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2021 Nobel Prize Summit

"Technological innovations are leveraging and combining developments in artificial intelligence, biotechnology, nanotechnology, and other areas, whereas the social innovations are being driven by a much more informed, demanding, and doubting society, contributing to both co-creation and consensus-based innovation." —Leena Srivastava 2021 Nobel Prize Summit: Our Planet, Our Future: Proceedings of a Summit



2021 Nobel Prize Summit: OUR PLANET, OUR FUTURE

PROCEEDINGS OF A SUMMIT

Franklin Carrero-Martínez, Negin Sobhani, Emi Kameyama, and Paula Whitacre, Rapporteurs

Committee on 2021 Nobel Prize Summit: Our Planet, Our Future

Global Sustainability and Development

Policy and Global Affairs

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-Carl Folke

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"Let us make it our goal that our discussions resonate with everyone on the planet and the theme 'Our Planet, Our Future' rings true to everyone, regardless of who they are, where they come from, and where they live." -Magdalena Skipper

PREFACE AND ACKNOWLEDGMENTS

On a train to the 2018 World Economic Forum Annual Meeting in Davos, Switzerland, former Nobel Foundation CEO Lars Heikensten and then incoming director of the Potsdam Institute for Climate Impact Research Johan Rockström agreed to convene a global event bringing together "a selected group of laureates in a scientific dialogue on the global sustainability challenge for humanity." In September 2018, Potsdam Institute leadership proposed a collaboration to U.S. National Academy of Sciences (NAS) President Marcia McNutt to help contribute the scientific foundation for what later became known as the Nobel Prize Summit.

Shortly afterward, a steering committee, including the NAS president and other NAS and National Academy of Medicine members, was established to begin the planning process for the summit in partnership with the Nobel Foundation, NAS, the Potsdam Institute, and the Stockholm Resilience Centre/Beijer Institute of Ecological Economics. Starting in 2018, a core working group from these institutions met via teleconference on a weekly basis and also in person in June 2019, October 2019, and January 2020 to plan the summit. The October 2019 meeting included a selected group of world-leading experts, which helped set the scientific underpinnings for the event. The Nobel Prize Summit was originally scheduled for April 2020 at the NAS building in Washington, DC, but was postponed due to the outbreak of coronavirus disease 2019 (COVID-19). To help set the stage for the summit, a virtual workshop on Progress, Challenges, and Opportunities for Sustainability Science was held in fall 2020, which allowed additional scientific experts to provide input to the summit and bring parts of the climate change and sustainability communities together based on six cross-cutting capacities of sustainability science (see Box 2-2 in Chapter 2). In January 2021, the committee launched the Nobel Prize Summit Webinar Series as a way to have additional, in-depth discussions ahead of the summit. In addition, a white paper on the Anthropocene biosphere was developed as the basis of planning the Nobel Prize Summit (see Chapter 2).

PREFACE AND ACKNOWLEDGMENTS

On April 26–28, 2021, the first-ever Nobel Prize Summit: Our Planet, Our Future was convened as a virtual event focused on pressing global challenges: climate change and biodiversity loss; rising inequality; and rapid societal transformation enabled by emerging and converging technologies. These three topics were selected in consultation with the summit steering committee and partner organizations to continue building trust in scientific reasoning while exploring transformative models for people and the planet on some of the most pressing existential challenges faced by humanity on Earth. The COVID-19 pandemic has awoken the world to the fact that some crises can only be solved on a global scale, and the themes addressed at the Nobel Prize Summit were deeply connected and linked to human health. This was a unique opportunity to examine challenges and opportunities for global sustainability science and evidence-based solutions by building a bridge between Nobel laureates and other world-leading scientists and experts, business executives, artists, and young leaders. Moving to a virtual format allowed the summit to reach a larger global audience with high-impact content, including 27,838 registered for the summit representing 210 countries and territories, more than 21,500 unique visitors to the platform during the 3 days, and 38 Nobel laureates actively engaging in the summit.

The Nobel Prize Summit would not have been possible without the sponsors of the summit, including Academia Sinica, Arizona State University's Julie Ann Wrigley Global Futures Laboratory, af Jochnick Foundation, Carl Bennet AB, Carnegie Corporation of New York, Elsevier, JPB Foundation, the Peace Department, Porticus, Sea Change Foundation, and Walton Family Foundation. Other partner organizations included DICCE, the Embassy of Italy in the United States, the Embassy of Sweden in the United States, the Global Solutions Summit, PeaceTech Lab, Project Syndicate, S&R Foundation, and the Club of Rome. Other partner organizations included DICCE, the Embassy of States, the Embassy of Sweden in the United States, the Peace Department, PeaceTech Lab, Project Syndicate, S&R Foundation, and the Club of Rome. The planning sessions in October 2019 and fall 2020 were made possible by financial support from the National Academies of Sciences, Engineering, and Medicine's George and Cynthia Mitchell Endowment for Sustainability Science.

On behalf of the National Academies, we want to express our sincere appreciation to the summit executive team responsible for organizing the summit, namely, Owen Gaffney, Potsdam Institute and Stockholm Resilience Centre/Beijer Institute; Holger Hoff, Potsdam Institute; Anna Sjöström Douagi, Nobel Foundation; and Negin Sobhani, the National Academies. The committee also recognizes the contribution of colleagues in the communications teams from the Nobel Foundation (Lena Abrahamsson, Ebba Bourghardt, Magnus Gylje, Rebecka Oxelström, and Maria von Konow), Potsdam Institute (Nadin Gaasch, Marie Kimbel, Juliane Otto, Jonas Viering, and Lila Warszawski), Stockholm Resilience Centre/Beijer Institute (Sturle Simonsen), and the National Academies (Jeffrey Fishman, Molly Galvin, William Kearney, David May, Ann Merchant, and Cortney Sloan) for their support and assistance with summit activities.

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PREFACE AND ACKNOWLEDGMENTS

This Proceedings of a Summit was prepared by the rapporteurs as a factual summary of what was presented and discussed at the summit. The planning committee's role was limited to planning and convening the summit. The statements made are those of the rapporteurs and do not necessarily represent positions of the summit participants as a whole, the planning committee, or the National Academies of Sciences, Engineering, and Medicine. We wish to extend sincere thanks to all the members of the planning committee for their contributions in scoping, developing, and carrying out this project.

This Proceedings of a Summit was reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise. The purpose of this independent review is to provide candid and critical comments that will assist the National Academies of Sciences, Engineering, and Medicine in making each published proceedings as sound as possible and to ensure that it meets the institutional standards for quality, objectivity, evidence, and responsiveness to the charge. The review comments and draft manuscript remain confidential to protect the integrity of the process.

We wish to thank the following individuals for their review of this proceedings: Thomas Lovejoy, George Mason University; Kate Pickett, University of York; and Miguel Román, Universities Space Research Association. Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the content of the proceedings, nor did they see the final draft before its release. The review of this proceedings was overseen by Frances Colón, Jasperi Consulting. She was responsible for making certain that an independent examination of this proceedings was carried out in accordance with standards of the National Academies and that all review comments were carefully considered. Responsibility for the final content rests entirely with the rapporteurs and the National Academies.

Franklin Carrero-Martínez, Senior Director

Global Sustainability and Development and Science and Technology for Sustainability Program "We can no longer act incrementally, we must act exponentially, collectively, and in parallel."



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OUR PLANET, OUR FUTURE

INTRODUCTION

"As we increase our pressure on Earth, there is a danger that... we will break through Earth's boundaries, causing the stability that we depend on to collapse." Sir David Attenborough

"Scientific discoveries have defined Earth's boundaries but may also provide the roadmap to guide humanity out of its current crises," stated **Sir David Attenborough** in a video to open the Nobel Prize Summit: Our Planet, Our Future, convened by the Nobel Foundation, National Academy of Sciences (NAS), Potsdam Institute for Climate Impact Research, and Stockholm Resilience Centre/Beijer Institute of Ecological Economics. He described how warming global temperatures, steep loss of global wildlife over the past 50 years, overuse of fossil fuels and nitrogen, and other impacts point to large-scale changes on the biosphere. "As we increase our pressure on Earth, there is a danger that ... we will break through Earth's boundaries, causing the stability that we depend on to collapse," he warned. The 2020 wildfires in Australia and the COVID-19 pandemic may be necessary wake-up calls to "rebuild in a new direction," he suggested, including by reducing carbon emissions to zero and stabilizing global temperatures through sustainable agriculture and other practices. Balancing optimism and concern, he told participants, "It's a remarkable time to be alive, but it also carries great responsibilities to act decisively to ensure our planet remains healthy and resilient."

Attenborough's opening statement was followed by a set of public and science sessions held virtually from April 26 through April 28, 2021. It brought together Nobel laureates and other leading scientists with thought leaders, policy makers, business leaders, young people, and others to explore solutions to three immediate and interrelated challenges (see Box 1-1):

- Mitigate and adapt to the threat posed by climate change and biodiversity loss;
- Reduce inequalities and lift people out of poverty, made more urgent due to the economic hardships posed by the pandemic; and
- Harness science, technology, and innovation to enable societal transformations while anticipating and reducing potential harms.

