About the Conference

The one-day Science and Diplomacy 2017 conference brought together scientists, policymakers, practitioners and students around emerging aspects of science diplomacy. Panel discussions included a broad variety of topics, such as conservation and national security at the U.S.-Mexico border, the technical and diplomatic aspects of space security, and science diplomacy as a foundation for mitigating disease threats across the globe.

SESSION SUMMARY AUTHORS
Summer Galloway, AAAS Science & Technology Policy Fellow, U.S. Department of Defense
Cyan James, AAAS Science & Technology Policy Fellow, Department of Defense Office of the Assistant Secretary of Defense, Human Performance, Training, and BioSystems Directorate
Tim Kochanski, Senior Program Associate, AAAS
Kirk Lancaster, student, University of Chicago
Lance Miller, Senior Program Associate, AAAS
Kirstin Neff, Congressional Science Fellow, Geological Society of America/U.S. Geological Survey
Shaaretha Pelly, Senior Program Associate, AAAS
Alejandro de la Puente, AAAS Science & Technology Policy Fellow, National Science Foundation
Enrique Lin Shiao, PhD Candidate in Biomedical Sciences at the University of Pennsylvania and Founder, Penn Science Diplomacy Group
Teresa Stoepler, Program Officer, National Academy of Sciences
Andrew Titmus, Knauss Marine Policy Fellow, National Science Foundation, Office of Polar Programs

EDITING
Lucy Fleming
Julia MacKenzie
Amy Shifflette
Tom Wang

Disclaimer: This summary report highlights the main discussion points of the conference. However, it is neither a consensus view of the participants nor does it necessarily represent the views of AAAS, the U.S. government, the authors, or any other affiliated institutions.

For more information, please contact: diplomacy@aaas.org
Science, Technology and Innovation for the Sustainable Development Goals

OPENING PLENARY

Science, Technology and Innovation for the Sustainable Development Goals

Rush Holt, CEO of AAAS and Executive Publisher of Science, gave opening remarks on AAAS and the importance of science diplomacy. Holt remarked that the conference’s high turnout is a result of AAAS elevating the concept of science diplomacy to international recognition. He emphasized that science brings a valuable long term perspective to foreign policy. The progress of science knows no borders and by providing a shared set of values, science enables bridges that are otherwise difficult to build. There is much work to be done to bring the United Nations’ (UN) Sustainable Development Goals (SDGs) into the public’s view. However, these goals can be reached only with progress in science and technology (S&T).

PLENARY SESSION: SCIENCE, TECHNOLOGY AND INNOVATION FOR THE SUSTAINABLE DEVELOPMENT GOALS

Rapporteur: Teresa Stoepler, National Academy of Sciences

SESSION ORGANIZER AND MODERATOR

E. William Colglazier, Member, 10-Member Group of the UN Technology Facilitation Mechanism and Editor-in-Chief, Science & Diplomacy

PANELISTS

Hana S. AlHashimi, Happiness Representative and Adviser to the Committee on Sustainable Development, Permanent Mission of the United Arab Emirates to the United Nations

Tateo Arimoto, Professor, National Graduate Institute for Policy Studies, Japan

Román Macaya Hayes, Ambassador of Costa Rica to the United States

Vaughan Turekian, Science and Technology Adviser to the U.S. Secretary of State

DISCUSSANT

Jerry Miller, Director, Science and Technology for Sustainability, National Academy of Sciences

William Colglazier remarked that the UN2030 agenda and the 17 aspirational SDGs are a great gift to the S&T community and to the world. Colglazier reiterated that we need to do more to ensure the SDGs are better known both by the public and the scientific community.

Vaughan Turekian opened the panel by stating that the SDGs are bold – and that an action plan is necessary to successfully implement them. S&T underpin each of the goals. The S&T Adviser to the U.S. Secretary of State (STAS) office provides objective scientific advice in matters of diplomatic relevance, and is essential to successfully implement them. S&T underpin each of the goals. The S&T Adviser to the U.S. Secretary of State (STAS) office provides objective scientific advice in matters of diplomatic relevance, and also captures scientific talent in the academic community for the benefit of the State Department through fellowship programs like the AAAS S&T Policy Fellowship and the Jefferson Science Fellowship. Dr. Turekian noted that investments in basic research are increasingly made outside of governments and the products of basic research are now going to market faster than ever before. Hence, STAS and others must not rely solely on government-to-government interactions. The cutting edge research is taking place in the private sector and NGOs. As the scientific R&D landscape grows faster and more complex, a positive sign is that more countries are beginning to bring S&T advice into their foreign policy bodies. For example, Oman, Senegal, and Poland have all recently created new science advisory positions to foreign ministries.

Hana S. AlHashimi highlighted that the SDGs were a watershed moment for the UN as they provide the most comprehensive roadmap ever developed. The SDGs resonated in the United Arab Emirates (UAE) as they aligned with the targets of the UAE’s National Plan, Vision 2021. The UAE has recently placed a greater focus on core values including tolerance and happiness and in so doing, have prioritized innovation for SDG achievement. Abu Dhabi Sustainability Week is currently the largest gathering on sustainability in the Middle East to date, with more than 30,000 participants each year. The 2017 annual World Government Summit included a session on “SDGs in Action” which brought together academics, leaders, and others to discuss implementation of the Goals. Participants pitched and voted on ideas, and the top ideas will be showcased at the Multi-stakeholder Forum on Science, Technology and Innovation for the Sustainable Development Goals (STI Forum).

Tateo Arimoto emphasized that we can transform our society through a combination of technological and social innovation. The SDGs are a gift for the S&T community but also for the industrial community. In Japan, Tokyo University has recently created an initiative in which Japanese and international students will undertake a “SDG Technology and Policy Innovation Lab” to develop creative technology and policy solutions to the SDGs. Japan also launched an S&T research partnership for sustainable development to promote research collaboration between Japan and developing countries. This was a unique partnership between Japan’s domestic and international funding agencies. Japan is also working to leverage biotechnology for commercially important seafood and to grow a next generation natural product industry.

Román Macaya Hayes remarked that the Embassy of Costa Rica has placed a new emphasis on science diplomacy, with at least one S&T-related meeting every day, on topics ranging from illegal fishing, to Zika, to natural disasters. They are engaging the scientific community globally and locally, including the Costa Rican scientific diaspora. The Embassy is planning a “Science Open House” to raise awareness about the SDGs in Costa Rica, and in particular, how to achieve several of the SDGs. The Embassy signed a memorandum of understanding (MOU) with the University of Pennsylvania Medical School and the Costa Rican Ministry of Health. Costa Rica has other MOUs with other universities to focus on specific issues. Achievement of the SDGs requires focused policies with science as a driving force.

