlin-Brandenburgische Akademie der Wissenschaften* - BBAW (Berlin-Brandenburg Academy of Sciences and Humanities) and the *Deutsche Akademie der Naturforscher Leopoldina* (National Academy of Sciences Leopoldina). Its remit is to promote interdisciplinary discourse and co-operation between outstanding young scientists and scholars, and to support initiatives at the interface between science and society." Ten new members are elected yearly and each member of the Akademie is allocated a research budget to support joint scientific projects." (http://www.diejungeakademie.de/english/index.html)

Note: There is also an Austrian Young Academy, a Royal Netherlands Young Academy, and a Royal Society of Edinburgh Young Academy. The InterAcademy Panel has furthermore established the Global Young Academy. These academies and other regional groups interact in creating international young scientist networks.

Other discussants wondered whether the Fulbright and similar programs could be modernized. While the Fulbright Program is an excellent opportunity for some of the brightest young minds around the world to get a first-class education and research experience in the United States, grant recipients often face difficulties in continuing their research once they return to their home countries (to fulfill the Fulbright 2-year home-country physical presence requirement), as many countries lack the necessary scientific and technological infrastructure. How can the United States and the home countries help these returning researchers to continue pursuing their research career? The U.S. Agency for International Development (USAID) supports some researchers in developing countries. One participant wondered whether Germany's Humboldt Foundation program[3] that provides funding for researchers when they return to their home country is a model that could be followed in the United States.

MAXIMIZING SCIENTIFIC ADVANCES IN AN INCREASINGLY GLOBAL RESEARCH COMMUNITY

Today's global research environment is highly competitive, innovation is critical, the cost of research is growing while resources are limited, and competition for the best and brightest minds is fierce. Workshop participants recognized that much is being done by U.S. federal agencies to encourage international research cooperation. Some participants also suggested additional areas of opportunity.

Access to Facilities and Equipment

Scientific and technological facilities and equipment can be vital to scientific progress, yet most researchers in the world depend on access to facilities in other countries—access that may be hindered by such barriers as costs, export controls, and, in some cases, cultural factors. Several participants thought it was important to overcome these barriers.

Pooling Resources

Many countries, industries, and universities around the world invest in science and technology. Celia Merzbacher, vice president for innovative partnerships at the Semiconductor Research Corporation, suggested that an assessment of foreign centers of excellence and investment priorities of other countries would provide ideas as to how the United States and others can take advantage of these investments by pooling resources and providing complementary efforts that would benefit the global science environment and, consequently, society

> *There are a lot of resources going into science and technology around the world, and the United States should take advantage of that.*
>
> Celia Merzbacher, Vice President for Innovative Partnerships, SRC

[3]After successfully completing the initial stay sponsored by the Alexander von Humboldt Foundation in Germany, Humboldt and Georg Forster Research Fellows can apply for a return fellowship to sponsor reintegration into an institute abroad. For more information see www.humboldt-foundation.de/web/return-fellowship.html (accessed September 28. 2011).

at large. Azamat Abdymomunov, former vice minister of education and science of the Republic of Kazakhstan, pointed out that an assessment should not be limited to projects that are sustained, but should include those that are being cut or eliminated, to see whether critical research needs additional support.

Combining Local Relevance with Global Intellectual Engagement

Some of the foreign workshop participants suggested that some developing countries have built up first-class science systems and research facilities. These provide excellent foundations for science and technology plans that address local priorities and global developments. While such plans need to come from within each country, these participants noted, some nations would benefit from greater support from the United States in developing national science and technology strategies to improve science education at all levels, and to strengthen a local science culture that increases the respect for scientists and their work. For other countries, such as Malaysia, the U.S. administration's emphasis on science and technology and investing in research is an inspiring role model that can be followed without much external guidance.

Learning from Industry

Workshop participants expressed considerable interest in the role of industry and what can be learned from private-sector approaches. Representatives from industry indicated that many of the barriers faced by government and academia do not exist for the private sector, where national boundaries mean very little and where multinational research activities are widespread. They suggested that governments should try to leverage the experience of industry, promote partnerships with industry and between academia and industry, encourage federal agencies to be as flexible as possible, and explore how government agencies could apply an entrepreneurial spirit similar to that shown by the private sector and public foundations.

Role of Government

Khotso Mokhele, former president of South Africa's National Research Foundation, pointed out that there is often an absence of an American voice at international science conferences and within international scientific bodies. The United States needs to promote its presence and participation in international science, he emphasized, which requires a critical look at how international science is and should be organized within its own boundaries.

Some international collaboration promoted by the U.S. government is driven by policy priorities that identify general areas of research. Other collaborations promote specific projects that are designed to meet the priorities of partner countries. Many U.S. government agencies face the dilemma that their mandate is predominantly domestic, which limits opportunities for actively supporting research cooperation with international partners.

As one participant noted, however, even under the constraints of a domestic mission, the leadership of an agency can significantly influence the status of science within the agency and encourage innovative ways to work with other countries on research projects. Several participants suggested that it would be extremely valuable to coordinate efforts supported by different agencies and to integrate similar projects whenever possible. For the science community, it is difficult to navigate through the opportunities provided by different U.S. government agencies, as there is no single agency or office that is responsible for international science. As Cutberto Garza, provost of Boston College, said, researchers wonder, "Who do we call when we want to speak to the individuals who are in charge of enabling and promoting international science in the United States?"

AREAS FOR INTERNATIONAL SCIENTIFIC COLLABORATION

In her introductory remarks, session moderator Cherry Murray, dean of Harvard's School of Engineering and Applied Sciences, suggested the following common existing modes of scientific collaborations (noting that the list is not exhaustive):

- International treaties (e.g., Antarctica, space, oceans)
- Bilateral agreements between nations
- Multinational agreements (telescopes and others)
- Cases in which a country is not part of a multinational agreement but is an important partner in a scientific project (e.g., Large Hadron Collider)
- Bilateral agreements between national labs (e.g., Russia and U.S. nuclear labs)

- Bilateral agreements between universities
- Small principal investigator or research group collaborations

In the ensuing discussion, several participants remarked that changes in the global scientific environment and new information and communication technologies will provide new forms of collaborative research and further opportunities for science to be international. As Vaughan Turekian of the American Association for the Advancement of Science pointed out, this development is already reflected in the number of articles published in *Science*: Only about 20 percent were based on international collaborations in the early 1980s, a number that has increased to 55–60 percent since then.