Although there were multiple challenges in organizing the summit due to implications of COVID-19, the availability of experts, and different time zones, a virtual format allowed the summit to reach a larger global audience, including 27,838 registered for the summit and more than 21,500 unique visitors to the platform during the 3 days. The summit was reported by media in 42 countries, and the top articles had a potential reach of more than 71 million people.

Organization of the Summit and This Proceedings

The Main Stage session was moderated from the Beckman Center of the National Academies by **Christiane Maertens** (DoGoodery). The Academic Science session was moderated from the Royal Swedish Academy of Sciences by **Karolin Johansson** (Stockholm Resilience Centre). The convening partners had planned to bring scientists and civil society together in person in Washington, DC, in April 2020, as related by Maertens in her opening remarks. The original 2020 meeting would have coincided with the start of what many experts believe is a milestone decade to ensure humanity's future on a prosperous, stable, and resilient planet. While the pandemic required cancellation and subsequent rescheduling in 2021, it also served to both deepen and broaden the summit objectives. As Johansson noted in her introduction, COVID-19 showed more clearly than ever that "people and nature are intertwined and embedded in the biosphere." An additional advantage of the summit's online format was that attendees from 147 countries could watch and participate.

The summit was scheduled with a Main Stage session on April 26, overlapping Main Stage and Academic Science sessions on April 27, and a second Academic Science and 12 concurrent Solution sessions, sponsored by diverse organizations, on April 28 (see Figure 1-1 for an overview of the schedule). The sessions addressed cross-cutting themes of climate

BOX 1-1

Nobel Prize Summit Statement of Task

The National Academy of Sciences, in partnership with the Nobel Foundation, Potsdam Institute for Climate Impact Research, and the Stockholm Resilience Centre/Beijer Institute of Ecological Economics, will host the first-ever Nobel Prize Summit from April 26 to April 28, 2021. Framed around the United Nations Sustainable Development Goals (SDGs), the summit will gather a powerful network of Nobel laureates, together with world-leading scientists, business leaders, writers, politicians, artists, and young people. The purpose is to continue building trust in scientific reasoning while exploring transformative models for people and the planet on some of the most pressing existential challenges faced by humanity on Earth: (1) climate change and biodiversity loss, (2) rising inequality, and (3) rapid societal transformation enabled by emerging and converging technologies. The summit will provide opportunities for direct engagement between the general public and Nobel laureates and experts. A Proceedings of a Workshop will be prepared by designated rapporteurs in accordance with institutional guidelines.



SOURCE: Nobel Prize Summit. 2021.

Available at https://www.nobelprize.org/events/nobel-prize-summit/2021/agenda.

change, biodiversity, inequality, and scientific and technological innovation. The following chapters combine highlights across the sessions structured around three common threads: Our Planet (Chapter 2), Breakthroughs (Chapter 3), and Our Future (Chapter 4). Appendixes A through C provide the full agendas and speakers for each session; video recordings of most of them are also available online.¹ Appendix D provides the text of a Call for Action inspired by the summit and issued by more than 125 Nobel laureates and other experts. In keeping with the guidelines of the National Academies of Sciences, Engineering, and Medicine, this proceedings was written by the rapporteurs and does not represent the views of the planning committee or host institutions.

MAIN STAGE: Introduction from the Partners

The Main Stage session began with short welcomes and discussion from representatives of the Nobel Foundation, National Academy of Sciences, Potsdam Institute, and Stockholm Resilience Centre.

As **Vidar Helgesen** (Nobel Foundation) noted, this first-ever Nobel Prize Summit brought together "the sciences and the arts, business and policy, the young and the old." He called attention to the fact that "never have so many Nobel laureates met such a large global audience to address our biggest global challenges." Harkening back to Alfred Nobel's

¹ Videos of most Nobel Prize Summit presentations are on the event's YouTube channel: https://www.youtube.com/ playlist?list=PLJE9rmV1-ouAEyeeX_SjUhBK6swU0owV0.

internationalist legacy and concern about the greatest challenges of his time, Helgesen pointed to the need for leading minds across disciplines to come together to address urgent and complex challenges facing the planet. "We want this summit to be a platform for critical thinking, discussion, and action," he stated.

Marcia McNutt (NAS) noted the mobilization around COVID-19 has put science in the spotlight in unprecedented ways through advances related to public health interventions, therapies, and vaccine development. "We need to bring this same sense of urgency to the coupled problems of climate change and inequality," she stated. "Can we reduce inequities to safeguard the long-term potential of all of humanity, and can we rapidly become effective stewards of Earth's climate and biosphere?" She expressed optimism that science can provide solutions. She noted that each institution brings strengths to the collaboration: The Nobel Foundation engages Nobel laureates and amplifies the message of the summit; NAS is recognized for its convening power and as a trusted purveyor of accurate information; and the Potsdam Institute and Stockholm Resilience Centre have international renown in taking on the coupled problems of climate instability, resilience, and sustainability as grand challenges.

Johan Rockström (Potsdam Institute for Climate Impact Research) stressed the need for action. Today's youth, he said, are urging policy makers and the public to listen to and act on the science, and he explained the summit was structured so that scientists could share findings around the summit themes (see Box 1-1). He likened the urgency of confronting the pandemic over the past 18 months with the emergency affecting the planet. "We can no longer act incrementally, we must act exponentially, collectively, and in parallel," he stressed. The next decade is critical to cut global emissions by half, although, he commented, this reduction will not be sufficient to meet the Paris Agreement targets on climate change and the United Nations (UN) Sustainable Development Goals.² With a loss of 68 percent of wildlife since 1970 as a clear example, "we're slicing, dicing, and simplifying Earth's biosphere and systematically stripping out resilience. The scientific message is that this has to end." Rockström stated. He also observed that those who have done the least to undermine Earth's resources are those who are hardest hit. While the Fourth Industrial Revolution promises to change health, employment, and other aspects of human culture, he cautioned, "it is still not clear if on aggregate, this revolution will address societal and environmental goals or make the goals harder to achieve."

Given the challenges, Rockström expressed optimism that the decade ahead could be transformative. "We are a resilient species, and cooperation is our superpower," he said. He noted important global meetings taking place in 2021, including the UN's upcoming conferences on biodiversity, climate change, and food systems, as opportunities to come together to act with speed and at scale.³

Picking up on the message of "realistic optimism," Helgesen observed, "We are seeing an unprecedented confluence in the right direction." He lauded the growing recognition of the

² For background on the Paris Agreement, see https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement. For the Sustainable Development Goals, see https://sdgs.un.org/goals.

³The United Nations (UN) Biodiversity Conference is scheduled for October 2021 in Kunming, China; the UN Climate Change Conference is scheduled for November 2021 in Glasgow, Scotland; the UN Food Systems Summit will take place in New York in September 2021. need to listen to science to understand the problems and find the right solutions at scale and speed, as well as positive movement in financial markets, industry, and politics. "But we have to give that movement further momentum," he stressed, and said the Nobel Prize Summit was organized to contribute to the momentum. McNutt said as a scientist, it is hard not to be an optimist, noting science has helped find a way out of difficult situations in the past. "Science is the one tool we have to allow more people to lead better lives without some being put back and living worse lives," she said. Examples she cited included the Green Revolution in agriculture, development of fiber optic cable for communications to overcome widespread worry that the world would run out of copper, and research to explain the reasons behind and effects of a hole in the ozone layer that led to the 1972 Montreal Protocol's ban on chlorofluorocarbons.⁴

"Science shows we must act, and science shows we *can* act," Rockström concluded. "We see clear signs of social transformation with sustainability as a path to a new modernity on Earth. This is what I would call evidence-based optimism. It requires realism and a sense of urgency. Above all, we need collective action, a sense of togetherness, and a collective coalition for change."

FROM THE SCIENCE SESSIONS: Close to the Tipping Point

The Academic Science portion of the summit launched with remarks by **Göran Hansson** (Royal Swedish Academy of Sciences). "We live at a critical time in the history of the planet and are uncomfortably close to a tipping point," he said. Changes are human-made and humanity can and must act to improve the situation. While daunting, he said, it is possible, as demonstrated when the impending crisis of a hole in the ozone layer was handled through the Montreal Protocol in 1972. Scientists played a key role; opinion leaders, decision makers and people were mobilized; and the ozone layer was protected. To change conditions for the better, he concluded, knowledge is the best weapon.

Her Royal Highness Crown Princess Victoria of Sweden extracted a lesson about human-nature interconnections from the blockage of the Suez Canal by a container ship.⁵ For almost a week, she recalled, an excavator and other machinery were deployed to extricate it, but it took a rising tide to finally free it. "Despite human efforts, in the end, we depend on nature to help us," she said.