Jerry Miller described the rapidly increasing demands on our life systems, including water and energy systems. These demands require forward thinking in S&T and innovation. The National Academies have been focusing on sustainability and providing advice to the government and private sector in this area since the 1990s. For example, the “Sustainability Roundtable” provides a high-level mechanism to develop expert guidance. The Academies’ Sustainability Program has focused on four areas: energy and water, food security, urban issues, and nationally-focused activities. Oceans are a new focus of the SDGs, but more targets are needed for these goals and many others. Finally, the SDGs create business opportunities. The Better Business, Better World! report sets out a business strategy to transform markets in alignment with the SDGs. The report finds that the SDGs have the potential to create $12 trillion in market opportunities in the 60 largest markets alone.
SESSION KEY POINTS

- Achieving the SDGs will require using a systems approach to create an S&T-based action plan, including developing more targets. It will also require greater outreach to governments, scientists, and the public about the SDGs.
- There is growing international recognition of the importance of integrating scientists and innovators into governments and advisory bodies.
- The U.S. will increasingly look to the international and the NGO community for help in working towards the SDGs in the coming years.
- Achieving the SDGs is predicted to create vast economic opportunities, including over $12 trillion in market opportunities and 330 million jobs. These economic opportunities can serve as a focal point in employing a whole-of-society approach in working towards them.

PARALLEL SESSIONS


Rapporteur: Lance Miller, AAAS

ORGANIZER AND MODERATOR
Alice Pennaz, AAAS Science & Technology Policy Fellow, U.S. Geological Survey

PANELISTS
Charles Cuvelier, Chief Law Enforcement, Security and Emergency Services, National Park Service
Christopher Wilson, Director of the Mexico Institute, Wilson Center
Steven Young, Former Co-chair of the Border Indicators Task Force for the U.S.-Mexico Border 2012 Border Environmental Program, Environmental Protection Agency

The U.S.-Mexico border is a topic of intense debate and has been a central policy issue of the Trump administration. This panel discussed the myriad of issues relevant to border policy: security, economics, human rights, and conservation. Further, the panel examined the intersection of S&T with these issues, and highlighted how science diplomacy may be further leveraged to advance bilateral discourse between the U.S. and Mexico.

Charles Cuvelier began his presentation by quoting the naturalist John Muir: “When we try to pick out anything by itself, we find it hitched to everything else in the Universe.” He went on to explain how this idea applies to the interconnectedness of the issues surrounding the border region between the U.S. and Mexico. The border is a site of migration of humans, animals, and plants. Migration can be a source of great benefit to both nations but simultaneously represents threats that are linked to the travel of people and cargo. Because migration over the U.S.-Mexico border is correlated to the economic conditions on both sides of the border, many speculate that as the U.S. economy continues to improve after the 2008 recession, illegal immigration to the United States will increase.

Though recently hotly debated in the U.S. presidential election, border walls are fairly common: over 70 countries have some form of them. In the U.S., border fencing, walls, and border agents have all increased since the 1980s. Mr. Cuvelier explored the dangers of unauthorized border crossing (e.g. over 2,000 illegal immigrants have died between 1999 and 2012 alone), and the potential for S&T to better inform the solution (be it a wall or other solutions) to unauthorized migration and crime. Further, science diplomacy can help to connect researchers across the border to ensure that border security and enforcement data collected by the U.S. and Mexico is shared to maximize data-use.
Steven Young focused on the numerous environmental issues important for the border region and how S&T can be used to monitor and address them. In 1983, the U.S. and Mexico announced the La Paz Agreement pledging bilateral cooperation on border issues that was signed by Presidents Ronald Reagan and Miguel de la Madrid. Mr. Young made the case of how that same spirit and history of cooperation is still important today to address the commonly shared problems of waste as well as air and water quality and quantity. As a multi-decade science diplomacy success story, he described how paving key roads to reduce dust particles in the air has measurably improved air quality, as has retrofitting of diesel engines used in the border region.

Christopher Wilson focused on the costs and benefits of increased border security and the role for science and technology in increasing security along the border. He explained how border security can be increased - which occurred in the wake of the September 11, 2001 terrorist attacks - but how there are also consequences. For example, more thorough screening at border checkpoints can lead to increased congestion and pollution due to idling engines and billions of dollars lost. There are programs that lead to a more efficient system such as the Trusted Traveler Program for frequent border crossers, but there is also a role for technology. To detect threats, various scanners and sensors can be deployed such as radiation scanners, sensors, scales to weigh trucks to catch illegal cargo, and x-ray scanners. For people crossing the border, technology has led to improved identification equipment, such as RFID chips and biometrics. License plate readers are used to monitor vehicles, and finally, pre-inspection programs are being used to mitigate congestion.

SESSION KEY POINTS
- There is a role for S&T in securing the border region, protecting the environment, and improving the lives of people on both sides of the border.
- Science diplomacy has a role to play in bringing together scientists on both sides of the border to understand and assess border security and enforcement issues.
- Bilateral cooperation is essential to address the commonly shared problems of waste, air pollution, and water quality and quantity.

Intersections of Security & Science in the Circumpolar Arctic


ORGANIZER & MODERATOR
Cyan James, AAAS Science & Technology Policy Fellow, Department of Defense Office of the Assistant Secretary of Defense, Human Performance, Training, and BioSystems Directorate

PANELISTS
Anjuli Bamzai, Arctic Natural Sciences, National Science Foundation
Sherri Goodman, Senior Fellow, Environmental Change and Security Program, Global Women’s Leadership Initiative, Wilson Center
Seth Andre Myers, Senior Fellow and Leadership Group Member, Arctic Institute Protection Agency

Warming in the Arctic has led to diminishing summer sea ice extent, potentially opening the region to expanded travel and shipping routes as well as development. The U.S. will pass the chairmanship of the Arctic Council to Finland in May 2017, creating a timely moment for reflection on the state of Arctic diplomacy.

Anjuli Bamzai highlighted the role the National Science Foundation (NSF) plays in supporting research in the Arctic. Governed by the Arctic Research Policy Act of 1984, the U.S. Arctic Research Commission (USARC) sets goals and objectives for Arctic research activities, which range from the health and wellbeing of Arctic residents, to national security interests, to understanding the role of the Arctic in global systems. The Arctic Council, as an intergovernmental forum, also hosts a Scientific Cooperation Task Force. Research focal areas include national defense; maritime safety; sea level rise; indigenous people and their sovereignty; and environmental stewardship and coastal erosion.

Within this context, NSF sponsored over 150 projects in the region from 2004-2014, and has participated in many large scale international research collaborations. Dr. Bamzai noted that the extreme environment of the Arctic requires the sharing of resources between Arctic states, encouraging collaboration. The Arctic is a unique region with implications for national security, and scientific collaborations across boundaries enable the sharing of data, facilities, and ideas, leading to an improved understanding of the Arctic system.