Some workshop participants suggested that there is an increasing need for multilateral collaboration, given the

- Global and multidimensional nature of many of today's challenges;
- Widely distributed expertise of researchers and facilities around the world;
- Massive amount of data that is being generated; and
- Advantages that cost sharing represents.

Cost sharing is particularly important for large-scale projects, for example in the space and earth sciences, because one country alone often cannot provide the necessary resources. Other workshop participants underlined that small-scale projects, some of which may be expanded easily in scale and others that involve only a few principal investigators, are equally important and often cost-effective. In addition, changing patterns of mobility require U.S. scientists to reach out actively to their counterparts around the globe, as the best researchers often are unable to come to the United States for extended periods commonly required by research. U.S. scientists and engineers increasingly understand that research conducted in other places in the world is relevant to their own work.

In their presentations, discussion leaders Karen Strier, professor of anthropology at the University of Wisconsin–Madison, and Thomas Casadevall, scientist emeritus of the U.S. Geological Survey, identified several fields as promising areas for international cooperation, including biodiversity and the environment (including climate, which affects sustainability, health, and energy) and humanitarian assistance (especially when expanded to include issues related to the earth sciences and responses in pre- and postcrisis situations). Casadevall added that the management, processing, storing, archiving, and accessing of scientific datasets increasingly require international collaborative efforts.

Flood of Data

According to Larry Weber, director of the Office of International Science and Engineering at the National Science Foundation (NSF), every year the world research community collects more data than in all of history previously combined, and this massive amount of data is changing the way science is done.[4] Being flooded with data creates many challenges (archiving, storage, processing, and interoperability) and many opportunities. Several workshop participants emphasized that open access to data is a key question for global collaboration. It is critical to ensure that quality data are collected and shared through a peer-review process, and to define principles through which various communities may gain access to these data.

Mobile technologies and networked information technology platforms enable sharing of data and information worldwide at lightning speed. Yet, many participants noted, there are barriers, including limited broadband availability, the sheer volume of data, and restrictions faced by U.S. government agencies to access and share data and information through various virtual means. Thomas Casadevall pointed out that the U.S. government should not miss opportunities to cooperate with private companies that propose innovative ideas to manage, store, and share data. One way to achieve this, he said, would be to expand cooperative research and development agreements between government agencies and private companies.

A good example of data collection and sharing, as suggested by James Herrington, director of international relations at the National Institutes of Health (NIH), is the National Library of Medicine. Every NIH grant recipient is expected to publish his or her results, which are then collected and made available by the National Library of Medicine. Similar efforts exist in other U.S. agencies and other countries, although he emphasized that much more needs to be done.

[4]For more information see https://www.teragrid.org/web/tg11/seidel-article (accessed September 23, 2011). This is also captured in a series of articles in *The Economist*, February 25, 2010 issue, for example: Data, data everywhere.

Responsible Science

Larry Weber directed workshop participants' attention to the importance of responsible conduct of research as another area in which the international scientific community needs to collaborate. Society will demand that research is done ethically and that governments and funding agencies have systems in place that ensure integrity and responsible conduct in research activities. With science becoming increasingly international, global principles for meeting these aims are needed, he noted. Other participants supported this suggestion, including Rita Colwell, who added that convincing the international science community to adhere to a uniform code of conduct should not be difficult and should be undertaken right away, as many scientists already follow various existing standards of responsible research conduct.

Conditions for Success

Several U.S. and international participants noted that international collaborative research activities are most likely to generate promising results when they

- Focus on areas that have been identified as priorities within collaborating countries;
- Engage researchers who possess cultural awareness and local language skills;
- Include educational and capacity-building programs;
- Have a data-sharing component; and
- Build on well-established collaborative activities.

Many workshop participants illustrated specific ways in which U.S. science is engaged in international activities through private, government, and academic enterprises. What is missing, they said, is a coherent story of how and why the United States is engaged in science globally and a focal point within the U.S. government that coordinates international science and serves as a resource for researchers.

EFFECTIVE GLOBAL SCIENCE

With the changing nature of science and the globalization of society, several workshop participants remarked that there is a growing need to address multidisciplinary grand challenges that increasingly require multinational, instead of bilateral, cooperation. According to Larry Weber, "that type of global science requires large investments, larger numbers of people, expertise across multiple disciplines, and support from multiple parties, and multiple stakeholders need to be engaged and satisfied." However, achieving truly global science policies is very difficult, and not much progress to achieving this goal has been made, argued Khotso Mokhele of South Africa. Instead, national policies for global science may be a better way to react to the changing paradigm of science, while more global approaches are explored through pilot exercises. This notion was supported by Hernan Chaimovich of Brazil, who pointed out that U.S. policies to promote global science are only effective if they serve the interests of all parties involved. According to him, policies of mutual benefit can center on enhancing the science infrastructure in a developing country or can be based on a more equal partnership, depending on the partners in question.

Judith Kimble, professor of biochemistry at the University of Wisconsin–Madison, highlighted that for global science to be effective, it is essential to engage early career scientists (a notion that was supported repeatedly by many workshop participants), to develop policies that promote talent exchange at every level, and to foster networks of excellence around the world. Kimble proposed that incentives be established for training grants to encourage development of programs to raise awareness of the global science platform[5] among early career researchers and promote their stays in laboratories abroad.

> *We should establish incentives for training grants to develop programs that raise awareness of the global nature of science.*
>
> Judith Kimble, Professor of Biochemistry, University of Wisconsin–Madison

Measuring the Effectiveness of Science Policy

Because the goal of these policies has not yet been clearly defined, measuring the effectiveness of science policy is difficult. Similar to many research projects, long-term achievements are more important than their short-term outcomes, said Shafiqul Islam of Tufts University.

[5]Similar to the way ethics programs were incorporated in training grants to raise awareness of responsible science.

> *Most of today's scientific leadership around the world were trained in the 1950s, 1960s, and 1970s; many of them in the United States. Owing to their knowledge of the system and culture of the United States and to contacts that they have made as students and often maintained throughout their career, many have been wonderful ambassadors for the United States in their own countries. Thus, their training was a very effective investment when we look at it from a long-term perspective.*
>
> *Unfortunately, the programs that supported those leaders have largely been eliminated over time, and most of them effectively ended in the 1990s. Thus, this type of investment was not made for an entire generation. The leaders of science in the upcoming generation have not had the same set of experiences and will not possess the same deep knowledge of the United States.*
>
> Michael T. Clegg, Foreign Secretary of the U.S. National Academy of Sciences

Some foreign workshop participants suggested that effective science policy could be measured by the level of engagement of policy makers and politicians. The number of countries that establish science and technology agencies, appoint science and technology ministers, develop new national science policies (or improve and implement existing ones), or adopt policies and legislation on science and technology could be other indicators of success.