"We are now at a moment of time when humanity is the dominant force for change on planet Earth, causing increasing turbulence in our biosphere," she said. "That can be a frightening thought; however, we can also choose to see it from the opposite angle. Humankind is at the steering wheel of our planet. We have science, we have technology, we have an interconnected global economy and that means we do have a choice. We can stay on the current course with devastating consequences, or we can choose to take a safer, more resilient path to turn the ship around before it is too late. The choice is ours and this is our window of opportunity."

⁴ For more information, see Montreal Protocol on Substances that Deplete the Ozone Layer, available at https://treaties.un.org/ Pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-2-a&chapter=27&clang=_en.
⁵ In March 2021, a container ship went off course and was wedged across the canal, blocking one of the world's major trade routes for 6 days.



OUR PLANET, OUR FUTURE

OUR PLANET

Presenters in the Main Stage and Academic Science portions of the 2021 Nobel Prize Summit spoke of the challenges and opportunities facing the planet. Scientists, politicians, activists, and others shared views on the state of the planet based on their professional and personal experiences. This chapter summarizes presentations from former U.S. Vice President Al Gore, as well as dialogues on biodiversity, human rights, inequality, sustainability, and technology. It also introduces several key inputs to the summit, including a 2021 white paper and highlights of a workshop on cutting-edge sustainability science.

MAIN STAGE: Our Planet: Its Health, Its People, Its Future

Former U.S. Vice President **Al Gore**, recipient of the 2007 Nobel Peace Prize, characterized the current time as filled "with abundant and legitimate hope that we are right now crossing the political tipping point on climate." While world leaders have announced ambitious goals to cut greenhouse gas emissions, he noted the technology, business, and investment sectors have also made great strides in shifting to a sustainable future. In 2020, for example, 90 percent of all newly installed electricity generation worldwide was renewable, much of it coupled with battery storage that magnifies its advantages over fossil fuels. In the decades ahead, the International Energy Agency projects that number will rise to 95 percent. The advantages and health co-benefits of clean energy are leading to replacement and early retirement of existing coal and gas facilities, he noted, transforming the market. In 2014, solar and wind power was cheaper than traditional sources in just 1 percent of the world, he pointed out. In contrast, they are now cheaper in more than two-thirds of the world and are expected to be so almost everywhere in the next 5 years.

As other examples of innovations, Gore called attention to the work of Climate TRACE, a global coalition that uses satellite data and artificial intelligence, updated in nearly real time, to report on global greenhouse gas emissions.¹ He predicted this "radical transparency"

1 See www.climatetrace.org.

will likely have a profound effect in holding polluters accountable to their governments, customers, supply chain partners, nongovernmental organizations, and others. Electric cars and trucks will achieve price parity with internal combustion vehicles in the next 2 to 5 years in key market sectors, and many governments are beginning to mandate electric vehicles by the end of the decade. Regenerative agriculture, sustainable forestry and fishing, the circular economy, and other innovations are also gaining momentum. "We are living in the early stages of a sustainability revolution empowered by machine learning, artificial intelligence, the Internet of Things, and the biotechnology revolution. It has the magnitude of the Industrial [Revolution] coupled with the speed of the Digital Revolution," he said. Investors are taking note of this ESG (environmental, social, and governance) business opportunity, although he warned against "greenwashing," in which companies convey misleading information about their environmental performance. Moreover, he said, people around the world, especially the rising younger generation, are demanding change.

The journey ahead is difficult, Gore cautioned. To limit global temperatures to meet the goals set out in the Paris Agreement, greenhouse gases must fall 7.5 percent every year for the next decade.² But, he said, market forces are powering this transition forward, and the opportunity to create tens of millions of new jobs is irresistible. Gore cited a paper published in the Oxford Review of Economic Policy that shows that green stimulus measures have both short-term and long-term advantages, and they generate 3 times as many jobs as fossil fuel investments, dollar for dollar (Hepburn et al., 2020).

Gore extracted several lessons from COVID-19. First, when the world's scientists join in unison to warn of a major threat, it is wise to listen and respond. Just as they warned about the need to mobilize and put safeguards in place to address a pandemic, their warnings based on climate science should be heeded, he said. The pandemic has made it easier to stretch "our moral imagination" to understand how the interconnected world can be knocked off kilter. Also, advances in science and technology have provided new tools to respond to global threats, and can be marshalled to respond to the climate crisis. However, COVID-19 also harshly revealed the dangers of growing inequalities and inequities. "Like the pandemic, the climate crisis is a global threat that must be addressed urgently in all nations," he said. One billion people may cross borders as climate migrants in this century, and this flow has led to xenophobia in many of the countries to which they are fleeing.

"We have the solutions we need, and we are gaining political will to implement them in time," he concluded. "Moreover, new scientific findings give us hope about the speed with which we can halt global warming if we act. For those who doubt, I would say that the will to act is itself a renewable resource."

MAIN STAGE: Updating the Concept of "Think Globally, Act Locally"

Thomas Lovejoy (Amazon Biodiversity Center) coined the term "biodiversity" in 1980 to convey the rich variety of life on Earth at the genetic, species, and ecosystem levels. In dialogue between him and **Sandra Díaz** (Córdoba National University), the connections between biodiversity loss, climate change, and inequality took center stage.

² For more information on the Paris Agreement, see https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement.

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Life on Earth is a living fabric that, taken together, drives great global cycles of carbon and nitrogen, Lovejoy explained. The carbon cycle is an important contributor to climate change, which is why, he commented, "climate change is a biological problem." As much carbon from destroyed terrestrial nature is in the atmosphere as survives in current ecosystems. A good ending to climate change will require ecosystem restoration. "For a satisfactory outcome, we need to manage ourselves," Lovejoy said.

Díaz noted people ask her how she views the biodiversity crisis compared with the climate change and poverty crises, as if they are separate entities. "Some see biodiversity as plants and animals, out there, separate from us. But science tells us that living nature is much more than an inventory of species," she said. All living things, including humans, are intertwined. This living fabric is essential to the functioning of the planet. "Runaway climate change, massive biodiversity loss, and intolerable social and environmental inequality are the three most serious problems. There cannot be an appropriate solution for these three existential challenges without tackling them together in a coordinated way and without realizing the living fabric of the earth is at the core of the three challenges," Díaz emphasized.

Drawing on his study of the Amazon since 1965, Lovejoy noted the region provides moisture to every country in South America except Argentina. Deforestation has to stop, accompanied by reforestation, to back away from a tipping point that affects the continent. Díaz said this is an example of a "distant connection" between ecosystems far apart from each other, known also as telecoupling.³ Natural telecouplings occur around the world; once disrupted, they are hard to restart. Human-made connections rapidly exacerbate telecoupling through

³ For more information on this concept, see the 2018 special issue of *Ecology and Society*, "Telecoupling: A New Frontier for Global Sustainability," available at https://www.ecologyandsociety.org/issues/view.php?sf=125.

global exchanges of goods, waste, information, organisms, and people. "This is why today nobody on Earth is fully local," she said. "First, we are receiving influences from distant places. Second, what we choose to eat, support, and buy has impacts on remote systems and people despite the fact that we will probably never see them in person." For this reason, she suggested, the classic slogan "Think Globally, Act Locally" has become a bit outdated. Instead she said, thought and action must occur at both global and local levels; similarly, action and coordination are needed at all levels.

Every species (microbes, plants, and animals) represents close to a 4-billion-year evolutionary lineage that must be respected, Lovejoy observed. These species constitute a gigantic library of the life sciences, and each represents a potential solution to a set of biological challenges and opportunities. The variety of life provides ecosystem services, Lovejoy said, which should be treated as assets and tracked in national accounts, a suggestion echoed by others throughout the summit. In moving toward a better future, Díaz said, "We need to act urgently in the shape of practical local measures where the physical impact is felt. But that is not enough. We also need to make fundamental changes at the social, economic, institutional levels.... They are more difficult to tackle but indispensable for a better future for all."

MAIN STAGE: Four Dynamic Dialogues

Actor, writer, and science enthusiast **Ahmed Best** moderated four panels that brought scientists together with whom he called "provocateurs" to discuss human rights, inequality, sustainability, and technology.

Science as a Human Right

Article 27 of the United Nations (UN) Universal Declaration of Human Rights includes language recognizing that all people have the right to participate in and benefit from science,⁴ explained **Martin Chalfie** (Columbia University), chair of the Committee on Human Rights of the National Academies of Sciences, Engineering, and Medicine. The committee advocates for the rights of scientists, engineers, and health professionals around the world.⁵

A 1966 covenant on economic, social, and cultural rights further elaborated on the concepts embodied in Article 27. In addition, the UN Committee on Economic, Social, and Cultural Rights published guidance in 2020 on how to measure and monitor implementation of the right to science.⁶ Access to science, it specifies, is not just access to the fruits of science but to participation. Chalfie noted that global access to COVID-19 vaccines serves as a test to these ideals. Scientific progress also raises rights-related challenges and questions, Chalfie said, and scientists often lead the way in calling attention to the human rights and ethical implications of scientific discoveries. For example, he called attention to Rafael Yuste and others, who have called for an expanded concept of human rights based on new neurological knowledge, with the elaboration of five new "neuro rights": personal identity, free will, mental privacy, equal access to mental augmentation, and protection from algorithmic bias.