Seth Andre Myers noted that international relations in the Arctic region (which includes the U.S. (Alaska), Canada, Finland, Greenland, Denmark, Iceland, Norway, Russia, and Sweden) are historically and currently complex. We must look intra-regionally to understand that the current Arctic peace reflects the relative international peace of the past few decades. The start of the present era of peace can be traced to a Mikhail Gorbachev speech in 1987, where he proposed coordinating scientific and environmental work in Arctic and opening up the Northwest Passage to foreign ships. At present, we are seeing changes to the international order, the consequences of which are spilling over into the Arctic. For example, Russia is trying to roll back NATO. China’s goals are less overt, but they favor a system where the U.S. is not the unchallenged master of the earth’s supranational shared natural resources. We have seen an increase in NATO intercepts of Russian aircraft and sanctions against Russia, including against energy companies working to develop Arctic resources.
Science diplomacy fits into this system in several ways. Science-supported diplomacy can reduce tensions by providing the geological mapping to resolve 40-year-old border disputes. Science can also be a strategic tool: the act of research could play a more complex role in regional posturing. Currently, non-Arctic countries such as China are using research as a way to enter the arena. China’s investment in the Icebreaker Snow Dragon and Yellow River station on Svalbard (Norway) exhibit their legitimate concern over sea level rise, which could have secondary goals. A new term for this kind of stakeholder has arisen: “Near-Arctic nations.” Along the same lines, some scientific research can be considered dual use. For example, bathymetric surveys expand our understanding of the Arctic Ocean environment, but could be used for submarine navigation. Ocean salinity levels tell us about global circulation patterns, but have applications in sonar as well. Mr. Myers concluded that while tensions exist, scientific cooperation offers opportunities to improve diplomatic ties by creating a track to diplomacy when traditional avenues are blocked or contested, and allowing scientists to move forward with their own agendas in the absence of government action.

Sherri Goodman focused on security in the Arctic. She argued that we need to think about science diplomacy in the context of the changing global security environment. At the U.S. Department of Defense (DoD) in the 1990s, a central mission was to engage Russia in Arctic military collaboration. Norway had concerns about radioactive waste from decommissioned Russian nuclear submarines that threatened fisheries. Arctic Military Environmental Cooperation (AMEC) was a set of science-related projects associated with environmental contamination from military activities in the far North. A bill to remove liquid nuclear waste in-situ relied on scientists working with engineers and policymakers to share information.

Currently, the Arctic is changing more rapidly than any other place, opening up a “Fourth Coast” and increasing tensions. The Secretary of State’s International Security Advisory Board, on which Ms. Goodman sits, last year released their “Report on Arctic Policy,” which identified six Arctic imperatives: (1) secure U.S. rights to sub-sea resources by ratifying Law of the Sea Treaty, which is currently at a political impasse in Congress; (2) add icebreakers to the U.S. fleet, which is behind in icebreaking capability and needs to maximize function; (3) improve telecommunications and broadband capability in the Arctic, as well as energy generation capacities; (4) deepen work with all states, including Russia, on the Arctic Council to assuage “geoeconomic” competition; (5) support sustainable development for the people of the Arctic, including consulting Alaska natives on their needs; and (6) sustain robust research funding.

Ms. Goodman highlighted three types of science diplomacy that are important to the Arctic: (1) NSF-type coordination that advances understanding of the environment and scientist-to-scientist exchange that undergirds diplomatic efforts; (2) contributions from scientists to diplomatic efforts, like former Secretary of Energy Ernie Moniz’s role in the Iran nuclear agreement; and (3) sub-national and sub-regional collaborations, like those between Alaskan state representatives and their counterparts in Canadian and Greenland Arctic provinces on the topics of energy, telecommunications, and infrastructure.

SESSION KEY POINTS
• The changing Arctic environment is increasing international tensions and presenting a challenge for science diplomacy.
• Emerging actors like the “Near-Arctic states” are highlighting their investment in the Arctic.
• Existing partnerships and collaborations at the sub-national, national, and international level provide opportunities for continued scientific cooperation and the incorporation of good science in diplomatic exchanges.

Science Diplomacy in Small Islands Developing States

Rapporteur: Alejandro de la Puente, National Science Foundation

SESSION ORGANIZER
Casimiro Vizzini, Expert, Division of Science Policy and Capacity Building, International Basic Sciences Programme, UNESCO

MODERATOR
Leo Trembley, Program Specialist, Division of Science Policy and Capacity Building, International Basic Sciences Programme, UNESCO

PANELISTS
Gregory Stone, Conservation International, Executive Vice President and Chief Scientist for Oceans
Jose Gomez-Solino, Professor, University of La and co-Director of CampusAfrica 2014 and 2016
Christine Greene, Honorary Counsel to the United States for the Sovereign Republic of Kiribati
Yoko Ebisawa, Project Manager, Japan – Caribbean Climate Change Partnership

The UN recognizes a distinct group of 50 developing, low-lying coastal countries as Small Islands Developing States (SIDS). The SIDS member-states are culturally diverse but share similar challenges: scarce resources, vulnerability to natural disasters, dependency on foreign trade, and small but growing populations in narrow and sometimes submerging portions of land. This session reviewed imminent climate change issues within these countries, and explored the role for science diplomacy in SIDS’ international relations and sustainable development.

Leo Trembley opened the session by discussing these diverse islands, many of which are vulnerable to the effects of climate change and in one sense are “paying for the mistakes made by other countries.” This panel covered three different perspectives: islands in Africa that are below sea-level, and those in the Caribbean and the Pacific.

Yoko Ebisawa focused on Japan-Caribbean partnerships, and how to promote sustainable development in the face of climate change. She noted that although the Paris agreement aims to keep the global temperature rise below two degrees, 1.5 degrees is more relevant for small islands in the pacific and Caribbean. These islands are already seeing negative effects due to changing climate conditions. In 2014, there was a Japan-Caribbean conference held in Trinidad and Tobago related to the UNDP 2015 project, which, with $15M in funding, aims to support countries to increase resilience to climate change by lowering emissions. Related projects focus on sustainable agriculture and water management as well as renewable energy. Japan and the Caribbean are implementing collaborative solutions and in many cases transferring relevant technology from Japan to the Caribbean.

Gregory Stone discussed his National Geographic expedition 20 years ago to the Republic of Kiribati, a small island nation in the central Pacific Ocean. The expedition marked the start of science diplomacy...
engagement that helped contribute to the country’s declaration of the first true marine protected area. He noted that corals protect islands such as Kiribati from sea-level rise. Hence, threats to coral reefs are threats to the existence of such island nations. Within the next several generations, Kiribati is expected to be unlivable, yet citizens do not yet have an emigration plan. During this critical time of transition, Stone discussed the importance of marrying indigenous knowledge and social practice with science in ways that are aligned with the local value system.