Many participants pointed out that although measurements are important, metrics need to be defined carefully. Many parameters were suggested, but no predominant set of measures emerged from the discussion.

Examples of Effective Global Science

The Human Genome Project (Box 1-2) was mentioned by James Herrington and Judith Kimble as one example of effective global science policy, in which scientists from 22 countries came together to establish open access policies for genome sequence data. The Human Genome Project was seen as demonstrative of the potential of open access policies to be highly effective. It also demonstrated that the effectiveness of such a policy can be measured easily, for example, by the number of papers published based on the open data made available by such a policy.

Norman Neureiter, first science advisor to the U.S. secretary of state, drew attention to the Indo-U.S. Science and Technology Forum (Box 1-3). Although the forum originally had joint, but very limited,

BOX 1-2
Human Genome Project

The Human Genome Project was a multinational effort that began in 1990. Originally planned as a 15-year project, technological advances accelerated the process and it culminated in 2003 with a complete human DNA sequence. In 1996, scientific leaders from 22 countries met in Bermuda to set guidelines for data sharing in this project. The resultant "Bermuda Principles" declared that primary genomic sequence should be released unconditionally to the public within 24 hours of its acquisition. This revolutionary standard of global cooperation was established for scientists and funding agencies and was adopted quickly. Its impact has been huge—both for advancing genome sciences and for paving the way to similar policies on other major projects designed to generate resources for the scientific community. These Bermuda principles provide a stellar example of policy driven by scientists with the express goal of setting guidelines for the common good.

For additional information, see http://www.ornl.gov/sci/techresources/Human_Genome/research/bermuda.shtml.

BOX 1-3
Indo-U.S. Science and Technology Forum (IUSSTF)

IUSSTF was established under an agreement between the governments of India and the United States in March 2000 as an autonomous, not-for-profit society that "promotes and catalyzes Indo-U.S. bilateral collaborations in science, technology, engineering, and biomedical research through substantive interaction among government, academia, and industry." IUSSTF is a grant-making organization whose principal objective is to provide opportunities; exchange ideas, information, skills, and technologies; and collaborate on scientific and technological endeavors "of mutual interest that can translate the power of science for the benefit of mankind at large." (www.indousstf.org)

financial support, it has brought about 10,000 scientists together, adopted the National Academies' Frontiers of Science and Engineering symposia for India, expanded its activities with the private sector to offer fellowships, and over time increased its funding significantly. Neureiter suggested that this is a remarkably successful model that could be implemented in other countries.

Funding Mechanisms for Global Science

It is extremely challenging for multiple agencies in different countries to provide support for researchers from multiple countries in an organized and coordinated way, stated Larry Weber, one of the discussion leaders in this session. In the absence of a global funding organization[6] functioning at the intersection of science and development, the U.S. National Science Foundation has entered into partnerships in which NSF supports U.S. researchers with their developing-country counterparts, funded by USAID or the Bill and Melinda Gates Foundation or both.[7]

Weber also pointed to a pilot effort similar to the idea of a Global Science Foundation that supports researchers from across the G8 countries to work together on projects that address global challenges. Researchers from three or more countries submit a single application, and if selected, these researchers receive grants from funding agencies in their home countries. This pilot approach is intended to help funding agencies in different countries develop mechanisms that consider single proposals for multinational research cooperation submitted by a multinational group of researchers.

Global Science for the United States

Judith Kimble suggested that many of the issues raised in the discussion of day one of the workshop should also be applied to domestic issues within the United States. This would not only benefit our own society but also help develop the support for international science within our domestic constituencies.

One example that shows how the United States benefits from medical experience in a different country was provided by James Herrington.

[6]While there is not a global funding organization for scientific research, there are two groups that should be mentioned. The European Research Council (http://erc.europa.eu), supporting investigator-driven frontier research, is the largest supranational funding agency currently in existence. The Global Science Forum of the OECD brings together science policy officials who seek to identify and maximize opportunities for international cooperation in basic scientific research (http://www.oecd.org/department/0,3355,en_2649_34319_1_1_1_1_1,00.html).

[7]As of February 25, 2011, NSF and USAID have worked on a memorandum of understanding between the agencies and have supported several successful projects on a case-by-case basis. A more structured program is planned to be announced soon.

NSF and the Bill and Melinda Gates Foundation partner on the program Basic Research to Enable Agricultural Development (BREAD) to support new collaborations between U.S. and international scientists and engineers that lead to a different way of thinking about developing-country agriculture.

The Mississippi delta region faces high rates of pregnancy and obesity and very poor access to health service delivery. The use of "health house" programs in Southern Iran, specifically the Shiraz region, has significantly reduced child mortality rates and improved health indicators related to maternal health, for example contraceptive use. The Mississippi delta region is learning from the Shiraz Medical School how to implement a health house program. Iran also has a very strong program in multidrug-resistant tuberculosis, an additional example of many instances in which the United States learns and benefits from experiences of other countries.

REFLECTIONS

During the last session of the first day of the workshop, participants reflected on the discussions and raised the following issues that had not yet been addressed:

- Many U.S. and international participants remarked that while social and behavioral sciences as well as humanities do not receive enough attention in the United States, they are critical for understanding the complex issues our societies are facing today.
- Several participants suggested that the ideas expressed in this workshop be considered in current and future activities of the White House Office of Management and Budget.
- The role of the scientific diaspora is critical for the development of many developing countries, including science, some participants noted. Yet many countries do not benefit from their diaspora as much as, for example, India and China. How can that change?

At the end of the session, committee chair Michael T. Clegg and others stressed that science policies can be developed at a national level, but that thinking of the necessary standards and norms for their successful implementation is more a scientific than an intergovernmental effort and thus is a particular challenge for the global science community. Both policy makers and the science and engineering communities have a role to play in developing policies that are global in nature and address the challenges of today's world.

2

Science for Diplomacy—Diplomacy for Science

Science diplomacy is not new, even though it has recently seen a significant surge of interest. For many years, governments and individuals have realized, and acted on, the value of science in furthering relationships, although these actions have often not been identified as science diplomacy.

