

Science Diplomacy to Promote and Strengthen Basic Research and International Cooperation

Workshop

The National Academies of Sciences, Engineering and Medicine (NASEM)
Washington, D.C., USA, 12-16 March 2021

The Workshop co-sponsored by NASEM and the U.S. National Science Foundation (NSF) was organized by a Planning Committee **Bill Colglazier** of the American Association for the Advancement of Science (USA), **Alice Abreu** of the Federal University of Rio de Janeiro (Brazil), and **Alik Ismail-Zadeh** of the Karlsruhe Institute of Technology (Germany) together with the **NASEM Policy & Global Affairs Division**.

The workshop addressed the role of the Global Research Council (GRC)¹ in science diplomacy to promote and strengthen basic research and international collaboration. The goals of the workshop was to (i) describe institutional goals and structures currently available or being proposed for international basic research cooperation in a frame of science diplomacy; (ii) consider areas within basic research that might be worth exploring in greater depth to better connect research funders and science diplomacy practitioners (e.g. diplomats, researchers); (iii) explore opportunities for GRC and funder communities to work together on those areas and projects; and (iv) discuss roles that multilateral organizations might play in contributing to international basic research cooperation.

The workshop was opened by **Bill Colglazier** and **Vaughan Turekian** (NASEM Policy & Global Affairs Division Director), who presented the goals of the meeting. The Planning Committee invited **Katja Becker**, German Research Foundation's (DFG) President, to give a keynote speech, as GRC Governing Board Chair, to introduce the GRC goals and work in science diplomacy. The keynote presentation was followed by two panels. Panel "National Funders' Perspectives of Basic Research and Science Diplomacy" featured leaders of the National science foundations of Brazil, China, Ireland, Japan, Russia, South Africa, and UK, namely, **Molapo Qhobela**, former CEO of the National Research Foundation of South Africa, **Susumu Satomi**, President of the Japan Society for the Promotion of Science, **Jinghai Li**, President of the National Natural Science Foundation of China, **Mark Ferguson**, Director General of the Science Foundation Ireland, **Vladislav Panchenko**, Chairman of the Board of the Russian Foundation for Basic Research, **Andrew Thompson**, UK Research and Innovation International Champion; and **Luiz Eugênio Mello**, Scientific Director of the São Paulo Research Foundation. The panel discussed the ways of using science diplomacy tools to promote bilateral and multilateral scientific cooperation. This panel discussion was followed by the panel "Perspectives of U.S. Government Funders and Private Foundations of Basic Research and Science Diplomacy", where the representatives of the U.S. Department of Energy (former Director **Chris Fall**), National Science Foundation (**Kendra Sharp**, Director of the Office of International Science and Engineering), National Institutes of Health (**Christine Sizemore**, Director, Division of International Relations, Fogarty International Center), Air Force Office of Scientific Research (**Ali Sayir**, Program Manager), and Kavli Foundation (**Cynthia Friend**, President) discussed how US national funding science agencies promotes bilateral and multilateral cooperation. The panelists discussed how (i) to select a few major challenging topics to be addressed and done well; (ii) to develop science diplomacy programs during the time of political tensions between nations;

¹ Global Research Council (GRC) is a virtual organization, comprised of the heads of science and engineering funding agencies from around the world, dedicated to promote the sharing of data and best practices for high-quality collaboration among funding agencies worldwide (<https://www.globalresearchcouncil.org/>)

(iii) to facilitate basic research to benefit nations and to complement each other; (iv) to concentrate on mission-driven research; and (v) to promote international cooperation for innovations. **Alice Abreu** moderated the final general discussion of Day 1.

Day 2 of the workshop was dedicated to the discussion of the international scientific partnership among nations. **Arthur Bienenstock** of Stanford University and **Shirley Malcom** of the American Academy of Arts and Sciences (AAAS) presented two major recent reports on Challenges for International Scientific Partnership developed by the AAAS. The presentations were followed by the panel discussing perspective of non-governmental national science institutions such as the US National Academy of Sciences (**John Hildebrand**, Foreign Secretary), the Indian National Science Academy (**Ashok Singhvi**, former Vice President), the Academy of Science of South Africa (**Jonathan Jansen**, President), and the Brazilian Academy of Sciences (**Luiz Davidovich**, President). The following panel “Perspectives of international scientific institutions that conduct research and/or represent the views of the scientific community” discussed how international basic research cooperation is promoted by multilateral organizations and featured **Heide Hackmann**, CEO of the International Science Council, **Albert van Jaarsveld**, Director General and CEO of the International Institute for Applied Systems Analysis, **Segenet Kelemu**, Director General and CEO of the International Centre of Insect Physiology and Ecology, in Nairobi, Kenya, and **Charlotte Warakaulle**, Director of International Relations of CERN, The European Organization for Nuclear Research. The panels’ discussions were concentrated around major points, such as importance of high-impact multilateral research collaboration, avoiding politicization of science, vaccine diplomacy, trust in science, the role of open science, and some others. **Alik Ismail-Zadeh** moderated the final general discussion of Day 2.

Day 3 features two panels related to the emerging issues related to science policy (the first panel) and to future opportunities for science diplomacy (the second panel). The first panel was moderated by **Alice Abreu** and presented discussion on open science (**Shamila Nair-Bedouelle**, UNESCO Assistant Director-General for Natural Sciences), Research Security & Cybersecurity (**Rebecca L Keiser**, National Science Foundation), Security & Visas (Amy Flatten, American Physical Society), and Diversity, Equity, Inclusion, Gender (**Dorothy Ngila**, The National Research Foundation of South Africa). The second panel moderated by **Alik Ismail-Zadeh** considered areas within basic research that might be worth exploring in greater depth to better connect research funders and science diplomacy practitioners. The panelist covered topics related to ocean presentation and UN Ocean Decade (**Craig McLean**, Acting Chief Scientist, NOAA), disaster risk reduction (**Rajib Shaw**, Chair, UNDRR Scientific and Technical Advisory Group), COVID-19 and other pandemics, social science aspects of trust and science advice (**Virginia Murray**, Senior Expert, Public Health England), climate change (**Abdalah Mokssit**, Secretary of the Intergovernmental Panel on Climate Change), and biodiversity (**Ana María Hernández Salgar**, Chair of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services). The panelists highlighted an importance of developing relationships between national science leaders, strengthening social innovations, north-south and south-south scientific relationship, and cooperation, improving communication skill and cooperation between scientists, policymakers, and society, learning of how to share the information and to assist in decision making, promoting science for crisis management and some others. The closing segment discussion was moderated by **Bill Colglazier**. The workshop provided a possibility for leaders of national science foundations, science academies, international and intergovernmental scientific organizations and programs to come together, to share ideas and to discuss important issues related to promotion of basic science via international scientific cooperation and science diplomacy.

Proceedings of the Workshop can be found below.