Christine Greene first brought blessings from the people of Kiribati and expressed deep appreciation to UNESCO and AAAS. In an i-Kiribati context, science means truth, and diplomacy means respect for dialogue. Hence, science diplomacy is a welcome term and concept. She discussed climate change as a very real, existential threat to her island nation and stressed that instead of placing blame we need to focus on solutions.

Jose Gomez-Solino focused on the Macaronesia system of islands in the North Atlantic Ocean off the coasts of Africa and Europe. The term Macaronesia was coined in the middle of the 19th century and means Islands of the Blessed. The Macaronesia islands currently strive for independent recognition but are currently considered mainly as a part of Europe. For example, the Government of the Canary Islands, within Macaronesia and currently considered an autonomous community of Spain, want this region recognized and differentiated from the EU.

Considered as a whole, Macaronesia encompasses diverse archipelagos. Some islands have disappeared below sea level but others are rising due to their volcanic origin. While the Canary Islands enjoy robust tourism and relatively high GDP, Cape Verde has a relatively low GDP per capita. Many challenges unite the islands within Macaronesia, including climate change, water resources, and unmet capacity building needs. Science diplomacy was cited as one important tool to better integrating the islands with one another, West Africa (via the CampusAfrica initiative), Europe, and the rest of the world.

 SESSION KEY POINTS
- SIDS benefit greatly from regional and global science diplomacy focused on partnerships that marry local knowledge and customs with scientific techniques and products.
- The threat of climate and environmental change is felt acutely on SIDS. Entire cultures will disappear in our lifetimes if more is not done to salvage them.

SESSION ORGANIZER & PANELIST
Jean-Christophe Mauduit, Graduate Student, Fletcher School of Law and Diplomacy and Former Research Scholar, AAAS Center for Science Diplomacy

MODERATOR
Marga Gual Soler, Project Director, AAAS Center for Science Diplomacy

PANELISTS:
Aditya Kaushik, Graduate Student, Fletcher School of Law and Diplomacy
Dennis Schroeder, Graduate Student, Harvard Kennedy School of Government, and Former Iran Country Director, DAAD
Malgorzata (Gosia) Smieszek, Researcher, Arctic Centre in the University of Lapland, and International Arctic Science Committee Fellow

This session featured graduate students of diverse background currently pursuing an interest in science diplomacy. Moderator Marga Gual Soler started the session with the official launch of the Science Diplomacy Education Network (SciDipEd). The aim of this network is to create a global community of students and educators interested in formal and informal science diplomacy education. Through the network members can share resources, education materials, course syllabi, conferences, and internship opportunities.

Jean-Christophe Mauduit discussed how his background brought him into science diplomacy and how this tied in to his current work at the Fletcher School of Law and Diplomacy (Tufts) and his career plans. He obtained his PhD in Astronomy from the Paris Observatory and is currently enrolled in an MA in international relations at the Fletcher School. As a Ph.D. student and through his postdoctoral work for the European Space Agency “Gaia” satellite mission and the NASA Spitzer infrared satellite, Dr. Mauduit was active in several science outreach programs and campaigns. During his postdoctoral work and as a project officer for the International Astronomical Union, he had the opportunity to work in highly international groups and across several different countries. This exposure to international scientific development and cross-country collaboration was a crucial driver for him to transition into a career in science policy and diplomacy. At the Fletcher School, Jean-Christophe co-founded the Fletcher Science Diplomacy club and is working to co-create with Aditya Kaushik the first science diplomacy education track in the country.

Aditya Kaushik is also a graduate student at Fletcher, focusing on international organisations and science diplomacy. He comes from a background in electrical engineering and worked as a support and data analysis engineer at MathWorks before venturing into science diplomacy. Kaushik talked about his past experiences at the UNDP working on green economies and green employment in the Central Asia and East Europe region. Some of the core skills of science diplomats highlighted by Kaushik include knowledge in
international relations theory; understanding of economics and sustainable development; conflict resolution; negotiations training; and a basis in international law.

Malgorzata (Gosia) Smieszek is currently a doctoral candidate and researcher at the Arctic Centre at the University of Lapland (Finland). She talked about her background in political science and how her current research requires coordination of experts in many different fields at the International Arctic Science Committee. She discussed the Arctic as a prime example of science diplomacy: it requires strict coordination of scientific efforts, due in part to the large financial and logistical challenges involved in working under such extreme conditions. She described a lack of dialogue and sometimes even a lack of respect between natural or “hard science” researchers, social scientists, and political scientists as a challenge to science diplomacy.

DENNIS SCHRODER received his bachelor and master’s degrees in history, education sciences and literature. He is currently enrolled in Harvard Kennedy School’s Mid-Career Master of Public Administration program. His entry into science diplomacy occurred through his work at the German Academic Exchange Service (DAAD). From 2010 to 2013 Mr. Schröder worked as a DAAD liaison officer in post war Sri Lanka, an experience that in his own words “first influenced me to explore science diplomacy’s full potential.” While he was sent to Sri Lanka to focus on exchange with Germany, he immediately harnessed the opportunity to identify areas and avenues to provide capacity building towards the development of the country. Mr. Schröder led projects that established research partnerships between professors across communities previously in war with professors in Germany, bolstering the post-war reconciliation process while increasing opportunities through local and foreign technical expertise. From 2013 to 2016 Mr. Schröder was the country director for DAAD in Iran. In this role he served as a liaison between both countries and a facilitator of educational and scientific partnerships. Schröder indicated an important distinction between science diplomats (primarily scientists) and facilitators of science diplomacy. He also stressed the need for stronger cross-talk between both, namely: “Science diplomacy emphasizes the value of science in diplomacy, but scientists need to acknowledge the complexity of policy-making and negotiations in this process.” He said he believed some of these skills should be embedded in a scientist’s training.

SESSION KEY POINTS

• On campus science diplomacy groups are crucial to expose students from different disciplines to the field.

• A science diplomacy study track requires a balance between scientific training and training in international relations, law, economics and negotiation.

• More cross-talk between disciplines is necessary as science diplomacy continues to grow.

• The role of political and social scientists must not be overlooked in the process of shaping science diplomacy.