Science diplomacy is a term now used to describe a variety of activities and often implies different things to different people; discussants suggested that this lack of clarity can sometimes be a disadvantage. Most workshop participants acknowledged that while science diplomacy is closely related to the topic of global science cooperation, addressed in the first part of the workshop and of this report, the two terms are not identical and should not be used interchangeably. They stressed the importance of clarity and transparency with regard to the motivations for various activities that have been described by the term science diplomacy, and simultaneously acknowledged the difficulties in arriving at a single definition of the term and in defining boundaries that should be drawn between science cooperation and science diplomacy.

DEFINITION OF SCIENCE DIPLOMACY

Lama Youssef of Syria pointed out that according to Webster's Dictionary, *diplomacy* is defined as "the art and practice of conducting negotiations between nations" and also as "a skill in handling affairs without arousing hostility." Those two are quite different definitions with different implications. Since a primary meaning of diplomacy is as an instrument of governments, some understand science diplomacy as a way to pursue a national agenda, or otherwise stated, a component of "soft power." Youssef noted that one of the international science community's main objectives, trust building, is not compatible with the idea of soft power. According to her, even though science diplomacy promises to rise above conflict, the term raises serious ideological questions and practical challenges. Such challenges are apparent in the Middle East, where U.S. policies evoke doubts about true intentions. John Boright, executive director for international affairs for the U.S. National Academy of Sciences (NAS), cautioned against implying that potentially divisive national agendas are being pursued when using the term "science diplomacy," in cases where the motivation is simply advancing science, addressing common problems, and building personal relationships. Scientific cooperation and exchanges between the United States and Iran were cited as an example of cases in which the label science diplomacy could affect scientific counterparts negatively.

> *Clarity and transparency are important. The kinds of things many of us are doing can help in improving people's lives. But it is not always clear that it is a good idea to label it "diplomacy."*
>
> John Boright, Executive Director, International Affairs, U.S. NAS

Diplomacy is also seen as the science or art of avoiding difficulties and successfully engaging in a dialogue with others; thus, it is not surprising that many workshop participants regarded science diplomacy as a useful means of global engagement. As Vaughan Turekian stated, science is a good way to engage with people from other countries, because it provides a common language, is collaborative, addresses major societal challenges, and is based on common methods (peer review, for example). But participants noted that, at the same time, global scientific engagement, if called diplomacy, can be problematic for many U.S. governmental agencies, such as the National Science Foundation (NSF), which have mandates to advance science—but not foreign policy. Therefore, there are advantages to using the simple, and accurate, label of advancing science through international cooperation.

Norman Neureiter, first science and technology advisor to the U.S. secretary of state, warned against defining science diplomacy exclusively by the words *science* and *diplomacy* together. Instead, it is a more complex concept and can be understood better by considering examples. Several examples from Neureiter's and others' extensive experience in international engagement are mentioned in the section "What Has Been Done with Science Diplomacy?" in this chapter.

Hernan Chaimovich from Brazil voiced concern about the definition of science diplomacy used in the United States because it implies the existence of a conflict. This, he observed, can result in less focus on scientific exchanges with regions such as Latin America and South America, where engagement is highly desirable.

Several times during the workshop, participants referred to the Royal Society and American Association for the Advancement of Science (AAAS) report *New Frontiers in Science Diplomacy* (2010)[1], which presents a proposed set of three roles related to science diplomacy:

1. *Informing foreign policy objectives with scientific advice (science in diplomacy)*

Science can be used to inform diplomatic decisions or agreements, which can be called science in diplomacy. In this case, a science study can set out the relevant evidence to help solve a disagreement between two countries.

2. *Facilitating international science cooperation (diplomacy for science)*

This role often refers to flagship international projects in which nations come together to collaborate on high-cost, high-risk scientific projects that otherwise could not be conducted. But it also refers to the set of policies, such as those governing international travel, that facilitate international science cooperation.

3. *Using science cooperation to improve international relations between countries (science for diplomacy)*

This role refers to the use of science as a means to improve strained relations between different countries. Science cooperation agreements and joint commissions between the United States and the Soviet Union (USSR) or China during the cold war are examples of the role science and scientists can play in diplomacy.

ACTORS IN SCIENCE DIPLOMACY

Participants suggested that a way to frame science diplomacy is to identify possible actors. Several felt that when discussing science diplomacy, one generally emphasizes the important role of the government. James Herrington praised the efforts in the 1960s by Congressman John Fogarty, who pushed for a global agenda in medical research and public

[1]The Royal Society and AAAS. 2010. *New Frontiers in Science Diplomacy*. London: The Royal Society.

health. Herrington deplored the scarcity of people with Fogarty's vision today. Jason Rao, senior policy advisor at the White House Office of Science and Technology Policy, also recognized government's essential role. He noted that much of the government policy framework is still stuck in the cold war, which makes actions on the ground difficult. However, at the same time, there is recognition at the highest level of the U.S. administration that the challenges mentioned in this discussion are the grand challenges of today.

Hernan Chaimovich also suggested that science diplomacy is done by the state, and while science can be a tool for diplomacy, it is part of a government's policy. According to him, the problem we are facing today is the relationship between a government's policy and the agencies that are effectively engaged with scientific cooperation, including the private sector. As an example, he referred to the stagnant budget of NSF's international division over the past few years, which appears to be mainly due to policy issues.

Several participants underlined the importance of funding. Daniel Goroff of the Sloan Foundation stated that science and scientific knowledge are a public good, which by definition is nonexcludable and nonrival, meaning that no one can be excluded from using it, and its "consumption" by one individual does not reduce its availability to another individual. Most people expect it to be free, but in fact, it does have a cost. Therefore, it takes collective will and organization to make science happen.

Another question was about whether the corporate world was doing science. Vaughan Turekian stated that "governments and metascience organizations (academies, associations, and so on) do science diplomacy, scientists do science, and businesses do business." One comment was that a science component in governmental diplomacy is valuable, but science must still be real science; it must be true to the scientific method, for example, not using selected evidence to reach a desired conclusion. Susan Gardner of the U.S. Department of State observed that although businesses do indeed focus on business, their activity can influence relationships and interstate diplomatic outcomes positively or negatively. This and several other examples and comments emphasized the scale, effect, and importance of science and technology efforts outside of government.

Participants offered examples where science diplomacy was valuable and where interactions among scientists, whether in the government, nongovernmental organizations (NGOs), or the private sector, contributed to building bridges and addressing common problems. Several participants suggested implementation principles, including clarity and transparency of goals; focusing on clear, common interests; sustained cooperative relationships with individuals and institutions; and the importance of involving young participants.