May 2021

SCIENCE DIPLOMACY TO PROMOTE AND STRENGTHEN BASIC RESEARCH AND INTERNATIONAL COOPERATION

Proceedings of a Workshop—in Brief

The Global Research Council (GRC) brings together heads of science and engineering funding agencies from around the world to promote data sharing and best practices, and to support high-quality collaboration.¹ The GRC plays an important role in science diplomacy, namely by promoting and strengthening basic research and international collaboration. To further define the broader role of the GRC in this space and to identify opportunities to advance science diplomacy, the National Academies of Sciences, Engineering, and Medicine (the National Academies) convened a virtual workshop on **March 12, 15, and 16, 2021**, with the goals of:

- Describing the institutional goals and structures currently available or being proposed for international basic research cooperation in the framework of science diplomacy;
- Considering the areas of basic research worth exploring in greater depth to better connect research funders and science diplomacy practitioners (e.g., diplomats, researchers);
- Exploring opportunities for the GRC and funder communities to work together; and
- Discussing roles that multilateral organizations might play in contributing to international basic research cooperation.

This Proceedings of a Workshop—in Brief provides a high-level summary of the workshop discussion, including ways in which science diplomacy can promote basic research. Workshop discussions and presentations also addressed challenges to science diplomacy, proposed strategies to address them, and future opportunities to advance science diplomacy.

WELCOME AND GOALS FOR THE WORKSHOP

E. William Colglazier, senior scholar at the American Association for the Advancement of Science and editor-in-chief of *Science & Diplomacy*, served as committee chair of the workshop and provided the opening remarks. The concept of science diplomacy has gained popularity, he noted. It was initially conceived as a tool for bringing together scientists and diplomats to accomplish concrete goals (which could be scientific or diplomatic). The GRC, which is viewed as an institution of science diplomacy, has accomplished several concrete scientific objectives by bringing together large national funders and removing barriers to international scientific cooperation. In addition to the workshop goals highlighted above, Colglazier noted that the workshop will explore opportunities for the GRC and funder communities to work together to build capacity and create new partnerships in support of science diplomacy.

Vaughan Turekian, executive director of Policy and Global Affairs at the National Academies, emphasized the critical need for science diplomacy, particularly during a time when so many global challenges are confronting humankind. The GRC has demonstrated the value of bringing together science funders around the world to examine major international basic research projects. The current workshop, stated Turekian, is intended to focus discussion on opportunities for the GRC and its members to engage the broader community of science and policy experts on these important issues.

¹See: <https://www.globalresearchcouncil.org>.

INTRODUCTION TO THE GLOBAL RESEARCH COUNCIL AND WORK IN SCIENCE DIPLOMACY

Katja Becker, GRC governing board chair and president of the German Research Foundation, introduced the GRC as an organization, including its efforts and role in science diplomacy. GRC participants are key actors in national science systems, serving as intermediaries between the scientific communities and political frameworks. Science diplomacy is a complex issue, Becker noted. The Royal Society (UK) and American Association for the Advancement of Science distinguish three types of science diplomacy: diplomacy for science, science in diplomacy, and science for diplomacy. *Diplomacy for science* involves facilitating international science cooperation and advocating for multilateral and interdisciplinary science. The GRC is well suited facilitating such activities. Secondly, *science in diplomacy*, refers to the act of informing foreign policy objectives with scientific advice. This area has proven to be of major importance when examining the science related to addressing the COVID-19 pandemic, which has required joint scientific efforts, and importantly, science rooted in curiosity-driven fundamental research. Thirdly, *science for diplomacy* is the use of science to improve diplomatic relations. This type appears to be the most challenging, Becker said. The GRC is critical to promoting science diplomacy, as it focuses on the common values of science and research, develops standards of scientific practice, and promotes common understanding of diverse regional efforts.

NATIONAL FUNDERS' PERSPECTIVES OF BASIC RESEARCH AND SCIENCE DIPLOMACY

Molapo Qhobela, former CEO, National Research Foundation of South Africa, moderated a panel of national funders from several countries to gather perspectives on basic research and science diplomacy.

Susumu Satomi, GRC governing board member and president of the Japan Society for the Promotion of Science (JSPS), stated that his agency is a major research funding agency in Japan and places high value on mobilizing researchers through research autonomy, diversity, and curiosity-driven research. The agency conducts multilateral joint research, supports a robust international research network, and has developed an invitational fellowship program² to support basic research. With 10 global offices to support its work, JSPS has also promoted an international research exchange program. It also supports bilateral cooperation, with and without memoranda of understanding, with the goal of promoting academic cooperation between highly qualified Japanese and overseas researchers. Satomi said that the COVID-19 pandemic has highlighted the need for science diplomacy, as scientists all around the world have needed to work closely to identify solutions and advance scientific research through research networks.

Jinghai Li, GRC governing board member and president of the National Natural Science Foundation of China (NSFC), noted that science requires joint action to address global challenges and that good science policies are essential in promoting the development of global science and building relationships within the scientific community. Globally, we are facing common challenges that require joint international efforts along with a science paradigm shift. There is a need to examine the 17 United Nations' Sustainable Development Goals (SDGs)³ in a systematic way that will allow for joint international action (see Figure 1).

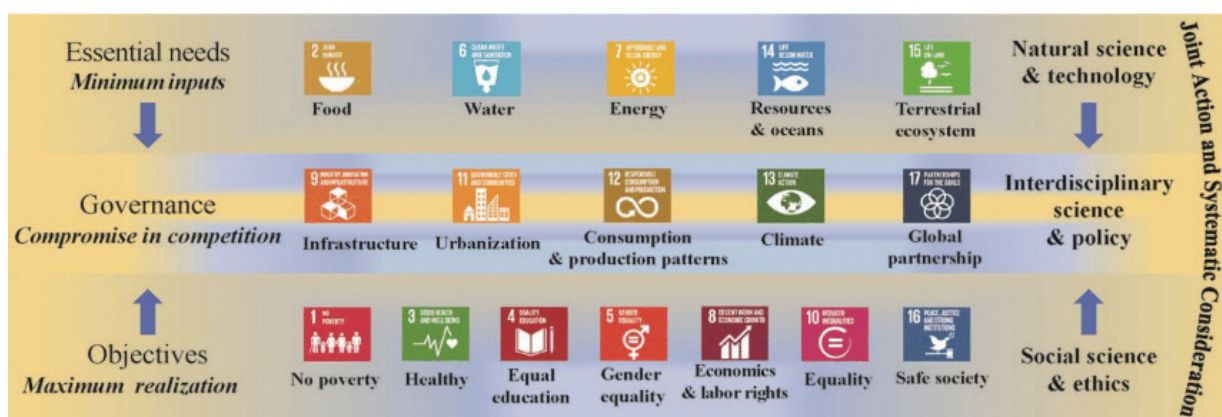


FIGURE 1 Applying science in the United Nations Sustainable Development Goals.

SOURCE: Bojie Fu, et. al. 2019. Unravelling the complexity in achieving the 17 Sustainable Development Goals. *National Science Review* 6(3):386-388.

² The JSPS carries out "invitational fellowship programs," which bring in overseas researchers to conduct collaborative research, discussions, and opinion exchanges with researchers in Japan. See: <https://www.jspf.go.jp/english/e-inv/index.html>.