⁵ For more information about the committee and to view an online exhibit created by the committee for the Nobel Prize Summit, entitled "Advancing Rights and Freedoms: Science, Human Dignity, and the Nobel Prize," go to https://www7.nationalacademies. org/humanrights.

⁶ See general comment no. 25 on science and economic, social, and cultural rights, available at https://undocs.org/en/E/C.12/GC/25. Copyright National Academy of Sciences. All rights reserved.

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⁴ See https://www.un.org/en/about-us/universal-declaration-of-human-rights.

Connie Nshemereirwe (Uganda National Young Academy) commented while science should be a human right, sometimes the advancement of science threatens other rights. "Knowledge itself is not intrinsically dangerous," Chalfie responded. However, he agreed that people can use knowledge inappropriately against others, and this is why laws and respect for human rights are necessary.

Picking up on Chalfie's concern about equitable vaccine distribution, musician and activist **Gingger Shankar** asked how to implement human rights into science when many communities are being decimated. Chalfie said the UN has tried to address this and has urged governments to look to laws to eliminate bias and ensure participation so that everyone gets these rights.

Gatwal Gatkuoth (Upper Nile Institute of Public Health) asked about global equal access to education to become a scientist. Chalfie noted that access to scientific information can be expensive, but there is an increasing effort to make scientific manuscripts freely available to the entire world. More broadly, he said, equal access to education is challenging, especially for the more than 80 million people who are displaced, but is critical to move forward. "In my experience, research progresses much more quickly when several people and multiple perspectives are involved," he commented. "For science to progress, we need a diversity of interests and perspectives—and that means bringing everyone in."

Economics of Inequality

Gary Hoover (Tulane University) shared data that show inequality has accelerated both within and between countries over the past several decades. The richest 1 percent of the population has seen their share of global wealth grow from 28 to 33 percent, while the lowest 75 percent's share has remained constant at just 10 percent. The poverty in countries rich in natural resources remains stubbornly high, while other countries have exploited those resources and widened the wealth gap.

Hoover noted some people argue that innovators and entrepreneurs take the risks to bring new products to the market and should receive the benefits and, consequently, a wealth gap occurs, but that these new products will eventually sift through society to decrease the inequality gap. What they miss, he countered, is that when inequality violates the social contract such that a person cannot advance and move up the economic ladder, it is harmful. In the United States, some argue that anyone who does not take advantage of the U.S. educational system must be satisfied with their situation in life. But, Hoover said, what if people do take advantage of available opportunities but are still underprepared compared with their peers. "It's a violation of the social contract when the quality of the education one receives is tied to their zip code," he said. In addition, to be an innovator or entrepreneur requires access to financial markets, which is not equal. Finally, he said, no economy works well without a well-functioning court system to adjudicate differences. Violations of the social contract do not occur in a vacuum, he stated, which could lead to instability. "We're standing on the knife's edge," he concluded. "We can have sustainable, long-run, and reliable economic growth when we appeal to the social contract or we can continue with the inequity we have now, which is going to see a destruction of the entire economic system."

Simon Levin (Princeton University) connected inequality with global sustainability. The West has been living in privileged societies for a long time, he commented, and developing countries want the right to engage in activities that may close the equity gap but may also threaten environmental sustainability. Hoover recognized the need to resolve this conflict, but said nations can choose to follow models that provide for economic growth without being destructive and that adhere to the social contract. Regarding the value of expanding access, he noted, "When we allow everyone to be innovative and come up with new ideas, how do we know there isn't a new technology that would allow us to close the wealth gap but also find climate sustainability? We don't know that when we block people from entering the discussion."

Film director **Joe Robert Cole** asked about historical context, in which the past affects current conditions. When there were fewer people on Earth, there were fewer inequities, Hoover said. As the world continues to increase, the margins for error are decreasing. New technologies (such as social media) make inequities more easily seen. **Zoë Jenkins** (Get Schooled) commented that some people profit from inequality, with slavery as a clear example. She questioned how to incentivize to strive for equity rather than just the highest profit possible. Hoover said some inequality will always occur—there will always be first movers and innovators—but opportunities must exist for everyone. He added that greater opportunities result in higher economic returns. "Every time I get ahead by holding you back, I am losing a consumer," he observed. "I want to make a product that enhances your life so you can enhance mine." The challenge is to reimagine the social contract that builds in equality, Hoover concluded.

From Sustainability to Stability

The changes that humans have imposed on the planet call for a redefinition of new ways of living, said **Brigitte Baptiste** (Universidad EAN). "We have to design options in the short term to deal with climate change and the loss of biodiversity without creating more inequity and social injustice," she said. A new and emerging global ecosystem has resulted because of human activity, with increased awareness about risks to survival heightened in the last century or so. "We have to realize we live in a shared world with ecological and cultural diversity," Baptiste said. "No single person, community, or nation will be able to adapt isolated, much less impose solutions for others." Framing nature's contributions to people as "ecosystem services" allows for humans' interconnections with nature to become more visible. Management options that encompass new ways of doing and thinking are needed. "To become stewards, we have to become ecosystem engineers, artists, and biological thinkers at the same time," she said. Some changes, such as population growth and extinction of some species, are irreversible. The building of cities represents an interesting ecological experiment. We need to deal with the ugly consequences of global change but also recognize human capacities for change, Baptiste concluded.

Nobel Prize laureate **Klaus von Klitzing** (Max Planck Institute) noted both long-term and short-term changes to the planet are occurring and asked about priorities on which the public should focus. Baptiste responded that people are experiencing conditions exacerbated by climate change, such as more frequent storms, fires, and intense heat. These experiences may provide the entry point to address transitions in agriculture, coproduction, and other areas, she suggested.

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Adam Riess (Johns Hopkins University), a fellow Nobel Prize laureate in physics, observed that decades of getting people to cut back consumption have not worked to meet targets. He suggested focusing on targeted geoengineering solutions as a way to address climate change and other impacts (NASEM, 2021b). Baptiste concurred with experimenting with all options, but for many developing countries, she noted, the most feasible option must be to rebuild resilience to deal with current conditions.

Anne Muthoni (Youth Arts Mentorship Initiative) asked about balancing the priority to limit temperatures by 2030 with adaptation. Baptiste observed that "it depends on which country you live in." In more industrialized countries, mitigation should be the goal of research and investment, she suggested. In countries that do not contribute significantly to global warming but are nonetheless vulnerable, their more limited research and innovation capacity may instead need to prioritize adaptation.

Technology's Promise

In the last "dynamic dialogue," Nobel Prize laureate **Stanley Whittingham** (Binghamton University) pointed out that the technology and tools to get around the fossil fuel economy exist, and they could mitigate climate change and improve resilience to natural disasters. Renewable energy is economically viable, he explained, although the intermittency of wind and solar power requires better systems of battery storage. Battery production is currently not sustainable; it takes 60 to 80 kilowatt hours of energy to produce 1 kilowatt hour of a lithium ion battery. Improvements include more localized supply chains, such as happening in Europe and could happen in North America. "We have the technical solutions in place; now we have to educate the politicians and public to get them on board," he stressed. Furthermore, "We cannot do it alone." As an example of the benefits of interdisciplinary, international collaboration and investment, he noted the 2019 Nobel Prize in Chemistry for development of the lithium ion battery was awarded to him and two other scientists whose work spanned three disciplines and three countries.

Musician **Beatie Wolfe** agreed that complex issues do not lead to a one-size-fits-all solution. Given the breadth, she asked Whittingham for the main takeaway for the audience from his research. Whittingham responded, "The message is that we can do it if we want to do it, we should do it, and don't let others get in our way of doing it." **Ahmad Mobayed** (Syrian Youth Assembly) asked Whittingham for ideas about connecting transformation and youth movements. Whittingham urged youth to speak out, pointing to the impact of climate change activist Greta Thunberg.

Nobel Prize laureate **David Gross** (University of California, Santa Barbara) questioned how to spur the development of technologies that are not part of multinational corporations' strategies or business models. Whittingham acknowledged that the United States is set up to operate on the profit motive. He noted solar voltaic and lithium batteries were invented in the United States, but commercial production moved to Asia when U.S. companies did not envision a profit. If the United States does not get involved, foreign companies will step in, he warned. Wolfe suggested finding ways to reflect real costs and learn from mistakes. Whittingham agreed and said, as an example, there needs to be a way to estimate costs of generating carbon dioxide (see also Nordhaus, 2017).

FROM THE SCIENCE SESSIONS: Scientific Underpinnings

At the Academic Summit, a synthesis of challenges was presented by four members of the U.S. National Academy of Sciences: Carl Folke, Pamela Matson, Sir Partha Dasgupta, and Jane Lubchenco. Three leading journal editors reflected on their presentations.