Audrey Schaffer noted that while space is a resource that underpins national security by providing direct earth observations of incidents, missile detection, communications, command and control, and navigation, it also underpins much of the national economic and social vitality. She focused on what the Department of Defense (DoD) is currently doing to enhance safety and security in space. For example, DoD currently provides spaceflight safety services across the globe. All 1300+ satellites in orbit are tracked by DoD, which has contact information for 99% of satellite owners and sends out close approach alerts free of charge to them every day. Today, private service collaborations are emerging as well for both collision detection and radio interference mitigation. DoD’s work also supports both soft and hard laws concerning space, which are becoming more important as the number of actors and objects increases. The hope is that through diplomacy, international space norms (similar to agreeing to drive on the same side of the road) will emerge. One challenge is getting both new and old actors to agree upon and adopt the same standards.
Laura Grego in her presentation referenced a 2003 RAND Report titled “Mastering the Ultimate High Ground: Next Steps in the Military Uses of Space.” The report was a reflection of the ethos of the time for those working in the area of space policy. Dr. Grego suggested that “space as the ultimate military high ground” is not an appropriate metaphor for space security.” She noted several constraints brought about by the physics of space which supported this assertion. For example: in space several actors can share the high ground; the laws of gravity and orbital speeds make prediction of satellite locations very easy and hiding very hard; existing missile to missile defense technology can be repurposed to strike the slow moving and predictable satellites; and satellite eaves droppers can be easily deployed to intercept objects. She also highlighted the high costs of using space as a strategic military position, caused by orbits far enough away that weapons transport costs are prohibitive. Costs are further impacted by the fact that many satellites are required for continued, accurate Earth observation. More importantly, debris issues create interdependence and incentive for cooperation among actors as nobody managing space objects wants to manage more debris. These questions of security and sustainability can never be resolved unilaterally.

In a question and answer session with the audience the panel further discussed the challenges of increased actors, satellites, and debris in space. It was noted that the Japanese government is currently experimenting with debris removal and several private companies are also working in this area. Legal, economic, and insurance issues were also discussed. For example, as risk of space collision grows, a legal framework and insurance practices among actors is expected to emerge. The role of diplomacy was also underscored, as state and non-state actors need to coordinate and have shared interest in mitigating issues such as debris/collision, and risks of space weather such as solar flares.

**SESSION KEY POINTS**

- Continued commitment to developing diplomatic solutions is required in the current environment, where:
  - no new hard laws (treaties, etc.) are expected given high threat perceptions among actors;
  - leveraging the universal concern over space debris to lower tensions among actors is not easy;
  - national laws (through unilateral/multilateral/regional agreements) have the potential to influence international soft laws; and
  - some hard law solutions might exist, such as banning anti-satellite weapons testing, prohibiting satellite signal interference, and expanding the Law of Armed Conflict (LoAC) to include space.
- As more private sector actors emerge industry collaborations should play a larger role in promoting the establishment of space norms and laws.
- The high-ground metaphor does not work for space. Being the first to weaponize space will not yield a significant or lasting advantage.
- Space security and sustainability will most likely be achieved with multilateral cooperation.

**SESSION ORGANIZER & MODERATOR**

**Rapporteur:** Andrew Titmus, National Science Foundation

**Jan-Stefan Fritz,** Senior Associate Research Fellow, Institute of International and Intercultural Studies, University of Bremen. Head, KDM German Marine Research Consortium (Brussels)

**Kristina Gjerde,** High-Seas Policy Adviser, World Conservation Union. Adjunct Professor, Middlebury International Studies at Monterey

**Janice Romaguera Tottie Duhá,** Special Adviser, Directorate-General for Science, Nuclear and Technological Development, Brazilian Navy

**Zdenka Saba Willis,** Former Director, U.S. Integrated Ocean Observing System, NOAA. Captain, U.S. Navy (retired)

This session explored how to best balance the scientific, as well as state, economic and security interests facing ocean observatories.

**Jan-Stefan Fritz** opened the session reflecting on how ocean observing is a highly technical issue, though ocean affairs in general is a highly emotive but distant issue for many. The value of ocean observing can be difficult to communicate to politicians and highly controversial oceans issues are difficult to couple with tangible targets and standards.

International tensions have risen as states have sought to extend their sovereignty over more of the ocean. The 14th Sustainable Development Goal (SDG 14)—conserve and sustainably use the oceans, seas, and marine resources—offers a framework for cooperation between states, though tensions remain as actors desire to manage the oceans together, yet maintain individual rights to access. Ocean observing data can be hard to visualize but is vital for many things including weather and commerce. Ocean observing data is collected globally, at over 8,000 sites. Despite the massive undertaking, funding streams are generally unstable. There is a hope that SDG 14 can spark a political change that will galvanize support for global ocean observing initiatives.

Zdenka Saba Willis noted that the value that ocean observing data brings to our everyday life needs to be better communicated by scientists, policymakers, and others. Ocean observing data allow us to facilitate the movement of 90% of global goods, which are transported by ship; monitor harmful algal blooms that have a huge negative impact on tourism and the seafood industry; understand the effects of the Deep Water Horizon and other oil spills; and predict the impact of storms on coastal areas which allow authorities to reopen ports. We need to ensure that ocean observing data are a public good, open and available.

Janice Romaguera Tottie Duhá described science diplomacy as an important part of ocean observing as ocean currents know no political borders and oceans provide a livelihood to many nations and people. Furthermore, the oceans play a vital role in regulating the atmosphere and the climate, absorbing carbon
dioxide emissions. Increasing carbon emissions and ocean acidity will lead to ecosystem impacts that are not yet fully understood. Networks of ocean observations are particularly important then to monitor the impacts of climate change.

Integrating ocean observations maximizes their use and potential impact. There are current examples of observatory networks, such as the South Atlantic Peace and Cooperation Zone (ZOPACAS), and the PIP-RATA ocean observing network—a cooperatively managed buoy network in the tropical Atlantic Ocean funded by Brazil, France, and the United States since 1997. But there is room for improvement. AtlanticOS is an example of a proposed advanced framework for integrating ocean observations in the Atlantic that is more sustainable and efficient. Improved coordination with also reduce the technology gaps that exist across states with different development levels. In addition to observing networks, research vessels provide further opportunities for partnerships regionally and globally.

Kristina Gjerde discussed the question of whether science diplomacy can transition two-thirds of ocean regions from a model of competition to one of collaboration. This will require a new wave of science diplomacy that incorporates both science for diplomacy and diplomacy for science. There is some consensus on a new legal convention for governing the high seas that would balance rights, interests, and share products. Biological Diversity Beyond Areas of National Jurisdiction (BBNJ) is a UN legal instrument on the conservation and sustainable use of marine biological diversity beyond areas of national jurisdiction, under the UN Convention on the Law of the Sea.

One example of “science for diplomacy” is the following: as scientists established that deep sea bottom trawling destroys benthic habitat in many ocean areas, the UN and others used that scientific information to restrain deep sea bottom trawling. Increasingly, governments are agreeing to area-based management using an Environmental Impact Assessment (EIA) approach. Perhaps science can be a driver for galvanizing support for a new system of ocean governance, much like how the International Geophysical Year drove the formation of the Antarctic Treaty. Diplomacy on the other hand can support science collaboration to achieve the goal of a sustainable ocean.