³ See: <https://sdgs.un.org/goals>.

The interaction between different research and development activities is currently linear, stated Li, beginning with basic research, moving to applied research, followed by experiments and development. However, a new non-linear model should be established. Promoting open and innovative international cooperation to adapt to the paradigm shift to address common science challenges is needed. Intensifying cooperation among international funding partners is needed to improve and strengthen science policy, Li added.

Mark Ferguson, GRC governing board member, director general of Science Foundation Ireland asked: What are we trying to achieve through science diplomacy that goes beyond collaboration in science? Science diplomacy takes us beyond the benefits of scientific collaboration. Describing Ireland's science diplomacy efforts, Ferguson noted that Science Foundation Ireland is a lead agency program that fosters scientific cooperation and collaborative projects with over \$100 million in funding for global research. Ireland is significantly involved in overseas efforts to expand science and innovation, particularly in Africa, also funding projects that support peacekeeping missions. Ferguson discussed opportunities to further science diplomacy, including opportunities to develop international science prizes and expanding collaborative funding with international agencies to address global scientific challenges. He said we need to think carefully about where international systems can be put in place to take on key scientific challenges.

Vladimir Kvardakov, board deputy chairman at the Russian Foundation for Basic Research (RFBR), explained that science diplomacy work at his organization involves the promotion of national scientific priorities, sharing scientific ideas, and addressing international scientific challenges. Funding agencies can serve as science diplomacy actors by opening areas of common interest in basic research, supporting the development of international rules and regulations, among other areas. For example, he noted, in April 2020, the RFBR launched an interdisciplinary initiative to support international scientific collaboration to address the COVID-19 pandemic. The organization is also working to develop global security programs to support scientific diplomacy and has also published a special issue of the *Russian Foundation for Basic Research Journal* describing its experience in science diplomacy, which has been translated into English.⁴

Andrew Thompson, GRC governing board member and international champion of UK Research and Innovation (UKRI), described the UKRI's range of mechanisms designed to foster science diplomacy initiatives, including funding mechanisms, research infrastructures, and multilateral fora. The Fund for International Collaboration, for example, includes more than 20 partner countries engaged in research. The Global Challenges Research Fund works to support organizations in addressing the UN SDGs. There is also significant UK involvement in international research infrastructures, such as the European Organization for Nuclear Research, or CERN. Describing the UKRI's multilateral engagement, Thompson noted that the organization offers policy fora between funding agencies as well as wider stakeholders, engages in multilateral funding initiatives, such as the Belmont Forum, and demonstrates leadership in intergovernmental multilateral initiatives, such as the G7 Summit. He said we should think about multilateral engagement as one way of driving scientific interests and promoting international cooperation and coordination.

Luiz Eugênio Mello, GRC governing board member and scientific director of the São Paulo Research Foundation (FAPESP), discussed the work of his agency in supporting basic and applied research. FAPESP, for example, has created opportunities for researchers in Brazil to cooperate with international partners all over the world. International collaborations make it possible to harness complimentary scientific knowledge across institutions and countries, allows for the sharing of costs (and risks) of taking on large and more challenging projects, and provides access to a diversity of assets. FAPESP has worked to develop an extensive network of international partners to share scientific expertise and resources, and is involved in several multilateral initiatives, such as the Global Alliance for Chronic Diseases.⁵ The foundation has also been participating in and co-funding international basic research initiatives, such as the Large Hadron Collider and Sirius.⁶ Mello noted that there is a constellation of institutions and networks aiming to develop research-based solutions to scientific, social, and economic problems. Many of these have a mixed composition of scientific academies, funding agencies, government agencies, science ministries, private foundations, and research institutes; however, few are truly global.

The GRC, however, has a wide global outreach with members from all continents and is solely constituted of funding agencies with a worldwide presence. The GRC plays an important role in helping link the existing multinational research initiatives and institutions of countries that lie outside of these collaborating networks. The GRC could liaise with existing international institutions, for example, the United Nations Educational, Scientific and Cultural Organization (UNESCO), by facilitating the participation of funding agencies and scientists from a myriad of countries. Mello noted that it may be appropriate to ask whether the GRC should become a mechanism for coordinating international funding for research, or rather, an instrument to facilitate the inclusion of multiple research funding agencies and re-

⁴ Panchenko, V. et al. 2018. Russian Foundation for Basic Research Journal. 1(97). https://www.rfbr.ru/rffi/download/%E2%84%96_1%2C_%D1%8F%D0%BD%D0%B2%D0%B0%D1%80%D1%8C%E2%80%93%D0%BC%D0%B0%D1%80%D1%82_2018_%D0%B3%D0%BE%D0%B4%D0%B0.pdf?objectId=2059986.

⁵ See: <https://www.gacd.org/>.

⁶ See: <https://home.cern/science/accelerators/large-hadron-collider> and <https://section-mpc.web.cern.ch/content/sirius>.

search bodies within existing international structures and institutions.

PERSPECTIVES OF U.S. GOVERNMENT FUNDERS AND PRIVATE FOUNDATIONS ON SUPPORTING BASIC RESEARCH AND SCIENCE DIPLOMACY

Chris Fall, former director of the U.S. Department of Energy, moderated a panel of U.S. government funders and private foundations to discuss their perspectives on supporting basic research and science diplomacy.

Kendra Sharp, director of international science and engineering at the National Science Foundation (NSF), which is the only U.S. federal agency that funds basic science research and education across all fields of science and engineering, discussed the agency's efforts to enable and support international collaboration. While NSF does not have a formal definition of science diplomacy, the agency considers it a tool to advance its vision. A key building block for collaboration, whether between government agencies or between individual investigators, is trust. Science diplomacy is about building trust at all levels and is fundamental to international collaboration, stated Sharp. NSF has developed agreements for collaboration with counterpart funding agencies and works closely with U.S. diplomats to advance its scientific mission, building a strong science-based relationship with other nations—for example, through the bilateral Joint Commission on Science and Technology. NSF, along with the United States Agency for International Development, also funds collaborative research programs for students relevant to development issues. Additionally, the agency has launched a multiplier program that sends subject matter experts overseas to meet with scientists and government officials to explore targeted opportunities for international collaboration. The GRC offers a global platform by which national science funding agencies can increase cooperation, Sharp said. There are opportunities to consider how to expand these partnerships to cover all regions of the globe.

The National Institutes of Health (NIH) also has a strong international focus, with a broad range of efforts related to international health, stated **Christine Sizemore**, director of the division of international relations at the Fogarty International Center, NIH. She noted that Francis Collins, director of NIH, has emphasized the importance of engaging with other countries in discussions about global health research. Much of the collaborative work that happens is through relationships among investigators; however, the agency also fosters this collaboration through targeted opportunities, including trainings offered at NIH laboratories, strategic bilateral science programs, and international workshops and conferences, among other opportunities. Sizemore provided an example of a large biomedical research funders collaboration in which global biomedical research is contributed from research institutions and captured in a database called "World Report."⁷ Through this effort, an investigator can examine data as well as identify research funders in a particular country or region. This allows for opportunities to identify complimentary or overlapping funding priorities and further opportunities to collaborate.