White Paper on the Anthropocene

Carl Folke (Stockholm Resilience Centre/Beijer Institute of Ecological Economics) and colleagues developed a white paper on the Anthropocene biosphere that was used as the basis of planning the Nobel Prize Summit (Folke et al., 2021). Folke summarized the paper, and noted a main message is that science can serve as a guide for a better future. He described the biosphere as a thin layer, only 20 to 25 kilometers within a huge universe, where all life is concentrated. "We are part of the biosphere, we are living in it, we have emerged within it, we have evolved with it, and we are embedded in it," he said.

The climate is one reflection of human impacts, he noted. In the last 11,000 years, civilizations have emerged, but a more dynamic period has occurred more recently. Fires, droughts, and excessive rainfall are part of an intertwined system of people and nature. At the same time as temperatures have risen, he noted, homogenization of the planet and simplification of landscapes have caused loss of biodiversity. Biodiversity is important to buffer shocks and disturbances.

The paper looks at challenges of potential tipping points, Folke said. Places that are critical greenhouse gas sinks may become sources of it, for example. Another dimension explored in the paper relates to inequality and global sustainability. Environmental changes hit poor and marginalized people disproportionately, and inequality shapes the biosphere. Collaboration requires trust and collective action; inequality works against such actions. Connecting the ongoing technological revolution to global sustainability has enormous potential but has not been fully realized. Social innovation is also important to discover how to shift from old to new ways of doing things. New narratives are emerging about how to develop in synergy with the planet, he added.

"It has become quite clear that if we think climate issues or the biosphere are marginal issues, the likelihood for a prosperous future is not high," he said. Instead, he said, it is necessary to shift development pathways to improve stewardship of global commons⁷ and to organize society in relation to the planet, to find ways for collective action and really move forward. Folke introduced the concept of "revitalizing biosphere resilience to strengthen the capacity of the biosphere to deal with shocks and climate change so that we can live and prosper peacefully for a long time into the future." He concluded, "Whether humankind has the collective wisdom to navigate the Anthropocene to sustain a livable biosphere for generations to come and for the rest of life with which we share the planet is the most formidable challenge facing our species."

⁷Appendix D, "Our Planet, Our Future: An Urgent Call for Action," defines the global commons as the climate, ice, land, ocean, freshwater, forests, soils, and rich diversity of life that regulate the state of the planet, and combine to create a unique and harmonious life-support system.

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Six Cross-Cutting Capacities of Sustainability Science

In December 2020, the National Academies of Sciences, Engineering, and Medicine convened a workshop to share cutting-edge sustainability science. Workshop Co-Chair **Pamela Matson** (Stanford University) shared highlights of the workshop, which was designed to update the scientific community on sustainability science and to provide scientific input to the Nobel Prize Summit (NASEM, 2021a).⁸ She elaborated that the six themes discussed at the workshop are capacities necessary for pursuing sustainability, no matter the issue, and that cutting-edge, research-based findings related to them can be used by decision makers (see Box 2-1). Underlying all six capacities is the recognition that "nature and society are intertwined in a single, coevolving complex system. Efforts to guide development must embrace that complexity." Frameworks to do this exist, she said, and those frameworks can be helpful to decision makers as well as researchers.

The first capacity described by Matson relates to adapting to shocks and stresses. Research has shown that the ability to respond effectively requires not just economic but also social, political, cultural, and biophysical resources. Focusing on just one asset may limit effectiveness of responses; building up of missing resources may help. In addition, she noted, adapting in the short term may be maladaptive in the long term and what works in one place may not work in another. Matson quoted a workshop participant, who said, "Adaptive capacity includes the ability to make and remake relationships across biophysical and social parts of the system over time."

Second, in addition to adaptation, structural transformations are likely to be needed to address sustainability challenges. Interventions are needed to break down the economic, social, and political drivers of lock-in, and bottom-up experimentation as well as top-down policy interventions can help destabilize established regimes and diffuse innovations. Frameworks have been developed to help actors understand the roles they can play in doing so, Matson said. Research also shows that transformative change rests on imagination and the engagement of all kinds of traditional and nontraditional participants and multiple cultures in creating alternative visions.

Third is the capacity to measure progress. While there are new tools and approaches to measure and share data about the system, practical and complete measures of the whole system, now and into the future, do not yet exist. One promising set of metrics is the Inclusive Wealth Index—tabulated by the United Nations, World Bank, and others—which aims to capture not just economic but also biophysical, social, and other assets.⁹ Expanding these approaches is a top priority for sustainability science going forward, Matson said.

Fourth, governance systems today need to anticipate and respond not just to single problems but to interacting changes and stresses, all happening at once. Research suggests that 20th century governance processes often are not able do this well, and instead must become ongoing collaborative processes that engage different people and communities with different visions, values, capacities, and concerns. New forms of cross-scale collaborative

⁸ For a video of the workshop, see https://www.nationalacademies.org/event/11-30-2020/progress-challenges-and-opportunities-for-sustainability-science-a-workshop.

⁹ See, e.g., https://www.unep.org/resources/inclusive-wealth-report-2018.

BOX 2–1

Cross-Cutting Sustainability Science Capacities

At a December 2020 workshop on progress, challenges, and opportunities for sustainability science, six promising, cross-cutting capacities were identified and explored:

- Adapting to shocks and surprise
- Fostering innovation for transformational change
- Measuring progress
- Managing and governing complex nature-society systems
- Linking knowledge with action
- Promoting equity and justice

According to workshop co-chair Pamela Matson, the six capacities are necessary for sustainability, no matter the issue. Moreover, cutting-edge, research-based findings related to them can be used by decision makers of all kinds.

SOURCE: Pamela Matson, Workshop Presentation, April 26, 2021, based on NASEM, 2021, *Progress, Challenges, and Opportunities for Sustainability Science: Proceedings of a Workshop-in Brief*, Washington, DC: The National Academies Press, https://doi. org/10.17226/26104.

"polycentric" governance, rather than top-down systems, are now being tested and used (see Ostrom, 2010).

Fifth is the need to link knowledge to action. Scientific knowledge is often "too little, too late" or not relevant to the problem at hand. Research and practical experience over the past several decades have clearly demonstrated the inadequacies of "pipeline" or "loading dock" approaches to usable knowledge. Matson noted that the development of trusted and useful knowledge in support of decision-making requires ongoing conversation, collaboration, and, often, coproduction that includes both researchers and decision makers. Matson expressed optimism that the next generation of researchers is learning how to link more effectively with a broad range of actors.

The sixth capacity calls for fostering equity in the well-being of people, now and in the future. "Justice, equity, fairness, and inclusion are essential to meet sustainability goals. Research has indicated the need to engage a broad range of people and a diversity of types of knowledge, experience, and values in order to work successfully toward the solution of sustainability challenges," Matson said. She noted that workshop participants said this capacity remains the least well understood and developed, yet essential, and a recurring message throughout the workshop was to "embrace plurality and equity."

Economics of Biodiversity

In The Economics of Biodiversity, Sir Partha Dasgupta (2021) (University of Cambridge) and colleagues observed, "It is not often that economy and nature are in the same sentence

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although they are heavily intertwined." Previous economic analysis has excluded nature to focus on produced and human capital, he said. After the devastation caused by World War II and the emergence of new independent nations, perhaps it made sense then, he acknowledged. However, the resulting macroeconomic models directed how economists collected data, and it became commonplace to bypass nature and its role in economic life. Dasgupta characterized this as "profound error, as nature is our most precious asset." Today, people live longer and healthier. Life expectancy and per capita income have increased, and the world economy has grown. But in achieving this growth, the demands made on nature have exceeded its capacity, he said. The difference between demand and sustainable supply has degraded nature and threatened future lives. Biodiversity is declining faster than ever before. By one estimate, it takes the equivalent of 1.6 Earths to meet current demands.

Nature is an asset, like produced and human capital, although it is not just an economic good. It also has intrinsic, even sacred, value, Dasgupta stressed. "Once we include these aspects of nature in our lives, the economics of biodiversity becomes a study in portfolio management, similar to how companies, households, and others manage assets in line with motivations and constraints." A central reason for failure to do so, he said, is because nature's worth to society is not reflected in market prices, and consequences for mismanagement are hard to trace. Also, there are no incentives to conserve. The oceans and air are global public goods from which all benefit but do not pay rent or other costs. Governments subsidize the use of nature at a rate of \$4 to \$6 trillion annually, he said. "In effect, we pay ourselves to exploit, not protect, our home," Dasgupta stated.

A transformative change is needed, Dasgupta said. He suggested three transitions: (1) address the imbalance between demands and supply on nature, which involves setting meaningful conservation targets and investing in nature to increase quality and quantity; (2) change measures of economic success beyond current gross domestic product measures; (3) transform institutions, especially financial and educational systems, to enable changes to take place at a global scale. After World War II, he noted, the community of nations had the courage to establish the World Bank and other institutions. Similar organizations with authority are needed to monitor and manage global goods like the open seas and the atmosphere, according to Dasgupta.

Because much of nature is silent, mobile, and invisible, no institution can eliminate all the negative impacts, Dasgupta concluded. Citizens must serve both as judges and juries of their own actions. They must demand needed changes and make informed decisions about their own actions. "Education is needed to understand nature, and understanding is the basis for science," he said.