WHAT HAS BEEN DONE WITH SCIENCE DIPLOMACY?

Workshop participants provided many examples illustrating the role that science can play in building bridges between nations. U.S.–USSR, U.S.–Japan, and U.S.–China cooperation was mentioned by several as a means of moving away from hostile relationships.

Norman Neureiter recalled that in 1961, as the nuclear arsenals were building up, scientists from the United States and Russia met privately to discuss how to prevent a nuclear catastrophe. In the same year, Edwin O. Reischauer, appointed as the U.S. ambassador to Japan by President Kennedy, helped initiate scientific exchanges through the U.S.–Japan Joint Committee on Scientific Cooperation at a moment of "broken dialogue" between the two intellectual communities. This joint committee is still operating today and is a classic example of successful science diplomacy.

Neureiter also reviewed President Nixon's historic 1972 diplomatic visit to China, noting its contribution to the normalization of relations between the two countries and stressing that science played an important role in that achievement. Neureiter, who was at that time the assistant for international affairs for President Nixon's science advisor, worked with the National Academy of Sciences on a previously established Committee on Scholarly Communications with China and produced several initiatives for science cooperation that were part of the diplomatic package discussed with the Chinese government.

Another example is the 1972 Moscow summit with President Nixon and Russian President Brezhnev, which led to the creation of a joint committee on science cooperation that resulted in seven science agreements. Unfortunately, U.S.–USSR science cooperation was cut off under President Jimmy Carter after Russia's invasion of Afghanistan. As Norman Neureiter noted, science was the driver in these programs, but results were achieved both at the scientific and at the diplomatic levels. This can still be done today, with the United States continuing to face many challenges in engaging the world.

David Hamburg, president emeritus of the Carnegie Corporation of New York, added to the historical perspectives on the important role of dialogue among scientists in reducing the threat posed by superpower confrontation. He noted that at times the science community was ahead of foreign policy leaders in demonstrating that value. For example, Hamburg was involved in discussions related to the Cuban missile crisis and consideration of communication steps aimed at prevention of a nuclear catastrophe. He recalled numerous discussions between scientists and policy makers and the important role they played in analyzing the crisis at that moment and setting approaches and practices for minimizing the risks of future confrontations. The scientific community remained closely involved in bridging the gap created during the cold war and was particularly helpful during Gorbachev's presidency as he was attempting to change Soviet policies. During Hamburg's presidency of the Carnegie Corporation, he participated in the creation of Carnegie commissions such as the Commission on Science, Technology, and Government in 1988 and the Commission on Preventing Deadly Conflict in 1994, subsequent to the deadly war in the former Yugoslavia.

After the end of the cold war, he said, the science aspect of U.S. diplomacy was considerably less dramatic. But in recent years, it is once again becoming increasingly clear that science is a valuable way to engage more actively with nations that have strained or complex relations with the United States, such as Iran, North Korea, Cuba, Syria, and Myanmar. Science is once again being used as a bridge-building strategy.

This is also true when science diplomacy is applied to bridging the societal domain (governance, economy, and values) and the natural domain (ecosystem, water quality, and water quantity) said Shafiqul Islam of Tufts University. He underlined the importance of building interdisciplinary teams and cited the program in water and diplomacy at Tufts University as a successful model, mainly because it created a network of complementary teams from different parts of the world.

Emerging nations such as Rwanda can act as ambassadors for science and play an active role in promoting it nationally and internationally, suggested Romain Murenzi, former minister of science, technology, and scientific research for Rwanda. Rwanda's government has a strong belief in the important role of science, technology, and information and communication technologies (ICT) in transforming the country from an agriculture-based economy to a knowledge-based economy. Murenzi highlighted the personal commitment of Rwanda's president, His Excellency Paul Kagame, who gave keynote addresses at meetings of the Royal Society, AAAS, and the U.S. Department of State and pointed toward the Rwandan Integrated ICT-led Socio-Economic Development Policy and Plan and the work of the Kigali Institute of Science and Technology. Murenzi then reiterated the role of the private sector and corporate partnerships in building science and technology capabilities.

BARRIERS TO PROGRESS IN SCIENCE DIPLOMACY

Workshop presentations and discussions on barriers to progress and best practices for advancing science in the global context and for science diplomacy were very similar. Participants suggested several barriers to progress that are also encountered in science diplomacy.

Unclear Motivations and Restrictions on Mobility

The U.S. government has been actively undertaking science diplomacy efforts in the last few years. Some participants stated that these efforts are most important when there are difficult governmental relationships, which can lead to sensitivity as to the motivation behind these efforts. They noted that the limitations on U.S. use of science in diplomacy are often long-standing policies and laws that were motivated originally and primarily by a concern for control of technology, whereas now what seems most needed is engagement and the embrace of competition. This is particularly salient in unnecessarily cumbersome mobility controls, that is, visas and travel restrictions.

Foreign professionals were described as often being of two minds: They value collaborating with U.S. counterparts, yet many are also apprehensive about attending conferences within the United States because of visa uncertainties and difficulties, and security controls. Science envoy Gebisa Ejeta noted that implementation of controls in the United States since September 11, 2001, has been very discouraging and has stifled its global engagement capacities. Several workshop participants also noted that U.S. policies ought to recognize that effective competition raises the bar for everyone and serves as a major source of future opportunities.

Weak Public–Private Partnerships

Many participants emphasized the importance of the private sector in global science and technology engagement. As Eric Bone of the U.S. Department of State observed, partnerships with the private sector are essential, and science diplomacy should not be restricted to a government-to-government exercise. Unfortunately, capacity for this type of partnership is weak in the developing world, noted Gebisa Ejeta. A related impediment, he said, is that existing policy and regulatory frameworks have been perceived by some as biased towards the developed world. This is particularly relevant to intellectual property rights, such as the ones generated by the 1985 Utility Patent Act for biological agents and products. This act encouraged the heavy infusion of financial resources to private-sector research in the field of molecular biology. It also resulted inadvertently in a significant reduction in public research spending in both developed and developing countries. These new investments in the private sector triggered a rush of patenting, in some cases fueling misunderstandings among poor and rich nations. Ejeta added that public–private partnerships in the developed world also need to be revisited. For example, increases of private investments in agricultural biotechnology are associated generally with decreased public spending, thus creating an unhealthy imbalance.