SESSION KEY POINTS

• Ocean observation networks provide data beneficial to our economy and society. The message of this value needs to be better communicated so that the public and policy makers can fully understand the value of ocean observations.

• Science diplomacy can help build internationally collaborative ocean observation networks which can build capacity, better integrate observations, and provide more sustainable and efficient ways to collect and use data.

• Collaborative ocean observing networks must equitably share the costs and commitments and reduce the technology gap between collaborators.

• BBNJ is a potential new way to cooperatively govern ocean areas beyond national jurisdiction using a science-based area management approach.

• BBNJ provides an opportunity for science to be a driver for a strengthened system of ocean governance using both science for diplomacy and diplomacy for science.

Broadening the Tent: A One-Health Approach to Global Health Diplomacy

Rapporteur: Summer Galloway, U.S. Department of Defense

SESSION ORGANIZER & MODERATOR

Ellen P. Carlin, Senior Health and Policy Specialist, EcoHealth Alliance

PANELISTS

Dennis Carroll, Director, Emerging Threats Programs, USAID

Franck Berthe, Senior Livestock Specialist, World Bank, and Coordinator, Livestock Global Alliance

Catherine Machalaba, Health and Policy Program Coordinator, EcoHealth Alliance

Estimates indicate that approximately 75% of emerging or reemerging infections are vector-borne or zoonotic. Within the last 20 years, there have been several instances of cross-species transmission that have caused severe public health, economic, social, and political consequences, underscoring how devastating zoonotic diseases can be, even if rapidly detected and geographically contained.

The American Veterinary Medical Association defines One Health as: the collaborative effort of multiple disciplines – working locally, nationally, and globally – to attain optimal health for people, animals and the environment. Achieving this goal has been articulated by the One Health Initiative.

Dennis Carroll described how the rapidly increasing human population has exerted pressure on our environment and animal populations, which has exacerbated the emergence of infectious diseases. Emerging infectious diseases outpace our global ability to respond effectively. To face this challenge, Carroll underscored that the global community must embrace a paradigm shift from a reactive response to infectious disease once reported in humans to a proactive preparedness culture that utilizes surveillance efforts to detect infectious disease in wildlife before they significantly impact human health. The “invisible value of prevention” is a major challenge to this effort: we do not know what is out there, so we fail to see what to prevent.

The Global Virome Project (GVP) is a global initiative intended to transition the science of emerging viral diseases into a Big Data science, allowing new ways to evaluate problems and solutions. The GVP is a global venture to document and characterize within ten years virtually all of the planet’s viruses in wildlife that could pose a threat to humans. The aim is to make it possible to analyze data for entire virus families to create a data-rich field that will enable a novel approach to developing countermeasures. Ideally, the resulting data will enable comparative analysis of thousands of members of each virus family to develop countermeasures that are broadly effective and highlight similarities in ecological profiles, host range, and epidemiology.

Franck Berthe discussed the economic impact of emerging zoonotic diseases (estimated at $800 billion from 1997-2009) and noted that improving surveillance systems to adopt a proactive versus reactive stance is often difficult due to the pathogenesis and transmission dynamics of certain infectious diseases. The ongoing outbreak of influenza A(H7N9) in humans in China is a prime example of this complexity. Until
recently, the majority of influenza viruses circulating in poultry that have caused disease in humans did not cause clinical symptoms in birds, making surveillance control measures difficult within bird populations.

Berthe also noted that the traditional Venn diagram representing One Health—which portrays the relationship between humans, animals, and the environment—should not be considered static but rather dynamic and varying across different infectious diseases. When considering pathogens such as Ebola virus, Rift Valley fever, and Brucellosis, all sectors—humans, animals, and the environment—play a role in transmission, but the weight given to a particular sector varies based on the pathogen and the nature of its transmission cycle. The notion of varied contributions from each sector then serves as the foundation for understanding the “drivers” of emerging infectious diseases and hence can shape the agenda for researchers, public health workers and others as they act to understand and mitigate emerging risks. Specific drivers include land-use changes, food and agricultural industry changes, international travel and commerce, war and famine, climate and weather, breakdown of public health measures, and human demographics and behavior.

Catherine Machalaba focused on the economic benefits of investing in global health. Analysis by the World Bank suggests that incrementally investing in the 129 World Bank client countries to bring prevention and control of zoonotic diseases up to OIE and WHO standards in the human and animal health sectors would require approximately $1.8 to $3.4 billion per year, but would yield an expected benefit of pandemic prevention of more than $30 billion per year. Of particular relevance are the outbreaks with low public health impact, but high economic costs, such as the MERS outbreak in the Republic of Korea that resulted in only 186 cases, but had an estimated impact of $700 million in economic losses.

Also relevant to One Health discussions are non-zoonotic diseases and their effect on agriculture, animal, and economic sectors. Two significant examples are the H5N2 outbreak in U.S. poultry and the white nose syndrome in North American bats. The H5N2 outbreak in poultry resulted in the culling of approximately 48 million birds and 80% egg product price increase. Perhaps one of the most underappreciated species of our global ecosystem is bats, which are not only one of the best natural indicators of the health of the environment, but also provide a tremendous food service at no cost that includes pest control, pollination, seed dispersion, and fertilization. It is estimated that the loss of bat populations in North America could lead to agricultural losses of $3.7 to $53 billion per year. To mitigate the deleterious effects to health caused by the pressures of rapid population increases on the environment and biodiversity, sectors should embrace non-conventional partnerships, multi-disciplinary risk assessments that address health, environment, and social impacts; cost-benefit analysis of investing in development, including disease risk as a financial outcome; considering food provision for workers at excavation sites to relieve wildlife hunting pressure; judicious use of antimicrobials; and reducing drivers of emerging infectious diseases to relieve pressures on biodiversity.

SESSION KEY POINTS

• Rapid human population growth is placing increased demands on the global ecosystem.
• To increase our preparedness to respond to emerging infectious diseases, we must better understand transmission dynamics of pathogens, considering humans, animals, and the environment.
• Current reactive response measures need to be replaced by proactive preparedness measures that utilize Big Data.
• The global community should seek to capture the socio-economic impacts of health disasters and expand multi-sectoral partnerships for policy change at all levels to better understand and effectively communicate the total burden of diseases, both zoonotic and non-zoonotic.