The Role of the Ocean

The ocean is a critical part of the global environment and requires stewardship, as discussed by **Jane Lubchenco** (advisor to the U.S. president; Oregon State University). She agreed with her co-presenters about the compelling need to harness knowledge and action to enable a transition to a sustainable and resilient future. "The challenges are real and daunting, but they are not insurmountable," she stressed.

Even though most people do not see the ocean on a daily basis, it is part of all humans' past and future, Lubchenco explained. It serves as a grocery store, pharmacy, highway, and playground. It regulates climate and produces weather, provides a sense of wonder, and offers an unfathomable library of still-undiscovered treasures and inspiration. In addition to tangible benefits, she noted the poetry of Pablo Neruda and the documentary film My Octopus Teacher as examples of the power of the ocean for the human spirit (see Ehrlich and Reed, 2020).

But, she said, the living ocean is at risk and so are humans. Through ignorance and arrogance, its beauty and bounty have been squandered, and the ability of the ecosystem to provide essential life support systems, especially over last half century, has been undermined. Significant inequities have been exacerbated. Climate change, ocean acidification, habitat destruction, overfishing, mining, oil and gas exploration and extraction, and pollution from the land have all taken their toll. The Intergovernmental Panel on Climate Change (IPCC) documented the massive effects of climate change and acidification on the ocean in its 2019 report (IPCC, 2019). It is warmer, more acidic, less productive, and less predictable, and coral reefs, mangrove forests, and kelp forests are in danger.

Ocean ecosystems can recover if stressors are removed soon enough, she said. People who depend on the ocean can also be resilient. For example, depleted fisheries and habitats have recovered, with science-based policies and the right incentives and conditions providing the "secret sauce" for success. Thousands of such efforts are under way and they are powerful, but they are not at the scale and pace needed now. Novel partnerships demonstrate the power of holistic approaches to achieve the "triple bottom line": protect effectively, produce sustainably, and prosper equitably.

The ocean has not been a go-to place for climate mitigation and to address the food security crisis, but it can and should be, Lubchenco suggested. New analysis suggests that managed protected areas can address climate, food, and biodiversity issues. She disputed two prevailing narratives. The narrative for thousands of years was that the ocean is so immense and bountiful, it would be impossible to deplete or disrupt it. That mindset persists today and drives exploitation. The folly of "too big to fail" is becoming evident. A second narrative is that the ocean is massively and fatally depleted and is "too big to fix." That narrative, she said, can lead to depression and inaction. However, she sees hints of a third narrative: "I believe the new emerging narrative could be quite powerful to reset expectations and inspire ingenuity. The ocean is not too big to fail or too big to fix, but it is too central to ignore."

Reflections from Journal Editors-in-Chief

Richard Horton (*The Lancet*) agreed that the film *My Octopus Teacher* makes a powerful plea to rethink human relationships with all forms of life and urged people to use the present moment to question long-held assumptions. Despite the toll, the COVID-19 pandemic provides the greatest opportunity of a generation to redefine goals of humanity, including considering people who have been most marginalized in society and are also now at the center of the political stage. The importance of cooperation and multilateralism to solve global challenges has been underlined, Horton said. Trust, integrity, and truth-telling have been at the foundation of good governance; when they have been absent, terrible consequences are also revealed.

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But, he warned, this opportunity is contingent on accepting that COVID-19 was not a pandemic, but rather a syndemic: that is, a virus that exploited preexisting biological vulnerabilities across societies and social fragilities. —Richard Horton

But, he warned, this opportunity is contingent on accepting that COVID-19 was not a pandemic, but rather a syndemic: that is, a virus that exploited preexisting biological vulnerabilities across societies and social fragilities. Forty years of neoliberalism and reliance on market mechanisms, he said, must be seen as a failed experiment that has created a culture of personal misery and undermined human dignity for billions of people. The response has proven the interdependence of science and society. Science must be strengthened and integrated into policy making and politics. "Let's use the new age of humility to redescribe who we are, what we want, and how we will achieve it," Horton urged.

"Guided by the science" was an often-heard phrase in 2020, observed **Magdalena Skipper** (*Nature*). The context was the pandemic, and everyone watched strategies succeed or fail depending on whether policies heeded the science. While she recognized the summit audience would agree with the role of evidence-based science at the center of solutions, "The real question is how to harness scientific guidance, which at times seems at odds with other priorities." She called for collaborations and partnerships to break down the silos across sectors, as well as within the research ecosystem, from anthropology to zoology, to address issues such as climate change, poverty, and habitat loss. Educational systems must be reimagined to train a new generation of researchers who identify as true interdisciplinarians, she added, and noted that interdisciplinary journals provide a platform for dissemination. Research is needed from academia and industry, with lessons from microscale to global experiences and collaborations that extend beyond research.

Skipper lauded countries' pledges of carbon neutrality, but noted they occur without a common understanding of what "net zero" means. Different definitions and pathways can have different outcomes, including whether the Paris Agreement target is met or not. Tensions between governments and industry can be ameliorated when trust is placed in neutral evidence, she commented. "Science is helping to find synergies where previously the world saw only tensions," she said. Harkening to the UN Universal Declaration of Human Rights, which calls science an expression of human dignity that belongs to everyone, she urged, "Let us make it our goal that our discussions resonate with everyone on the planet, and the theme 'Our Planet, Our Future' rings true to everyone, regardless of who they are, where they come from, and where they live."

Holden Thorp (*Science*) referred to previous presenters' messages about linking knowledge and action, fostering equity, and developing and installing new narratives. He issued a special appeal to scientists who are university faculty to educate a population that is more cognizant about science information and process. The "digital monster" of misinformation

issued by autocratic politicians and enabled by tech companies poses a great threat to the public's appreciation for scientific expertise, Thorp said.

But, he warned, those threats cannot be effectively countered "unless we get our own house in order." To Thorp, that means recognizing that the traditional university science model of lecture teaching and high-stakes testing is optimized for European males, and not for women and people of color.¹⁰ He pointed to studies that more inclusive teaching will expand the diversity of the people in science, yet lamented these methods are rarely used. Traditional teaching methods and curricula raise barriers to entry and crowd out courses in social sciences and humanities that place science in a larger context. "It makes no sense to bemoan the lack of science literacy in the world when we still play such a large role in excluding people from science," he charged. Rather than accept excuses for the status quo, he said, "We have the collective power as a scientific community to stop weeding people *out* of science and start weeding them *in*. COVID-19 has been a reset point on so many things—including the way to teach science." He suggested that a populace more enlightened about science will partner to find solutions for climate change.

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10 For a high-stakes test, see https://www.edglossary.org/high-stakes-testing.

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"The youth and the generations of tomorrow demand that you use your knowledge and power of innovation to prevent runaway climate change." —Xiye Bastida

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BREAKTHROUGHS

From cutting-edge technology to the performing arts, from youth activists to senior leaders, the Main Stage and Academic Science portions of the 2021 Nobel Prize Summit included a range of ideas and actors. This chapter highlights presentations by climate justice activist Xiye Bastida, President of the Federated States of Micronesia David Panuelo, and U.S. Special Presidential Envoy on Climate John Kerry. Both the Main Stage and Academic Science sessions convened panels on technological and social innovations, which are also summarized in this chapter.

In introducing the theme of "breakthroughs," Johan Rockström explained on the Main Stage, "Breakthroughs are what we need because we have entered the decisive decade for humanity. We are running out of carbon budget. Intact nature that builds our resilience is increasingly rare, and we are coming dangerously close to the tipping point. At the same time, we see social tipping points emerging. Can we make this year a positive tipping point for humanity?" He pointed to the alignment of four unstoppable forces: political, economic, technological, and social movements. He looked to an integration of policy, technology, and behavior change that must add up to planetary scale during what he termed a disruptive decade.

MAIN STAGE: Diverse Voices

Next Generation

Xiye Bastida (Re-Earth Initiative) introduced herself as a 19-year-old climate justice activist born and raised in Mexico. She noted she is one of many young people demanding climate justice by protesting and organizing strikes to stop investment in fossil fuel spending and infrastructure and, instead, promote investment in climate education, renewable energy, and meeting the 1.5 °C temperature target contained in the Paris Agreement. Carbon dioxide, methane, and other greenhouse gases must be targeted, she said. Noting the communities that rely on the health of the Amazon rainforest, Congo Basin, and other

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fragile ecosystems, "We must keep in mind that climate justice is social justice," as well as examine "our very own foundation of morals and values." She requested that summit participants question the assumptions on which their knowledge and expertise are based. "Most of our frameworks for science, international relations, economics and other fields are rooted in areas of objectivity and emotional detachment with the ultimate goal of striving for money and power," Bastida asserted. She challenged those frameworks, especially the assumption of the tragedy of the commons, which is when people look out for their own good. She countered with the work of Nobel Prize laureate Elinor Ostrom, who asserted that local communities are able to work together to maintain balance with nature. Instead of always striving to get ahead, she said, "it is time to look back at ancestral wisdom that teaches how to live in harmony with Mother Earth, nature, and each other."