Ali Sayir, program manager at the Air Force Office of Scientific Research (AFOSR), began by noting that the agency focuses on basic research, for example, investing in areas such as nanotechnology applications for medicine. The agency funds research all over the world, including 271 international research efforts in 37 countries, with funding ranging from \$150,000 to \$400,000 over a 3-year period. Of critical importance for AFOSR is the connection between principal investigators. Sayir added that the GRC could expand its efforts in science diplomacy by further engaging mission-oriented funding organizations.

Similarly, the U.S. Department of Energy (DOE) is the largest federal supporter of basic research in the physical sciences, stated **Helena Fu**, director of international and technology cooperation and trusted research at DOE. The office of science is the steward of 10 of the 17 total DOE laboratories, supporting more than 33,000 researchers and some of the most advanced tools in modern science, such as accelerators, colliders, and supercomputers. The overarching goal of DOE's international approach is to pursue mutually beneficial collaborations to advance and accelerate scientific discovery. Trust in terms of intellectual and financial contributions as well as sharing scientific credit, offering openness, transparency, and reciprocity are all critical to the agency's international work. With its overseas presence, the DOE works closely with the U.S. Department of State to achieve its science goals through diplomacy.

Fu discussed an international project, called the Deep Underground Neutrino Experiment (DUNE), which is based in the U.S. and supported by the DOE.⁸ The project is a combination of the world's most intense neutrino beam, a deep underground site, and a massive liquid argon detector that enables research to address some of the most fundamental questions in particle physics. DUNE includes 1,180 collaborators from 184 institutions in 32 nations, offering an example of how the agency leverages financial resources, expertise, facilities, and the capabilities of international partners. DUNE serves as an example for basic science and science diplomacy connecting to advance and accelerate

⁷ See: <https://worldreport.nih.gov>.

⁸ See: <https://lbnf-dune.fnal.gov>.

scientific discovery.

Cynthia Friend, president of the Kavli Foundation, described the mission of the private foundation as advancing science for the benefit of humanity. With a strong international presence, the Kavli Foundation has more than 20 research institutes funded worldwide, largely concentrated on fundamental science. The foundation also has a public engagement program that focuses on expanding public understanding of science, which Friend indicated is a critical need. Differences in cultural norms across borders can create funding challenges, as each country has different mechanisms for funding research and thus, gaps in funding vary significantly by country. Philanthropy often has the benefit of being more flexible and can provide much needed support for international research, for example, by supporting longer term and higher risk projects. Friend discussed a key coalition of philanthropic organizations called the Science Philanthropy Alliance, which is dedicated to supporting fundamental research and which includes 30 funders and \$1 billion in private funding. This alliance has worked to identify and fill gaps in science funding and has fostered international talent development. It has also taken on issues of diversity, equity, and inclusion in science. Informal science diplomacy can be a key tool in addressing international challenges. Investing in diplomatic relations is necessary to advance science and to promote a healthy scientific research enterprise, said Friend. Friend added that it is critical for government, philanthropy, academia, and industry to commit to continuing to work together for the benefit of humankind.

SUMMARY DISCUSSION: PERSPECTIVES OF NATIONAL FUNDERS, U.S. GOVERNMENT FUNDERS, AND PRIVATE FOUNDATIONS OF BASIC RESEARCH AND SCIENCE DIPLOMACY

Alice Abreu, professor emerita at the Federal University of Rio de Janeiro and committee member of the workshop, summarized the discussion from national funders, U.S. government funders, and private funders related to basic research and science diplomacy. National funders highlighted the importance of trust in science diplomacy, including discussing mechanisms for building trust and finding a common ground to pursue science initiatives. As Ferguson emphasized, partnerships are formed based on a need to build on the scientific expertise of others. Size, geography, political missions, and diversity were also identified as important factors that impact science diplomacy. The GRC plays an important role in bringing together diverse funders to support science across these factors. Funders in the U.S. and elsewhere also discussed the important role government and philanthropic institutions play in supporting and driving science.

Mike Bright, GRC executive secretary and deputy director of international (global partnerships) at UKRI, stated that the GRC itself is both an object of science diplomacy and a platform for science diplomacy. Through the GRC's convening power, it can help foster and strengthen key relationships. Ferguson stated that a good first step for the GRC to further advance science diplomacy would be to agree on a single topic of focus. Once selected, the next step would be to identify a simple mechanism for funding the selected focus area, perhaps through a lead agency. This approach would help to move beyond the traditional national funneling or the existing mechanisms for funding science, requiring all to be engaged on one issue and building research around it. Colglazier added that there are many political hurdles that are challenges to international scientific cooperation and dialogue. Science communities and countries should engage in candid dialogue on what actions are needed to ease or moderate these challenges and facilitate stronger collaboration.

Colglazier added that one of the strengths of science funded in the U.S. is that it is largely decentralized and driven from the bottom up; however, this can create its own challenges to developing a cohesive plan and response. The COVID-19 pandemic is an example of this type of challenge. While science rapidly contributed to the development of vaccines, the political apparatus in the U.S. and other countries has not done as well in distribution.

REPORTS ON THE CHALLENGES FOR INTERNATIONAL SCIENTIFIC PARTNERSHIP INITIATIVE BY THE AMERICAN ACADEMY OF ARTS AND SCIENCES: BOLD AMBITION FOR LARGE-SCALE SCIENCE

Colglazier moderated a session focused on reports from the Challenges for International Scientific Partnership Initiative, which is an initiative by the American Academy of Arts and Sciences.⁹ The Challenges for International Scientific Partnerships project aims to articulate the benefits of international collaboration and recommend solutions to the most pressing challenges associated with the design and operation of partnerships. Two working groups within this effort include the Large-Scale Science working group, which approaches international collaborations through the lens of

⁹ See: <https://www.amacad.org/project/CISP>.

issues particular to large-scale science (as opposed to peer-to-peer or small-scale international work), and the Emerging Science Partners working group, which explores issues particular to U.S. scientific collaborations with countries seeking to boost their scientific capacity.¹⁰

Arthur Bienenstock, professor emeritus of photon science, special assistant to the president for federal research policy, and director of the Wallenberg Research Link at Stanford University, is the co-chair of the Challenges for International Scientific Partnerships project. He stated that large-scale science facilities make science possible, citing the example of the discovery of the Higgs Boson particle at the Large Hadron Collider in CERN. This facility and others like it allow researchers from institutions with limited infrastructure to perform cutting edge science, bringing scientists from different organizations and nations together. However, facilities must be maintained, require political support over an extended period, and must be effectively managed. While a report by the American Academy of Arts and Sciences, *Bold Ambition: International Large-Scale Science*, provides several characteristics of large-scale projects necessary for success, Bienenstock stressed the importance of project reviews and developing stages in a project. He noted an example of next-generation gravity wave detectors, a multi-billion-dollar project that will require several detectors around the world as well as significant international collaboration. UNESCO could play a role in registering the commitments and providing some organizational capabilities for this project and others like it. The GRC might consider how these large-scale research endeavors can be supported most effectively.