Cybersecurity: Multilateral Relations and Our National Security

Rapporteurs: Tim Kchanski, AAAS, and Lance Miller, AAAS

SESSION ORGANIZER
Alejandro de la Puente, AAAS S&T Policy Fellow, National Science Foundation

MODERATOR
Sarah C. Flores, Science Education Analyst, National Science Foundation

PANELISTS
Diana Burley, Executive Director & Chair, Institute for Information Infrastructure Protection: Professor, Human & Organizational Learning, George Washington University; and Researcher, Cyber Security and Privacy Research Institute
Matthew Noyes, Cyber Policy Advisor, United States Secret Service
Adam Sedgewick, Senior Information Technology Policy Advisor, National Institute of Standards and Technology (NIST)

This panel was an open, moderated discussion focused on three broad cybersecurity themes: stakeholders, challenges, and collaboration. Adam Sedgewick began the discussion by describing the history and role of the National Bureau of Standards within the National Institute for Standards and Technology, NIST, in promoting cybersecurity. This role dates back to when it was called “information security” or “computer security.” The agency’s goal is to work transparently with industry to develop standards and guidelines for cybersecurity. It makes sense for the federal government to be involved in setting standards for cybersecurity given the more than $70 billion spent annually by the government on various computer platforms and applications.

The domestic and global demand for cybersecurity professionals is greater than the current or projected supply. Diana Burley leads a Joint Taskforce for Cybersecurity Education, which has the goal of developing the first set of cybersecurity education curriculum guidelines that can be adopted internationally to help meet the need for a growing number of cybersecurity professionals. The curriculum guidelines will be released at the end of 2017. She described the challenges of engaging with international stakeholders but highlighted the need to ensure that the curriculum guidelines meet the needs of the workforce and will be used as a model globally.

Matthew Noyes continued the discussion of the international aspects of cybersecurity by explaining the Secret Service’s role in investigating computerized crime involving financial and payment systems. As an example, a recent cyber-attack resulted in the perpetrators being able to steal $45 million in 13 hours through unauthorized access to bank payment cards, ATMs, and manipulation of withdrawal limit settings. In order to combat this threat, the government must be able to bring charges against the perpetrators and nations must put politics aside for the shared interest in cooperating against the common threat of cyber-crimes.
Everyone has a responsibility in promoting cybersecurity from developers to users. There is a need for developers to make more usable systems that make it easier for the user to do the right thing, harder to do the wrong thing, and easier to recover if the wrong thing happens. Next, the conversation turned to international standards when the moderator asked if there were international examples that the U.S. could adopt. Adam Sedgwick pointed out that the internet is basically a set of standards, and the recommended approach is for the US to first use international standards and to leverage what happens internationally with industry. It was noted that some nations—Russia and China, for example—take a different approach and view the control of information as a central element of cybersecurity. Some Islamic states have what is referred to as a “halal internet,” which is a substitute for the global internet. Panelists discussed the issue of privacy, and the sacrifices individuals make in exchange for the greater public good of cybersecurity. The question is how to balance public desire with public interest. Some view privacy as the right to be left alone by the government and free from widespread surveillance. Many Americans do not trust institutions to guarantee cybersecurity, and when it comes to privacy and cybersecurity, many users feel that they have no choices or are not even aware of the issues and their role and responsibility. Diana Burley gave the analogy of driving a car: one must trust car makers to build a safe machine, but the user must take responsibility for safely operating and performing maintenance.

Moving into the future, many small businesses are increasingly using third party managed security. NIST has published a guide for small businesses that outlines steps that can be taken to improve cybersecurity and aims to help organizations think about risk: How is company data used? What is the cost of compromised data? What resources are available for protection? A little work can go a long way, and most of the NIST guidelines are broadly applicable.

SESSION KEY POINTS
• Cybersecurity is dependent on both technical solutions and the social norms of governments, industry, and individuals. A tradeoff must be navigated that balances freedoms for individual users, industry control of its products, and government controls of the IT infrastructure.
• NIST’s goal is to work with industry through an open process to develop standards and guidelines for cybersecurity.
• The Joint Taskforce for Cybersecurity Education has the goal of developing the first set of cybersecurity education curriculum that can be adopted internationally to help meet the need for a growing number of cybersecurity professionals.
• NIST has published a guide for small businesses that outlines steps that can be taken to improve cybersecurity and aims to help organizations think about risk.

Practicing Science Diplomacy at Museums and Science Centers

Rapporteur: Cyan James, U.S. Department of Defense

SESSION ORGANIZER AND MODERATOR
Mandé Holford, Associate Professor, Department of Chemistry and Biochemistry, CUNY Hunter College and Graduate Center, American Museum of Natural History

PANELISTS
Ana Luz Porzecanski, Director, Center for Biodiversity and Conservation, American Museum of Natural History

David Schindel, Executive Secretary, Consortium for the Barcode of Life

Walter Steveloz, Director International Relations, Association of Science-Technology Centers

This session highlighted unexpected ways scientists can exercise science diplomacy and explored trans-boundary means by which scientists may influence public opinion and policy, whether that be through field work, museum design, education, collaboration, international travel, youth empowerment, partner skills-building, or public engagement. Museums and educational experiences have been undergoing a revolution, moving away from didactic instruction toward immersion, collaboration, and the thoughtful articulation of scientific values.

Dave Schindel noted that research activities led by entities from the global north in the global south have traditionally emphasized obtaining specimens, offering commodities, and engaging in one-way transactions that often leave southern countries feeling exploited. Southern countries, Schindel commented, would generally prefer to be compensated fairly, to develop equitable working partnerships, and to become adept at managing their own resources.

In the era of great empires, conquering countries and researchers typically took whatever they wanted, viewing the natural world as a playground for their own desires. In more modern times, treaties such as the International Plant Protection Convention, the Convention on Biological Diversity, the Nagoya Protocol, and the Cartagena Biosafety Protocol establish more just ways of studying and managing countries’ biological resources while preserving biodiversity.

Treaties also codify how to manage organisms, such as agricultural pests, that do not respect territorial boundaries, and how to creatively share resources for the common good. Under the International Treaty on Plant Genetic Resources, for example, 60-some species of crop plants are protected in a free-trade zone, exemplifying a creative way to negotiate international agreements for mutual benefits.

Ana Luz Porzecanski presented the American Museum of Natural History as a case study of promoting science collaboration and diplomacy. A recent exhibit of theirs featured Cuba, but rather than resort to a “postcard” view of the country, the Museum wanted to reflect rich Cuban ecosystems and biodiversity many visitors may not have previously considered. To build their exhibit, the Museum used key framing questions, adopted a bilingual approach, and collaborated with Cuban partners on every aspect of exhibit
design and visitor experience. Exhibit designers built consensus with local experts and used the insights they gained to contextualize Cuban’s natural resources and culture in a living practice of science diplomacy. Using props, live animals, and an innovative design that paired information galleries with a boulevard demonstrating a typical Cuban street scene, the Museum particularly sought to show how many of Cuba’s native species are unique and how Cuban researchers contribute to science.