Bastida urged closing the gap between science and policy by drawing on scholarship from feminist international politics, climate psychology, urban health, and other fields. "Most of this research remains within journals," Bastida lamented. Instead, she urged for a uniting of academia, public policy, and civil society to develop intersectional climate solutions that address the complexities of the crisis in a just and equitable way. She concluded:

The youth and the generations of tomorrow demand that you use your knowledge and power of innovation to prevent runaway climate change. We must keep fossil fuel in the ground. We must stop the production of plastics. We must draw down excess carbon in the atmosphere. We must stop the overproduction of goods. We must receive comprehensive climate education. We must center marginalized communities in solutions. We must acknowledge the rights of nature in legislation. We must heal our relationship with Mother Earth, and we need all of us. Science, innovation, and government must be aligned to take care of life, not destroy it.

Island Nations

President of the Federated States of Micronesia (FSM) **David Panuelo** issued "an island nation's call to action" and cited the findings in Making Peace with Nature, which provides a scientific blueprint to tackle the climate, biodiversity, and pollution emergencies (UNEP, 2021). Actions today—not tomorrow or next year—must change, Panuelo asserted. He noted his government's full endorsement of the recent work of Sir David Attenborough and his conclusion that "the living world is a unique and spectacular marvel, yet the way we humans live on Earth is sending it into a deep decline." Panuelo drew on Attenborough's (2020) film *David Attenborough: A Life on Our Planet* and this statement from the film to describe what climate change means for his country and actions the global community should take.¹

As of April 2021, FSM comprises 607 islands covering more than 700,000 square kilometers of land and more than 2.2 million square kilometers of ocean territory. This ocean-state is threatened, Panuelo said. Most of the land consists of low-lying atolls just 1 to 5 meters above sea level and is vulnerable to floods, typhoons, landslides, eroding shorelines, and other disturbances. The western Micronesian states lie in the most active tropical cyclone basin in the world. The Global Climate Risk Index assesses the FSM as the third most at-risk among the

¹ For more information, see https://www.attenboroughfilm.com.

Pacific island nations (after Fiji and Vanuatu) (Eckstein et al., 2021).² The effects of climate change are already being seen, including both increased and reduced rainfall depending on location. As the sea level rises, protective coral reefs are overwhelmed and storms become stronger. "For the FSM, climate change is our single greatest security threat. Part of the answer to this threat is that the world must transition to sustainable and renewable energy," he said. He called for global action to meet the commitments under the Paris Agreement and the United Nations (UN) Sustainable Development Goals, similar to what happened with the Montreal Protocol and the recent Kigali Amendment.³ He urged the UN Security Council to work toward these goals.

MAIN STAGE: A Commitment to Cooperation

U.S. Special Presidential Envoy on Climate **John Kerry** spoke with National Academy of Sciences (NAS) President **Marcia McNutt** several days after participating in the April 22–23, 2021, Leaders Summit on Climate convened by President Biden.⁴ At that gathering, he reported, the world leaders present announced ambitious targets to reduce emissions to keep the goal of limited global warming to 1.5 °C within reach. McNutt asked Kerry what scientists could do to help meet those targets.

Kerry responded that scientists have provided information about the problem and solutions but the information has been misused in some situations. "We're in a difficult moment," he acknowledged. "We are confronting in the United States and around the world whether we can establish a baseline of truth in our society. It is critical to do that in respect to the climate crisis because the stakes are so high. And yet, we see a polarization based on politics and exploitation," Kerry asserted.

People need to fight back against "paid-for denial" claims related to climate. "We have to reestablish a baseline of truth or we cannot build consensus in society," he stated. Post–World War II, scientists helped rein in atomic weapons, including some of the same scientists who developed the technology. A leading role for science and scientists is needed now, he urged, especially in the decade ahead. "We are in a war against denial," he said and urged scientists to be at the front of the fight. He underlined that 2020 to 2030 is a critical decade.

Kerry agreed with McNutt that "we need to put 'science on steroids." For example, discoveries are being made related to battery storage and to green and blue hydrogen, but the challenge is getting technologies to scale and in the marketplace. "We are on the cusp of the greatest transformation since the Industrial Revolution," he said. "This is an enormous market, with 10 billion potential users in the next 30 years." The private sector is moving in this direction, but coal must be reined in. "It has to happen at an accelerated pace. Business-as-usual and polarization will make it difficult," he stated. Kerry noted his team is pushing toward the UN Climate Change Summit in Glasgow ambitiously, because the United States and other top 20 economies represent 81 percent of global emissions.⁵

² According to Table 4: Climate Risk Index for 2000–2019, three Pacific island countries most affected include Fiji (rank 19), Vanuatu (rank 37), and Micronesia (rank 40).

³ For information on the Kigali Amendment, which aims for a phase-down of hydrofluorocarbons, see https://www.unido.org/our-focus-safeguard-

ing-environment-implementation-multilateral-environmental-agreements-montreal-protocol/montreal-protocol-evolves-fight-climate-change.

⁴ For information on the Leaders Summit, see https://www.state.gov/leaders-summit-on-climate.

5 For information on the 26th UN Climate Change Conference, see https://ukcop26.org.

MAIN STAGE: Innovative Solutions

Two panels on the Main Stage focused on breakthrough ideas related to technology and community empowerment.

Avenues for Action

Nisha Anand (Dream Corps) moderated a panel on the Main Stage about breakthrough ideas in different fields. Participants included Nobel Prize laureate **Sir Richard Roberts** (New England Biolabs), **Tamar Krishnamurti** (University of Pittsburgh and Naima Health), and **Rana el Kaliouby** (Affectiva).

To ensure effective communication between scientists and the general public, Roberts says scientists should be able to clearly explain what is happening in their labs to their family and friends. Language accessibility is essential to ease distrust about science, he stressed. "We use acronyms and terms that are hard to understand to show how smart we are," he asserted. "That is not smart. What is smart is explaining things in terms that everyone can understand."

"We are all connected economically, through the environment and in a One Health manner as seen in the pandemic. And we are connected socially as well. It is summits like this that allow us to understand the connections we all have and how these connections can make us stronger." —Marcia McNutt

Krishnamurti compares quality of life today to that of earlier generations. "I believe you can measure the health and thriving of a nation by how its mothers are faring. By that metric, we are not doing that well in the United States," she said. The United States has the highest maternal mortality rate in the developed world, and the rate has been increasing while the rate in other developed nations has been decreasing. She noted the majority of these deaths are preventable and occur because of systems failures in which risks are not identified and addressed. Racism plays a role, she added, with the maternal mortality rate in Black and Indigenous communities 2 to 4 times higher than in white, Hispanic, and Asian American communities. Patient-centered technology—collecting information between prenatal visits to connect patients with resources in a more timely way—is one proven solution.

Technological stewardship is a guiding principle for el Kaliouby, who builds artificial emotional intelligence tools so computers can detect and interact with humans more similarly to how humans interact with each other. One application is a more data-driven approach to mental health. When asked how diversity, equity, and inclusion (DEI) can be brought into technology, el Kaliouby said one issue is that technology is a male-dominated industry, but offered suggestions for different stakeholders. Consumers and users of technology have power to support companies that support DEI values. Thought leaders and managers can be intentional about prioritizing DEI, such as by ensuring data diversity and mitigating against algorithmic bias.

In discussing leadership during science-related crises, Krishnamurti commented that women leaders have been lauded for their pandemic responses. Returning to Roberts's discussion of science communication and its role in decision-making, she said many successes in female-headed nations have been in implementing behavioral changes in response to the pandemic. A key is to engage in good risk communication from the start, rather than counter misinformation when it emerges. If people hear clear, transparent messages from trustworthy sources, especially paired with social structure supports, they will act. Diversity in leadership is necessary with different lived experience, she added, to represent the voices of the people the leaders are serving.

Other obstacles exist even with strong leadership, as seen in vaccine distribution, Anand pointed out. Developed countries focus on what is good for them without giving much thought to the rest of the world, Roberts said. He related this to food security and said he is undertaking a campaign to support GMO (genetically modified organism) agricultural technology, especially on lands affected by climate change. He added that without higher yields, people will flee hunger in their native countries, and migration will increase.

Empathy is at the core of communications, trust, and loyalty, and it represents a strand in solving problems, Anand commented. She asked el Kaliouby if and how machines learn emotional intelligence and empathy. El Kaliouby replied that machines learn emotional skills without truly being empathetic. They can contribute to transformative technologies, such as in health and transportation, but the technology could be misused. She said she supports thoughtful regulation to stop nefarious use cases and that company leaders must also take a stand and refuse business that may misuse the technology. Krishnamurti stressed the importance of bringing in the human element in planning, conducting, and disseminating research, including research based on artificial intelligence (AI).