Inflexibility in U.S. Government Programs

Despite the many efforts put forward by the U.S. government, the discussion identified difficulties for foreign organizations in engaging U.S. governmental science agencies. Discussion leader Michael Clegg pointed to the diversity and the structural complexity of the U.S. science agencies and the lack of mechanisms for coordinating and integrating diplomatic activities undertaken by the government, businesses, and NGOs. Existing bureaucratic diversity and inflexibility, he said, often makes communication with U.S. agencies difficult and inhibits science diplomacy endeavors. Eric Bone also noted the disconnect between the form that science diplomacy is taking today and the current organizational structure.

Volker ter Meulen, of University of Würzburg and former president of the German Academy of Sciences Leopoldina, underlined the common inflexibility in decision-making processes and described a political culture of "short-termism" among policy makers, where science is expected to provide easy answers quickly and contribute on short notice to single issues. Instead, he suggested building longer-term relationships between scientific and political communities based on trust and mutual confidence. He also noted the importance of creating and maintaining flexibility in political decision making and of being "prepared for the unexpected" to be able to deal with future developments and a changing evidence base.

Lack of Incentives

Another barrier that was identified by several workshop participants is the lack of incentives in both the U.S. government and academia for the participation of U.S. professionals in international science. Gebisa Ejeta observed that scientific achievements enabled by global collaborations are often not credited appropriately, and for most academic leaders, engagement in international development is undertaken at the expense of their domestic responsibilities. Several workshop participants also highlighted the importance of engaging scientists in diplomatic conversations. They emphasized the need for more science attachés in U.S. embassies and suggested implementing a better structure within the State Department to make it easy, attractive, and useful for people from the science community to serve as science attachés.

> *We need more people from the science community to work within the Department of State.*
>
> Eric Bone, Senior Scientist and Policy Advisor, U.S. Department of State

Lack of Human Capital and Infrastructure in Partner Developing Countries

A serious lack of human capital, coherent national science and technology strategies, and research infrastructures in potentially partnering countries was identified by some workshop participants as an important barrier to more effective international engagement. Gebisa Ejeta and others stated that weak human capacity, in part owing to brain drain, and the lack of adequate research infrastructure in developing countries has too often derailed promising science-based developments or worse, prevented their successful exploitation.

Ejeta also underlined the differences in goals and aspirations between institutions in the United States and those in developing countries that often create an awkward dialogue about the objectives of collaborative partnerships. Most of the advanced research institutions in the developed world aim at creating a global public good; in contrast, research centers in most developing countries focus on the development of locally needed products and services. Nevertheless, he believed that the two goals are mutually supportive, and if the parties communicate and work together, a win-win scenario often can be reached. He also noted an overreliance in developing countries on external funding to capitalize on science diplomacy and global science cooperation opportunities, which is, of course, largely because of insufficient local resource commitment to science. There is a shortage of functional research centers and science support architecture such as science and technology commissions, merit-based funding mechanisms, or science academies in the developing world.[2] Several participants identified building such structures as an important goal of science diplomacy.

Lack of a Unified Voice Within the Science Community

Many workshop participants underlined the failure of scientists to effectively engage policy makers and the public in understanding the role of science and its potential value in diplomacy and in development.

According to Volker ter Meulen, the main challenges are the lack of a unified voice to speak on behalf of science and the lack of experience within the political institutions to use science and effectively communicate with the science community. This challenge is often compounded by the multiplicity of other voices in a crowded world. In a very complicated diplomatic system, involving NGOs, intergovernmental organizations, media, and new communication modes and networks, the scientific community must learn how to inform and engage more effectively with all these groups and governments. Furthermore, several participants underscored the importance of recognizing that many of the major policy challenges require science in diplomacy across a broad front. For example, tackling the Millennium Development Goals requires understanding and action on food, health, and the environment, which involves multiple government departments

> *The scientific community needs to understand the dynamics of the increasingly complex diplomatic system and make sure that the science voice is heard.*
>
> Volker ter Meulen, former President, German Academy of Sciences Leopoldina

[2]While not every country has a science academy, the number is growing. The Academy of Sciences for the Developing World (TWAS) is an autonomous international organization whose principal aim is to promote scientific capacity and excellence for sustainable development in the South (http://twas.ictp.it/).

There is also the Inter-Academy Panel (IAP), a global network of the world's science academies launched in 1993. Its primary goal is to help member academies work together to advise citizens and public officials on the scientific aspects of critical global issues." (http://www.interacademies.net/)

and requires a coherent and integrated policy. Unfortunately, noted one discussant, there are often organizational barriers within and between governments, in addition to the low public understanding and support for such policies.

Broken Promises

Some workshop participants felt that another challenge to effective science diplomacy is the failure of governments to implement commitments made in bilateral, summit, and other meetings, thus undermining the credibility of the science diplomacy process. As observed by Michael Clegg, the United States and other advanced nations make commitments that they do not always honor. For example, unmet expectations of U.S. agency participation in joint projects of the U.S.–Mexico Foundation for Science, created by good intentions, have led to an awkward situation between the two partners. Larry Weber of NSF noted a similar situation after the U.S. government put forward a broad Middle Eastern agenda, fueling large expectations in the Arab and Muslim worlds. Considerable efforts and progress have been made, yet financial support was insufficient to meet high expectations created by publicly announced agendas.

> *New is not always better; we may want to do more of what we have always done well.*
>
> Gebisa Ejeta, Distinguished Professor of Agronomy, Purdue University, and U.S. Science Envoy

There may be too much of a tendency to assume that new initiatives are needed, noted Gebisa Ejeta. In many cases there are already existing programs and agencies for international cooperation that have important goals and have built capabilities but do not have enough resources, and it may be effective to provide the programs already in place with needed resources.

BETTER APPLICATIONS OF SCIENCE DIPLOMACY

Workshop participants suggested a variety of ways to improve current and future science diplomacy efforts, some of which are described below. These suggestions came from individual participants and do not represent a consensus of the workshop attendees or the committee.

Better Partnership Between Government, Private Sector, and NGOs

Several participants believed that there is a need for better partnerships between the government, the private sector, universities, and NGOs, in both the developed and the developing world. C. D. Mote Jr. and others promoted revisiting the government-university partnership articulated in Vannevar Bush's *Science: The Endless Frontier,* in light of the global challenges we are facing in the twenty-first century, the large private-sector role in technology transfer, and the global nature of contemporary scientific inquiry.

For developing countries, Abdul Hamid Zakri, science advisor to the prime minister of Malaysia, noted the increasing number of U.S. companies with branches and operations and many technical employees in the developing world. These companies could collaborate easily with local universities and thus further capacity building in developing countries.