Co-chair of the American Academy of Arts and Sciences Emerging Science Partners working group, **Shirley Malcom**, director of Education and Human Resources Programs at the American Association for the Advancement of Science, stated that peer-to-peer collaboration is essential and has generally been under-appreciated and undervalued in science. There is a need to utilize global scientific talent and strengthen the international collaboration that already exists as well as support more equitable collaboration across and within countries. Malcom highlighted a lack of understanding in the U.S. around the framing of research internationally, including the focus on the UN SDGs. This has resulted in differing research priorities, approaches, and a mismatch in capacity. The working group discussed ways the U.S. could become a stronger partner in research and international collaboration, for example by supporting funding for collaborations and providing credit appropriately in publications and patents, etc. Recognition of the need for fundamental science, for example, projects such as the H3Africa initiative,¹¹ was also identified along with the need for targeted efforts to address gender equality and engage young scientists.

PERSPECTIVES OF NON-GOVERNMENTAL NATIONAL SCIENTIFIC INSTITUTIONS

John Hildebrand, National Academy of Sciences Foreign Secretary, moderated and presented during a panel addressing the perspectives of non-governmental national scientific institutions on strategies to encourage science diplomacy and international collaboration.

Ashok Singhvi, former vice president of the Indian National Science Academy (INSA), noted that the Indian approach to science has been to share and collaborate through cooperative, bilateral, and multilateral engagement and research contributions with other countries. INSA represents India in international science fora as well as bilateral exchanges with other academies. Singhvi discussed INSA efforts around science and diplomacy, including the agency's creation of frameworks to support partnerships in areas related to the ocean, space, and health, among others. Education and human capital are also critical for science and diplomacy, along with the need to strengthen open access, mentorship, and foster socially responsible science, stated Singhvi. Developing shared goals, a focus on global equity, and supporting efforts to ensure the safety of scientists from international conflict, are essential to moving science diplomacy forward.

Jonathan Jansen, president of the Academy of Science of South Africa (ASSAf), began by highlighting the perspective of social science in discussions about science diplomacy. He noted that the Global Research Council paper on science diplomacy¹² was focused on the different types of science diplomacy, and he was concerned that the paper lacked political and social context. He discussed the race to develop and distribute COVID-19 vaccines and the existence of vaccine nationalism, an example of a barrier to international cooperation and science diplomacy. Vaccine distribution is also an example of an area in which science diplomacy is critically needed, Jansen noted. COVID-19 vaccines are more readily available in the West and are arriving in far too small quantities for all nations. He said there is a serious

¹⁰ Two reports by the American Academy of Arts and Sciences are forthcoming in 2021 on these initiatives, *Bold Ambition: International Large-Scale Science* and *Global Connections: Emerging Science Partners*. See: <https://www.amacad.org/news/challenges-international-scientific-partnerships>.

¹¹ See: <https://h3africa.org>.

¹² See: https://www.globalresearchcouncil.org/fileadmin/documents/GRC_Publications/Discussion_Paper_on_Science_Diplomacy-_The_Role_of_Research_Councils_and_the_Global_Research_Council.pdf.

lack of trust in science right now, which should prompt us to take a step back to ask more foundational questions about health equity, social justice and commercial interests, and common humanity above national interests.

Luiz Davidovich, president of the Brazilian Academy of Sciences, described the pillars that define his organization's understanding of science diplomacy. The first pillar is identifying the big challenges for science-based global governance, including climate change and global health, among others. The second pillar is the recognition of widespread inequality between countries and within countries, which is strongly correlated to the research and development expenditure of countries. Science diplomacy should pay attention to this inequality as well as work to mitigate it. The third pillar includes the UN SDGs. Science diplomacy should be based on these goals, which would require additional U.S. involvement and a strengthening of international institutions, including the United Nations. The Brazilian Academy of Sciences is working to address the SDGs, for example, through efforts to further the science of poverty eradication in line with the SDGs. The Brazilian Academy of Sciences also supports multilateral cooperation and is working to address critical sustainable development issues with an emphasis on the BRICS countries,¹³ which comprise 40 percent of the world's population. Davidovich also discussed the importance of encouraging open science, including data collection repositories, peer review knowledge sharing, and integration of research publications. We have learned important lessons from the COVID-19 pandemic, highlighting the need to ensure that the benefits of science are accessible to all, Davidovich said.

Hildebrand described the U.S. National Academies' efforts to foster international cooperation, collaboration, and research, particularly around empowering young scientists and professionals. He described the Kavli Frontiers of Science Symposia¹⁴ which began about 30 years ago, and which offers an opportunity to convene outstanding young scientists from around the globe. The Partnerships for Enhanced Engagement in Research (PEER) Program, another example, was established in 2011 to fund scientists and engineers in developing countries who partner with U.S. government-funded researchers to address global development challenges.¹⁵ The benefits of the PEER program model, stated Hildebrand, include that it provides funds directly to the institutions of the international researchers, empowering them with resources they need to be full partners in collaborative research. The program also helps to build international goodwill. Hildebrand also discussed the Academies' Arab-American Frontiers of Science, Engineering and Medicine, initiated in 2011, which convenes young scientists (under the age of 45) from the U.S. and 22 Arab League countries to discuss advances and opportunities in their field.¹⁶ The goals of the program include exchange and dialogue among young researchers in Arab countries and the U.S. These examples demonstrate the value of supporting young researchers by investing in capacity building in their countries, Hildebrand noted.

PERSPECTIVES OF INTERNATIONAL SCIENTIFIC INSTITUTIONS THAT CONDUCT RESEARCH AND/OR REPRESENT THE VIEWS OF THE SCIENTIFIC COMMUNITY

Colglazier moderated a panel of international scientific institutions on issues related to institutional structures and goals for international basic research cooperation within a framework of science diplomacy.

Science for diplomacy is scientific cooperation to support or improve international diplomatic relations and underpins the work of the International Science Council (ISC) as a global membership-based organization, said **Heide Hackmann**, CEO of ISC. Science diplomacy, however, is science that informs and supports foreign policy objectives. The ISC focuses on 3 areas relevant to science diplomacy. These include the need to (1) catalyze and support relevant research and scholarship, including through large international programs, priority projects, and strategic actions; (2) integrate science in global policy; and (3) further develop science systems, such as essential capacities, safeguards, and enabling conditions for international scientific collaboration. The GRC should support research and action on science diplomacy, Hackmann said. This includes leveraging influence with relevant political communities, including the ISC and other international scientific bodies, to strengthen the case for science globally.

Segenet Kelemu, director general and CEO at the International Centre of Insect Physiology and Ecology (icipe) in Nairobi, Kenya, noted that in addition to ongoing research projects, the Centre also has major capacity building program to support the work of graduate students, including through partnerships with 43 universities globally. Highlighting the importance of international collaboration, Kelemu stated that international partnerships were crucial to addressing a massive locust invasion in East Africa in 2020. The COVID-19 pandemic has also highlighted the power of science, as described previously. We need to work collectively to educate policymakers and government around the important role of science, Kelemu added. Inequities in research, particularly in Africa, where funding is less available than in Europe or the U.S., is of particular concern. While there has been progress, developing stronger research partnerships

¹³ BRICS is an acronym representing the major emerging economies and includes Brazil, Russia, India, China, and South Africa.