Walter Steveloz described science museums as both playgrounds for children and places for controversial conversations. As an organizer of international programs, he does more, he said, than “just talk to kids.” Young people are excellent researchers from the start, impelled by natural curiosity to explore their worlds in ways that should be emulated and encouraged. Scientists could support teenagers’ internal drive to make the world a better place by helping them use new technologies to connect with their peers around the world as a practice of international science diplomacy.

Under his programs, young people organize youth summits, develop local solutions for problems, pilot solutions, connect with researchers, talk with other youth around the world, including young refugees, and learn to communicate science in their own communities.

We need to give young people the skills that traditional science curriculum doesn’t always convey including how to use science in decision-making, and not merely because science is commendable, but also because science can affirm public virtues and inform public policy.

SESSION KEY POINTS
- Science diplomacy is integral at science museums and science centers. As these cultural centers develop their science diplomacy skills, they will move forward in service of the populations who visit them.
- Exhibits built as thoughtful collaborations can instruct visitors in much more nuanced and challenging ways that could go beyond merely providing entertainment to provoking actual change.
- Young people are often overlooked, but are powerful science diplomats in their own right, and their effectiveness can be supported with creative approaches to team-building and teaching science.
- Scientists have many ways to use science diplomacy for the benefit of public venues such as museums and science centers: through the fieldwork they conduct; the relationships they build with colleagues in different countries; and the educational messages they promote.

CLOSING PLENARY
Keynote Address: Dr. Carl June

Richard W. Vague Professor in Immunotherapy, Perelman School of Medicine, University of Pennsylvania

Rapporteur: Shaaretha Pelly, AAAS

Carl June introduced his presentation, entitled “CAR T cells enter Mainstream Oncology: Opportunities in T cell engineering and synthetic biology”, as the story of a new cancer therapy that he had been working on for 25 years. He noted that new therapies raised numerous issues affecting science policy, and that there are no current standards for cell therapy. Carl finally noted that his work was supported by Novartis, and that a press release about the new therapy had just been released.

June’s presentation began with an overview of the cancer epidemic and treatment. Cancer is the number one killer in 22 of the 50 U.S. states. In 2010, the first curative therapy for metastatic melanoma, which normally does not respond to chemotherapy, was approved by the FDA. Since the release of this therapy, 20% of people have become long term survivors, living past 10 years. The goal in oncology is to have this be 100%. To achieve this goal, the cancer field is moving away from chemotherapy and towards a combination of immunotherapy and targeted therapy, an approach that is more potent and less toxic.

Manipulating the immune system to treat cancer has been explored in the field for the last decade. However, early therapies were ineffective in patients, resulting in policies that made it difficult to obtain funding for such research. Since the breakthrough in 2010 with the first curative therapy for melanoma, which normally does not respond to chemotherapy, was approved by the FDA. Since the release of this therapy, 20% of people have become long term survivors, living past 10 years. The goal in oncology is to have this be 100%. To achieve this goal, the cancer field is moving away from chemotherapy and towards a combination of immunotherapy and targeted therapy, an approach that is more potent and less toxic. Manipulating the immune system to treat cancer has been explored in the field for the last decade. However, early therapies were ineffective in patients, resulting in policies that made it difficult to obtain funding for such research. Since the breakthrough in 2010 with the first curative therapy for melanoma, funding became widely available from government, industry and philanthropic organizations.

June then discussed the drug his team has developed, CTL019, noting that the underlying idea behind their approach is synthetic biology: “making the immune system do things it never could”. In the case of cancer, this would be repurposing cells to become “cancer killing cells”. The impact of this drug was highlighted through a short video from the Emily Whitehead Foundation. June outlined the drug’s mechanism.
of action which involves removing white blood cells called T-cells from the patients' blood; using a modified virus to introduce a synthetic gene into T cells, which cause T cells to target cancer cells rendering them "leukemia-specific killer cells;" these cells are called chimeric antigen receptor T cells or CAR T cells; infusing the CAR T cells back into the patient, where they divide and proliferate, acting as a "living drug," unlike other drugs that are metabolized and need to be reintroduced.

This therapy is technologically intensive. Each drug is made individually from a patient's own T cells, instead of mass manufactured for large populations. Consequently, this raises the policy issue of how to price a drug that is expensive to make, for a single patient only, but potentially curative. The first global CAR T cell therapy trial conducted by Novartis found that 41 of 50 patients had complete remission with no detectable leukemia, confirming the single center trial that Carl had conducted at the University of Pennsylvania. Current FDA regulations require that gene therapy patients be followed for at least 15 years. To date, cumulative patient data for CAR T cell therapy has not produced a single side effect with 468 patients and 1586 patient years of safety among them. Leukemia is the first indication for this therapy, but translating this technology for the treatment of solid tumors, pancreatic cancer and autoimmunity are current challenges.

The next steps for this technology include incorporation of CRISPR/Cas9 gene editing to enhance T cells. June's team is involved in the first-in-human evaluation of safety and feasibility of CRISPR/Cas9 technology. This protocol engineers T cells to be more resistant to autoimmunity issues. While this is the first trial in the US, there is competition with China as to who will be able to demonstrate this technology in humans first. Now that we have the technological ability to conduct genome editing in humans, policy, ethics and risk taking are key issues to consider with its uptake in medical care. Varying risk-taking capabilities mean "people with the same data will make different choices," as demonstrated by the use of fluoridated water in only some states in the US.

The therapies discovered in the June lab have enormous health policy implications. He noted that countries approach genetic modification with varying degrees of caution, resulting in regulatory policies that have influenced the distribution and scale of clinical trials across the globe: there are now 160 clinical trials, with China recently overtaking the US in number conducted, and Europe conducting very few.

Healthcare challenges include the need for the industry to add a "fourth pillar" of therapeutic-cell therapies- to the current 3 pillars, namely pharmaceuticals, biologics and devices. Compared to other therapeutics, each drug is generated from the individual so a local blood bank model for manufacturing is where the industry may head, compared to the central, controlled manufacturing facility which is what current US regulatory policy requires for genetic modifications. Finally, the cell therapy industry is so new that there are currently no standards. This, combined with the fact that the field is highly multidisciplinary, makes the establishment of standards complex. A consortium at Georgia Institute of Technology and the National Institute of Standards of Technology are currently tackling this.

**KEY POINTS**

- CAR T cell therapy for leukemia is likely to be the first FDA approved cell therapeutic
- The healthcare industry (nationally and globally) will require new manufacturing standards, pricing models and policies to add a brand new arm of therapeutic delivery.
- Globally, the uptake of this technology will be affected by public perception of risk, affordability, and each country's regulatory policies regarding genetic modification.