Involvement of Young People

Many participants underscored the role of young people, describing existing and potential ways to involve them in science diplomacy efforts. Marvadeen Singh-Wilmot of Jamaica told of the creation of a Young Scientist Ambassador Program (YSAP, see Box 1-1) in 2010, aimed at bridging the international scientific gap by facilitating cultural and scientific interactions through the ambassadorship of young scientists. The YSAP itself grew out of the InterAcademy Panel program that involves young scientists in the World Economic Forum Summer Davos Program. The U.S. NAS Kavli Frontiers of Science symposia for leading young U.S. and foreign scientists was given as another example. Some of the early career workshop participants also noted that it is important to recognize and make efficient use of the increasing role of social media as a communication tool, especially among younger generations. For example, through the Young Scientist Volunteer Program (YSVP), early career scientists use social media forums (such as Facebook) to share scientific papers or analytical data among each other. One reason given for the importance of such programs is the huge demographic bulge of youth in many countries.

Enhancement of Scientific Capability in the Foreign Service

Abdul Hamid Zakri and other participants emphasized the value of greater scientific expertise within the Foreign Service and the State

Department. They encouraged the appointment of science attachés to U.S. embassies and suggested making this effort symmetrical in order to build sustainable relationships, thus encouraging developing countries to appoint science attachés in their embassies as well. It is important to make this career choice attractive and professionally relevant for scientists. As Rita Colwell pointed out, working on very good and real problems "might not get you the Nobel science prize, but [it could get you] the Nobel peace prize." She also suggested that, given modern communications capabilities, in some cases the most effective way of strengthening the science and technology capacity at U.S. embassies is by a series of short-term visits from U.S. technical agency representatives, instead of a multiyear assignment of one science officer.

Enhancement of Agencies' Ability to Operate

Many participants recognized that the U.S. science agency architecture is very complex and diverse. U.S. agencies have to operate within constraints, such as restrictions on spending outside of the United States, and overall flat or decreasing funding, making innovative international collaboration difficult. "Form has to follow function," said Cutberto Garza, which means that these constraints need to be addressed so that we can move forward and make it more straightforward for our partners to collaborate with U.S. agencies.

Encouragement of Competition

In several cases, participants noted specific global challenges, such as creating food security, meeting energy needs, adjusting to climate change, and controlling infectious disease, that require collective action. Khotso Mokhele noted various ways in which the U.S. policy and science system could gain significantly from embracing the emergence of new major centers of research in other parts of the world and the consequent healthy scientific competition. He suggested that instead of remaining hobbled by outdated restrictions reflecting circumstances and security concerns of past decades, the U.S. system should rise to the challenge by becoming

> *We are in a different world; let us embrace it as a positive development for humankind.*
>
> Khotso Mokhele, former President of South Africa's National Research Foundation

more attractive; this includes reducing mobility constraints on incoming students, visitors, and scholars and revising the current visa system, perhaps requiring new Congressional action, as suggested by Rita Colwell.

Emphasis on Educational and Professional Development

Azamat Abdymomunov, former vice minister of education and science of the Republic of Kazakhstan, underlined the need for a stronger emphasis on science and technology in higher education and professional development. He added that meeting this need is crucial to economic development and other important goals of science diplomacy. Unfortunately, in some developing countries, higher education is separated from research and, instead of providing opportunities to develop relevant skills for the modern workplace, or even more for innovation and job creation, higher education is limited to being a buffer zone between high school and labor-force entry. As a result, many young people seek to enter the labor force without the necessary professional skills or experiences. And, as observed by Abdymomunov, “a young frustrated, unemployed person can be as dangerous as a nuclear physicist or a bioweapons engineer.”

Cutberto Garza noted that in the United States there is a need for better preparation for the globalized world, including science diplomacy opportunities. Despite English being the language of science, there should be more emphasis on making Americans more culturally and linguistically aware and globally skilled to both engage effectively and compete effectively in the twenty-first century. There is also a need to develop new communication tools, so that scientists and science programs can reach out to non-anglophone communities, said Mohamed Behnassi of Morocco.

Effective Involvement of Politicians and the Public

Several workshop participants noted that scientists need to develop appropriate communication skills and experiences to engage domestic and international politicians and the public more effectively. One participant suggested publishing science diplomacy-related articles in foreign affairs journals instead of scientific journals, to expose politicians and the public to the importance of science in international affairs, and to the significance of what is currently being done. Furthermore, Hernan Chaimovich stated that science diplomacy and leadership can help convey that science literacy is a vital part of general education in globalized, knowledge-driven economies, and key to national success and cultural independence.

> *We need outstanding scientists from the United States to come to our countries and bombard the people and the children with science. Let them know that science has answers.*
>
> Marvadeeen Singh-Wilmot, Professor of Chemistry, University of the West Indies, Jamaica

Participants from some developing countries noted that there often is an unmet need to strengthen a science culture and help position science appropriately within civil society. "In my part of the world, science and scientists have no status," said Marvadeeen Singh-Wilmot. She asked outstanding U.S. scientists to visit developing countries and bring the importance of science to public attention. In many developing countries, sustained cooperative activities and frequent exchanges will be needed to maintain momentum and finally build a science culture.

Emphasis on the Interface of Science and Policy

Abdul Hamid Zakri and other participants called for the creation of centers of excellence that would focus on the interface of science and policy. Lama Youssef added that the discourse on science diplomacy should not only be based on emotions but be based mainly on research to see whether it is efficient.

Importance of Transparency and Clarity

Many participants reiterated the importance of clarity, transparency, and directness in the science diplomacy process: We need to be selective in choosing clear terms to explain what we are doing and why. Azamat Abdymomunov suggested clearly defining and communicating national interests to partners, to avoid future misunderstandings and contribute to building mutual trust.

During the last session, participants reflected on issues that were raised during the two days of the workshop. They noted that there was a substantial overlap between the applications of global science and science diplomacy, while recognizing the importance of distinguishing between the two types of endeavors and clearly communicating the motivations behind each.

Appendix A

Workshop Agenda

U.S. AND INTERNATIONAL PERSPECTIVES ON GLOBAL SCIENCE POLICY AND SCIENCE DIPLOMACY

February 25–26, 2011
Palomar Hotel
Washington, DC

February 25

8:00 a.m. **Continental Breakfast**

8:30 a.m. **Welcome**

Ralph J. Cicerone, President, National Academy of Sciences
Philip Coyle, Associate Director for National Security and International Affairs, White House Office of Science and Technology Policy

8:50 a.m. **Statement of Meeting Goals**

Michael T. Clegg, Foreign Secretary, National Academy of Sciences, and Committee Chair

U.S. Policy for Global Science

The practice of science is increasingly globalized. At the same time, global problems often require science and engineering resources and solutions that one nation alone cannot provide. Thus, global policy for science requires new approaches and allocation of resources to meet these changing needs. This session will look at ways to advance global science overall, to make U.S. science investments more effective in a globalized world, and to respond to important societal needs.