¹⁴ See: <http://www.nasonline.org/programs/kavli-frontiers-of-science/>.

¹⁵ See: <https://sites.nationalacademies.org/PGA/PEER/index.htm>.

¹⁶ See: <https://www.nationalacademies.org/our-work/arab-american-frontiers-of-science-engineering-and-medicine>.

would benefit all, and clear communication is necessary to build these collaborations.

Albert van Jaarsveld, director general and CEO of the International Institute for Applied Systems Analysis (IIASA), discussed several key challenges we face globally, for example, global poverty, wealth inequities, and climate change (Figure 2 illustrates the complexity of global scientific challenges). There are difficulties addressing these challenges as part of the UN SDGs due to funding instruments that are not structurally aligned. Global multilateral scientific cooperation is urgently needed, particularly as science efforts are primarily national and fragmented, he said.

van Jaarsveld added that about \$70 billion is distributed on an annual basis through funding agencies associated with the GRC, and much of that funding is directed in-country for science (see Figure 2). Our current funding system is not equipped to address these global priorities; the GRC can be a force for this agenda. Global research priorities and objectives cannot be unilaterally achieved without collaboration. Also, there is a need to fund multilateral mission-driven global priority research efforts at scale.

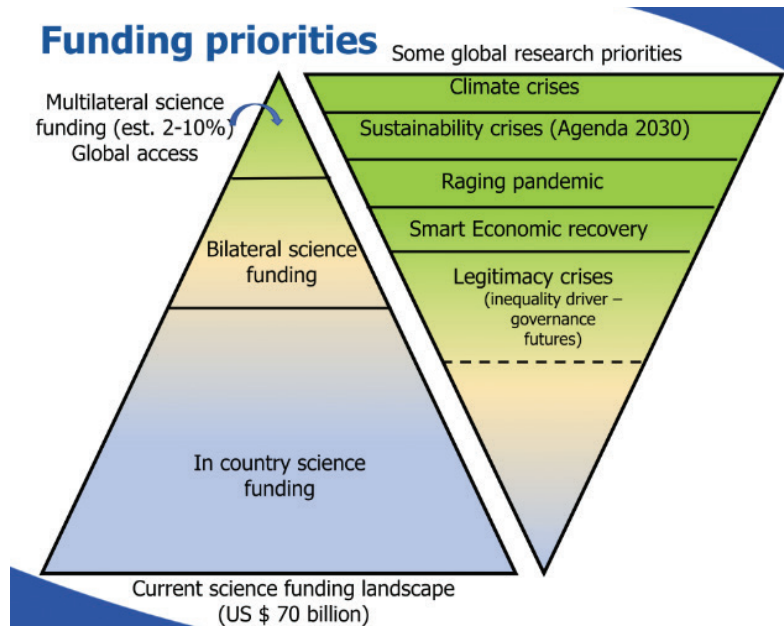


FIGURE 2 Current science funding priorities for the GRC.

SOURCE: van Jaarsveld, A. 2021. Presentation at Workshop on Science Diplomacy to Promote and Strengthen Basic Research and International Cooperation.

Charlotte Warakulle, director for international relations at CERN, the European Organization for Nuclear Research, reinforced previous comments about the importance of transparency, openness, and the need for partnerships in advancing science diplomacy. She also discussed the need to address funding challenges on issues of inclusion and equality. CERN itself is a product of science diplomacy, initially established by 12 European nations, and currently bringing together a community of more than 17,000 scientists, physicists, engineers, technicians from around the world. CERN's efforts in science diplomacy are primarily through its daily work in conducting fundamental research, as well as its efforts in capacity building and educating the next generation of scientists. Science diplomacy has an important role promoting the values of openness, equity in access to information, and access to education. It is also imperative to keep in mind the underlying values of science and how they can drive collaboration, said Warakulle.

SUMMARY DISCUSSION: PERSPECTIVES OF NON-GOVERNMENTAL NATIONAL SCIENTIFIC INSTITUTIONS AND INTERNATIONAL SCIENTIFIC INSTITUTIONS

Alik Ismail-Zadeh, senior research fellow at the Karlsruhe Institute of Technology and research professor at the Russian Academy of Sciences, and workshop committee member, summarized themes identified by panelists from non-governmental national scientific and international scientific institutions related to advancing basic science and science diplomacy. Workshop participants discussed the definition of science diplomacy, which was described as either a formal or informal process. Panelists also discussed how science for diplomacy and diplomacy for science work together. Discussions also highlighted the scientific infrastructure needed to support science, including the challenges in developing the infrastructure facilities for scientists. The need to increase the collaboration between the social sciences and natural sciences was also identified.

Workshop discussions also focused on COVID-19 vaccine equity, and the role that science diplomacy can play

in providing a foundation for communication between scientists and policymakers on this issue and other global challenges. Communication on the value of science was discussed by workshop participants as an important need, including its vital role in addressing global challenges, such as climate change. Participants also discussed the need for the GRC in developing clearly articulated goals that society must achieve with aligned research objectives.

CHALLENGES TO SCIENCE DIPLOMACY FOR BASIC RESEARCH AND SUGGESTED STRATEGIES

Abreu moderated a panel addressing possible strategies to address or overcome issues related to open science; cybersecurity; security and visas; and diversity, equity, inclusion, and gender as they relate to strengthening basic research through science diplomacy.

Shamila Nair-Bedouelle, assistant director-general for natural sciences at UNESCO, spoke about strategies to address open science, data rights, intellectual property rights, and material transfer agreements. The COVID-19 pandemic highlighted the important role of open science, particularly in terms of timely and free access to scientific data, publications, and information. UNESCO is working to make scientific information, data, and outputs more widely accessible, particularly as open science is increasingly being recognized as an accelerator of the SDGs. Despite its potential, there is also a lack of understanding about the opportunities and challenges of open science. To address this, the organization is developing an international standard setting instrument on open science. Specifically, UNESCO has identified the potential of open science of democratizing knowledge, reducing inequalities between and within countries, promoting peace and collaboration, and in supporting cultural diversity. Open science, however, requires a profound change in scientific culture across borders, moving from competition to collaboration through information sharing. Nair-Bedouelle added that UNESCO promotes science diplomacy through several mechanisms, including the organization's work on the ground and capacity building through international cooperation.

Rebecca L. Keiser, chief of research security strategy and policy at the National Science Foundation (NSF), discussed strategies to address research security and cybersecurity, stressing the importance of training a robust science and technology workforce to support international collaboration. A key priority should be to ensure that international students and scholars continue to contribute significantly to the U.S. research enterprise. However, it is necessary to balance the open environment with the needs of research and security. To address concerns related to research security, NSF is coordinating with other U.S. government interagency partners as well as international colleagues, particularly working toward guidance related to "trusted research." As part of this effort, there is a need for continued communication and awareness with the scientific community on these research security issues as well as clarity from the government perspective on requirements, including why it is important to disclose information about sources of research support. Keiser said that NSF has found that non-disclosure issues are apparent in about 5 percent of the proposals that the agency has funded. Keiser reiterated that while we need to actively encourage international collaboration, we need to simultaneously encourage full disclosure.

Amy Flatten, director of international affairs at the American Physical Society (APS), discussed challenges to science diplomacy related to security and visas, and strategies to address them. APS, a professional organization for physicists, undertook research to better understand why fewer international physics students pursued a Ph.D. in the U.S. in 2019 and 2020. The resulting report, *Building America's STEM Workforce*,¹⁷ indicated that more than 70 percent of students surveyed reported difficulties in obtaining a visa, and more than 50 percent reported experiencing stress and anxiety related to dealing with the U.S. visa immigration system (see Figure 3). Flatten noted that the APS asked international members to advocate for changes to U.S. visa policy. When the U.S. Department of Homeland Security (DHS) proposed a rule change in September 2020 that eliminated "duration of status" guidelines and no longer allowed F-visa students and J-visa scholars to remain in the U.S.—despite compliance with their terms of admission—APS members took action to submit more than 1,500 comments to DHS. Flatten added that this is an example of science diplomacy, speaking more loudly with a common voice. To address challenges related to visas, Flatten noted the need for communication, both to policymakers to highlight the national benefits of international science and technology collaboration, as well as to international scientists themselves. To address security issues, Flatten added that there is a need to continue Track II diplomacy through identification of mutually beneficial and joint projects, along with addressing areas of regulatory and security concern. Convening global science leaders to create ongoing dialogue about security concerns is also needed.

¹⁷ American Physical Society. 2021. "Building America's STEM Workforce: Eliminating Barriers and Unlocking Advantages." <https://www.aps.org/policy/analysis/stem-workforce.cfm>.

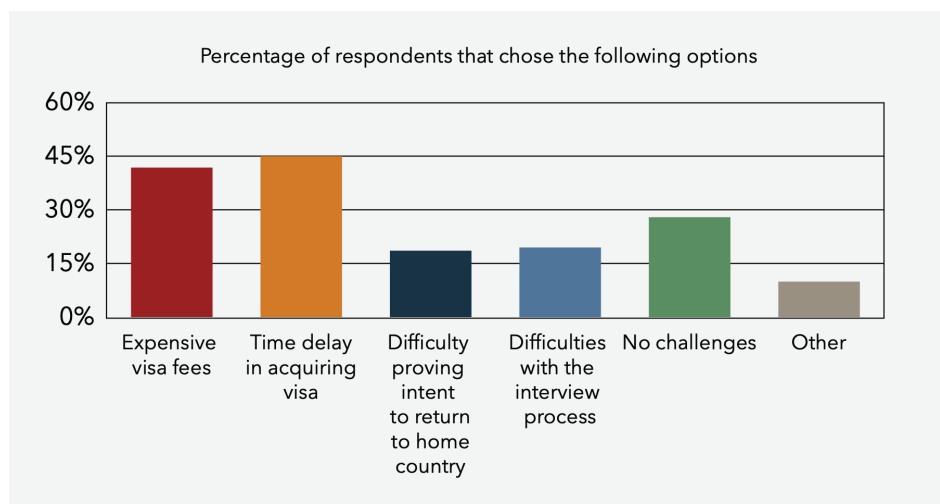


FIGURE 3 U.S. visa system creates many challenges for international students and early-career scientists.
SOURCE: American Physical Society, 2021.

The COVID-19 pandemic has highlighted the extent of gender inequality at a global scale, stated Dorothy Ngila, project specialist at the National Research Foundation of South Africa. A working group of the GRC on diversity, equity, inclusion, and gender—with a focus on promoting the status and equality of women in research—highlighted the need to utilize science diplomacy to advocate for change on gender equality. The GRC has developed a statement of principles and actions around promoting the equality and status of women in research. Similarly, the GRC is supporting science diplomacy on gender equity in science through mechanisms such as peer learning and ensuring that the voice of the GRC as a collective is included in other international initiatives promoting the equality of women in research. The practice of science diplomacy can effectively integrate equality, diversity, and inclusivity, Ngila said.

FUTURE OPPORTUNITIES FOR SCIENCE DIPLOMACY AND HOW TO ACHIEVE POSITIVE OUTCOMES

Ismail-Zadeh moderated a panel addressing areas within basic research that can better connect research funders and science diplomacy practitioners. The panel discussants also addressed opportunities for the GRC and funder communities to work together on major science themes that cross borders.

Craig McLean, acting chief scientist at the National Oceanic and Atmospheric Administration (NOAA), noted that the agency works collaboratively with international bodies, for example, the Intergovernmental Oceanographic Commission (or IOC, which is part of UNESCO), the World Meteorological Organization, and the Intergovernmental Panel on Climate Change. The IOC is a 150-member body that has been productive in organizing science across many countries to protect the health of the ocean. The U.S. government has supported IOC programs by providing funding and tools and devices to support basic research.¹⁸ McLean discussed the Seabed 2030 program, which aspires to complete mapping of the world’s ocean floor by 2030.¹⁹ He also discussed an international initiative, the UN Decade of Ocean Science for Sustainable Development, which is gathering ocean stakeholders worldwide behind a common framework to ensure ocean science can fully support countries in creating improved conditions for sustainable development of the ocean. McLean stated that we will need these international collaborative efforts to tackle the challenges facing the ocean, which is critical to human security and the ability to sustain the world.

Rajib Shaw, chair of the United Nations Office for Disaster Risk Reduction’s Scientific and Technical Advisory Group, noted that global science advocacy needs to be desegregated into regional perspectives. Also, multi-stakeholder science diplomacy should not occur with scientists only but should also be broadened to other stakeholders. Additionally, Shaw noted that there has been much discussion around increasing the presence of young researchers in science diplomacy, but there are few mechanisms currently available for this to happen. Shaw reiterated that the COVID-19 pandemic highlighted the importance of science and research, particularly noting the rapid development of COVID-19 vaccines that occurred in 1 year.

Virginia Murray, consultant in global risk reduction at Public Health England, discussed opportunities for science diplomacy, with a focus on disaster risk reduction and COVID-19 research. Murray discussed the adoption of the Sendai Framework in 2015, in which 38 indicators were defined to measure progress in achieving seven global

¹⁸ See: <https://ioc.unesco.org/node/2>.

¹⁹ See: <https://seabed2030.org/>.

targets (see Figure 4).²⁰ The Sendai Framework states that there is a need to strengthen technical and scientific capacity to capitalize on and consolidate existing knowledge. The Framework also notes the need to develop and apply methodologies and models to assess disaster risks. In 2019, there was an effort to review the Framework’s hazard definition and classification.²¹ Subsequent recommendations from more than 40 participating organizations included the need to facilitate the development of a multi-hazard information system; engage with users and sectors for greater alignment and consistency of hazard definitions; conduct further work to operationalize parameters for exposure, vulnerability, and capacity; and address cascading and complex hazards and risks, among others.