9:00 a.m. Introduction by C. D. (Dan) Mote Jr.

9:15 a.m. Session I: Patterns of Mobility and Changing Patterns of Movements of Global Talents

What mobility and special skills do U.S. scientists need in today's globalized world? What challenging and beneficial implications does the reverse brain drain in countries like India and China have for the United States? How can the United States help developing countries deal with the effect of brain drain? What special initiatives that foster new linkages and collaborations and engage young and promising scientists and engineers (including in developing countries) should be pursued?

Moderator: Charles M. Vest
Discussion Leaders: Rita Colwell, Khotso Mokhele

Short Break

10:30 a.m. Session II: Maximizing Scientific Advances in the Context of an Increasingly Global Research Community

How can bilateral and multilateral scientific collaborations be enhanced by removing barriers and by finding ways for federal programs to be more flexible and innovative? Could resource allocation be more efficient? Are there important gaps?

Moderator: C. D. (Dan) Mote Jr.
Discussion Leader: Celia Merzbacher

12:00 p.m. Lunch

1:00 p.m. **Session III: Promising Areas for High Impact Collaboration and Activities**

What scientific areas or cooperation modes for highly effective collaboration and activities will be most likely to generate promising results? What role can small-scale scientific collaboration projects play? What is best done within the private sector, the public sector, and in public–private partnerships?

Moderator: Cherry Murray
Discussion Leaders: Karen Strier, Tom Casadevall

Short Break

2:30 p.m. **Session IV: Effective Global Science**

What are examples of effective global science policy? How can effective global science policy be measured?

Moderator: Judith Kimble
Discussion Leaders: Hernan Chaimovich, Larry Weber

4:00 p.m. **Reflection on the Day's Discussion**

Moderator: Michael T. Clegg

5:30 p.m. **Working Dinner**

February 26

8:00 a.m. **Continental Breakfast**

Science for Diplomacy—Diplomacy for Science

While scientists have acted as representatives of their own countries and thus used, consciously or unconsciously, diplomatic approaches in their scientific engagement with international partners for a long time, the term science diplomacy has gained increasing use in recent years. This session will look at barriers to and better application of international science diplomacy.

8:20 a.m. **Introduction by Norman Neureiter**

8:30 a.m. **Session I: Framing the Issue: The Role and Definition of Science Diplomacy**

The term *science diplomacy* has been used widely in recent years, not always with the same understanding of its definition. This session will set the basis for how this term is being used in this workshop.

Moderator: Norman Neureiter
Discussion Leaders: Lama Youssef, Doron Weber

9:30 a.m. **Session II: What Has Been Done with Science Diplomacy?**

In which cases has science contributed successfully to diplomatic goals and vice versa? When has it failed and why?

Moderator: John Boright
Discussion Leaders: Shafiqul Islam, Munir Alam, David Hamburg

Short Break

11:00 a.m. **Session III: Barriers to Progress in International Science Diplomacy**

Science and diplomacy meet and are being applied to a complex environment of different interests. What are the main impediments to progress in international science diplomacy?

Moderator: Michael T. Clegg
Discussion Leaders: Gebisa Ejeta, Volker ter Meulen

12:30 p.m. **Lunch**

1:30 p.m. **Session IV: Better Application of Science Diplomacy**

How can the United States and its partners make better use of science diplomacy? How can international science diplomacy methods be improved, including special initiatives and engagement of young scientists that help foster new linkages and collaborations? What lessons can the United States learn from successful examples of science diplomacy?

Moderator: Vaughan Turekian
Discussion Leaders: Abdul Hamid Zakri, Marvadeen Singh-Wilmot, Azamat Abdymomunov

3:00 p.m. Going Forward: Summary of the Workshop Discussion

Based on the discussions and the attendee's reflections, this session will respond to the workshop goals and summarize promising examples of successful approaches and suggestions for science diplomacy and offer more flexible and innovative ways for federal agencies to enhance international scientific collaboration and respond to changing patterns in global scientific movement.

Moderator: Cutberto Garza

Appendix B

Workshop Participants

Azamat Abdymomunov
Massachusetts Institute of Technology
Office of the Prime Minister, Kazakhstan

Munirul Alam
International Center for Diarrheal Disease Research, Bangladesh

Mohamed Behnassi
Faculty of Law, Economics, and Social Science
Ibn Zohr University, Agadir, Morocco

Eric Bone
Office of Science and Technology Adviser to the Secretary of State
U.S. Department of State

John P. Boright
U.S. National Academy of Sciences

Thomas Casadevall
U.S. Geological Survey

Hernan Chaimovich
Butantan Foundation, Brazil

C. I. (Jim) Chang
Army Research Laboratory
U.S. Department of Defense

Michael T. Clegg
U.S. National Academy of Sciences

Corey A. Cohn
Office of Science
U.S. Department of Energy

Rita R. Colwell
Center for Bioinformatics and Computational Biology
University of Maryland

Gebisa Ejeta
Department of Agronomy
Purdue University

Mohamed M. El-Faham
Center for Special Studies and Programs
The Library of Alexandria, Egypt

Susan C. Gardner
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Cutberto Garza
Boston College

Daniel L. Goroff
Alfred P. Sloan Foundation

David A. Hamburg
Carnegie Corporation of New York
American Association for the Advancement of Science

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Tufts University

Judith Kimble
Department of Biochemistry
University of Wisconsin–Madison

Celia Merzbacher
Innovative Partnerships
Semiconductor Research Corporation

Khotso Mokhele
Impala Platinum Holdings Ltd. and Adcock Ingram Holdings Ltd., South Africa

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Romain Murenzi
American Association for the Advancement of Science

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Norman D. Neureiter
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Vaughan Turekian
International Office
American Association for the Advancement of Science

James M. Turner
Office of International Affairs
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Charles M. Vest
U.S. National Academy of Engineering

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Doron Weber
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Larry H. Weber
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National Science Foundation

Lama Youssef
Ministry of Higher Education, Syria

Abdul Hamid Zakri
Office of the Prime Minister, Malaysia