FIGURE 4 Seven targets of the Sendai Framework.

SOURCE: Sendai Framework Monitor, used in Murray, V. 2021. Presentation at National Academies of Sciences, Engineering, and Medicine Workshop on Science Diplomacy to Promote and Strengthen Basic Research and International Cooperation. <https://www.preventionweb.net/sendai-framework/sendai-framework-monitor>.

Turning to COVID-19, Murray added that science collaboration has been at the heart of its response. The World Health Organization and other partners developed a Coordinated Global Research Roadmap, which includes principles such as coordination of research and the need for fair and equitable access to research. Murray also discussed another example of international funding collaboration, the Global Research Collaboration for Infectious Disease Preparedness, a network of research funding organizations in infectious disease preparedness research that has funded 8,569 projects through 132 funders in 136 countries.²²

Abdalah Mokssit, secretary of the Intergovernmental Panel on Climate Change (IPCC), began by noting that the IPCC provides a strong example of the interface between science and policy, including supporting science diplomacy. It produces a comprehensive assessment on climate every 5 to 7 years along with a special report and methodology report. The IPCC’s assessments have been instrumental in informing policy; for example, the second assessment was foundational to supporting the Kyoto Protocol. The role of the IPCC is to not only bring science to policymakers, but also to make science as accessible as possible to the public. In 2019 the IPCC published a Special Report on the Ocean and Cryosphere in a Changing Climate. The report included information for policymakers about the impact of climate change on human health, water supplies, food security, and ecosystems. Through this and other efforts, the IPCC serves as the voice of climate science, contributing to the evidence base of policymaking over the past three decades. The next assessment, while delayed due to the COVID-19 pandemic, will have a more regional focus than past assessments.

Solid, transparent, and open science is critical to informing policy, said **Ana María Hernández Salgar**, chair of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Science diplomacy must be able to showcase, with conviction, research findings that constitute the priorities arising from research at different scales. Science diplomacy also depends on the development of common agendas that have support from development sectors. One of the most important ways that governments and scientists can prioritize issues and encourage scientific progress is to identify existing information and highlight research gaps. Because of international efforts supporting research on ecosystems and biodiversity, there has been action to make changes at the political level. There is no viable future if we do not manage to understand through science the impacts generated by the loss of biodiversity.

²⁰ See: <https://www.undrr.org/publication/sendai-framework-disaster-risk-reduction-2015-2030>.

²¹ See: <https://www.undrr.org/publication/hazard-definition-and-classification-review>.

²² See: <https://www.glopid-r.org/about-us/>.

SUMMARY DISCUSSION: SCIENCE DIPLOMACY TO PROMOTE AND STRENGTHEN BASIC RESEARCH AND INTERNATIONAL COOPERATION

Several key themes were discussed during the workshop, particularly related to the important role that science diplomacy can play in addressing global challenges, including COVID-19 and climate change. The international research communities that are collaborating on these issues are also elevating the research at a global policy level. These communities simultaneously depend and build upon international research networks that have been developed over decades. This also affects the way that research is translated and transmitted into helping inform several key global policy drivers, whether it is the IPCC process, or otherwise.

Other areas of focus included discussions about the UN SDGs. Turekian stated that the sustainable development goals themselves represent an accumulation of thinking around a broad range of topics that are both defined by and informed by advances in science and technology. Basic research has helped to inform these connections, supporting translation into an international body such as the UN. Turekian noted that while there is overlap between international science cooperation and science diplomacy, there are also key differences and distinctions that allow these areas to operate within their sphere of connectivity.

Colglazier highlighted workshop discussions about the unique role of the GRC in basic research and science diplomacy. The GRC network is itself a science diplomacy institution and has strengthened the equitable partnership between the global North and South. Scientific institutions, especially national science academies in both the North and the South, highlighted how they have their own priorities and aspirations for addressing the major challenges that face their nations, discussing topics such as the importance of trust in science, disseminating the values and ethics of science, and informing the decisions of policymakers and the public on important issues.

To expand the GRC's role in science diplomacy, participants highlighted the need to continue to learn from one another, exploring partnerships and initiatives, including joint calls and specific areas of common interest, as well working to promote the importance of basic research to policymakers, at both the national and global level.

Bright noted that there is a need to acknowledge the important role of the GRC as a mechanism for science diplomacy in and of itself and to clarify the distinction between science diplomacy and international collaboration. The global challenges we face require a coordinated effort among stakeholders, funders, and researchers. There is also a need to balance opportunities of open science with research security to ensure we can maximize opportunities and minimize risks.

Other areas discussed by participants included the need to bring social science to the table; a greater focus on issues related to diversity, equity, inclusion, and gender; and assessing the impact of the COVID-19 pandemic on the careers of young scientists.

Colglazier highlighted the importance of basic, fundamental research as the foundation of the science enterprise. He encouraged participants to tell their foreign ministries that one of the strongest diplomatic initiatives they can engage in is supporting their basic research institutions; these institutions are working to further international scientific collaboration around the world.

DISCLAIMER: This Proceedings of a Workshop—in Brief was prepared by **Jennifer Saunders** as a factual summary of what occurred at the meeting. The statements made are those of the rapporteur(s) or individual meeting participants and do not necessarily represent the views of all meeting participants; the planning committee; or the National Academies of Sciences, Engineering, and Medicine.

COMMITTEE ON SCIENCE DIPLOMACY TO PROMOTE AND STRENGTHEN BASIC RESEARCH AND INTERNATIONAL COOPERATION: **E. WILLIAM COLGLAZIER** (Chair), Editor-in-Chief of *Science & Diplomacy* and Senior Scholar, American Association for Advancement of Science; **ALICE ABREU**, Professor Emerita, Federal University of Rio de Janeiro, Brazil; and **ALIK ISMAIL-ZADEH**, Senior Research Fellow, Institute of Applied Geosciences of the Karlsruhe Institute of Technology, Germany, and Chief Scientist/Research Professor at the Russian Academy of Sciences Institute of Earthquake Prediction Theory and Mathematical Geophysics. **STAFF:** **ROBERT GASIOR**, Staff Officer; **NICOLE CERVENKA**, Research Associate; **FLANNERY WASSON**, Senior Program Assistant.

REVIEWERS: To ensure that it meets institutional standards for quality and objectivity, this Proceedings of a Workshop—in Brief was reviewed by **E. William Colglazier**, American Association for the Advancement of Science; **Alik Ismail-Zadeh**, International Science Council; **Cherry Murray**, University of Arizona; and **Richard Catlow**, University College London. **Marilyn Baker**, National Academies of Sciences, Engineering, and Medicine, served as the review coordinator.

SPONSORS: This workshop was supported by the National Science Foundation.

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SUGGESTED CITATION: National Academies of Sciences, Engineering, and Medicine. 2021. *Science Diplomacy to Promote and Strengthen Basic Research and International Cooperation: Proceedings of a Workshop—in Brief* (2021). Washington, DC: The National Academies Press. doi: <https://doi.org/10.17226/26182>.

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