In addition to its benefits, technology can breed misinformation, the participants noted. Roberts expressed concern about social media when algorithms direct information, especially deliberately biased information, from the internet to certain recipients. He suggested using AI in a more positive way. El Kaliouby pointed to the Partnership on AI consortium as a way to get involved.⁶ Krishnamurti is focused on going from "big data" to "better data." Scientists must be more thoughtful about data, she urged. They should include other fields and community members as coproducers of research. She urged scientists to get involved politically.

Giving Power to Solutions

United Nations Under Secretary-General **Natalia Kanem** (United Nations Population Fund [UNFPA]) and Nobel Prize laureate **Steven Chu** (Stanford University) engaged in a conversation about empowering local communities, especially girls and women. The world's population is projected to reach almost 10 billion by 2050, an increase of 25 percent from today. "It is critical that we get smart about the relationship between the population and the planet to make the best policy decisions and choices, and avoid the pitfalls of the past," Kanem said.

6 See https://www.partnershiponai.org.

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Global concern might be expressed about population growth, but decisions about family size are implemented on an individual basis, Kanem stated. She continued, "Over time, the world has realized that you can't dictate population size to people. It's the woman's choice. Given the choice, women know what they want. They want the number of children they can afford and nurture." To Kanem, one way to "give power to solutions" is by supporting women's power to control their own fertility. Studies have shown that when women have this control, they are more likely to have power in other spheres of their lives related to health, education, income, and safety. Currently, about 218 million women want to avoid pregnancy but lack access to modern contraception, she said, which UNFPA addresses through work with low- and middle-income countries. Data and evidence show that humans created but can also solve many of the problems related to population and to other issues discussed throughout the summit, she added.

Chu reflected that a woman's right to choose is linked with many sustainability problems, such as growing food and providing water for a growing population. "As people rise out of poverty, they will naturally consume more energy," he added. "We can't really talk about sustainability until the world's population is stabilized." He noted that in societies with rapidly increasing prosperity and education, and where women have the ability to control their own bodies, population rates go down. This phenomenon cuts across all countries, religions, and races, he added, and he disputed the notion by some economists that falling birth rates will hamper prosperity, which he likened to a Ponzi scheme. "I deeply believe it is possible to have rising prosperity with a stable or even declining population. Unless we get off this treadmill, we can't have real sustainability," he said.

Global population figures can mask inequalities within societies, Kanem said. "How you invest in the people you have makes a huge difference. A girl who marries as a child has limited options for participation, which has implications for herself, her family, and society," she explained. The pandemic has revealed the "fault lines" of what years of poor health systems and structural inequality will do. Climate issues also hit the poorest and most vulnerable first.

Kanem noted that UNFPA used digital technology during the pandemic, including telehealth, and will continue to do so, especially to reach remote areas, although bridging the digital divide is a challenge. "As head of the UN's sexual and reproductive health agency, one of my greatest wishes for the girls of the world is for them to have mobile phones under their control," Kanem said. She explained this connects a girl to information and connections for rescue during an emergency, among other benefits. "Part of a 'power of solutions' discussion is flexibility, whether policy on the page or practice on the ground in communities, to be able to let people devise their own solutions," she said.

Chu recalled a visit to villages in Africa and a conversation with a resident who explained that, in the past, having a large family was a form of insurance, given child mortality rates, something less required today. Increased health care lowers the birth rate, and more resources can be focused on fewer children. "In this deeply connected world, relieving poverty, increasing education, and improving health care mean that you aren't on this [population] treadmill," Chu said. Kanem said ultimately the power of human rights is part

of preserving the planet. The ability of women and girls to exercise control leads UNFPA to develop the message that "the future belongs to the 10-year-old girl." A girl should be equipped, educated, and able to exert power over her own body and sphere, Kanem said.

Both Chu and Kanem expressed optimism about the "leapfrogging" of technology so that, for example, families do not have to wait for landlines or electricity but instead have access to cell phones, solar power, and energy storage.

FROM THE SCIENCE SESSIONS: Science-Supporting Transformations

Reflecting on previous presentations during the summit, **Rosina Bierbaum** (University of Michigan and University of Maryland) commented, "We have heard the science needs are great and the time to achieve global sustainability is short. We need transformational change and not incremental change." Bierbaum led a facilitated discussion about science in the service of society with Nobel Prize laureate **Brian Schmidt** (Australian National University), **Marcia McNutt** (NAS), Nobel Prize laureate **Yuan Tseh Lee** (University of California, Berkeley), and **Hans Joachim Schellnhuber** (Potsdam Institute).

"We are confronting in the United States and around the world whether we can establish a baseline of truth in our society. It is critical to do that in respect to the climate crisis because the stakes are so high."

—John Kerry

Science for Transformative Change

Bierbaum began by asking the panelists what they see as scientific priorities to achieve change. Schellnhuber called for more awareness of risk. Recalling the research leading up to the Montreal Protocol, he said that "humanity had a very narrow window of escape," which science made clear to policy makers. He questioned whether the current level of risk to the system is truly understood. To look at climate change, biodiversity loss, and related issues, Schellnhuber said, "We need a radical systems analysis of existential risks." Bierbaum commented on the need for a risk assessment that encompasses not just economic risks but also ecological and social risks.

Given the intersection of food, water, and energy systems, science is needed to advance adaptive capacity, Schmidt said. For example, as the climate changes, the places where food is grown will change, creating the need for agricultural transformation. Technology exists, but he warned about the need to look at opportunities and threats together: "You must be careful about what you do. If you think only about an opportunity, you can set off a cascading set of events that causes more harm than good."

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BREAKTHROUGHS

"My view is that whether we achieve climate goals or not will depend on how we reach out to the developing world," McNutt said. "We do not have the time or the carbon budget to allow them to follow the tortuous path that the developed world took—carbon-based sources and then switch to renewables." Leapfrogging technologies, such as cell phones, are an example (see also "Giving Power to Solutions," above). Looking at the equity issue, solutions must be cheaper, better for the environment, and better for people. "The academic community needs to create roadmaps for doing that," she said. "It is possible. We have to make it a priority."

Historically, physics, chemistry, and biology have identified environmental problems, but Lee called for a larger role for social sciences and for redesigning higher education so that students learn both social and natural sciences. Figuring out what types of technologies are wanted and acceptable is needed for leapfrogging. He warned not just to add a token social scientist to a team but ensure that social science plays a central role in technological development.

New Funding Models and Frameworks

Bierbaum observed that the private and philanthropic sectors are funding research and development, which may be changing the historic public-private science relationship and may play a role in scale-up. Schmidt said public funding often focuses research within national boundaries, while philanthropies can build systems across boundaries to deal with systemic global issues. He noted that the reality is that private-sector funding is small relative to government funding, but it has been leveraged effectively. "Researchers from different countries can work together in a more holistic way, and that's where the opportunity comes from," he said.

Science can serve as an integrating force across different international agreements and Sustainable Development Goals, Bierbaum commented. Schellnhuber noted he considers effective demonstration projects as "disruptive innovation plus good governance." He said his involvement with the European Green Deal has made him realize the need for a "new narrative of modernity."⁷ He pointed to research to transform the built environment from a source of carbon dioxide (CO₂) to a sink for CO₂, such as articulated by the New European Bauhaus movement.⁸ "We need a narrative about the transformation of the sector and then move in all types of innovation. An integrated project at continental scale—we can learn from each other and bring everyone along," he said. "Rapid scale-up is needed but is often not thought through."

Convergence of the blue (ocean-based) and green (land-based) economies has gained momentum. McNutt referred to earlier comments by Partha Dasgupta that "if we can't put a price on nature, we aren't going to value it." Science needs to help put a price on nature, she said. Demonstration projects can show what works and help put a price on how conservation helps multiple generations in the future. She noted that the benefits of the Information Age are recognized. "A new age could be ushered in by valuing the blue-green economy that could surpass even the Information Age in terms of its value to society," McNutt asserted. "But we have to first make sure we know how to measure worth and policies to revalue nature." With these values quantified, she predicted, private industry would step in and make sustainability the way to conduct business.

7 See https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en.

⁸ See https://europa.eu/new-european-bauhaus/index_en.

Humans are part of nature, Lee commented. "Humanity and nature must survive together; this is a philosophical understanding. Realization of complex problems and solutions must undergird education of the next generation."

Key Building Blocks for Transformative Change

Bierbaum asked each panelist for a takeaway suggestion about achieving transformative change. Lee said he would encourage people to live better with less and reduce consumption. Schmidt agreed but added there must be incentives. The most rapid area of progress, he said, is around electricity and solar energy, and this should be a priority. Schellnhuber offered two ideas: solid analysis to transform the built environment into a carbon sink and development of an Earth system model. "We do not have an Earth system model that can be run on a planetary scale. It sounds utopian, but it could be achieved in the next 10 years." To help the public understand what is at stake, McNutt suggested scientific cooperation with Hollywood on a blockbuster movie that shows what would happen if the natural world were not preserved. Bierbaum said this idea underlines the importance of narrative. She recalled that going to a location to describe the specific impacts of climate change on that place was more powerful than discussing more abstract, global climate change.

Schellnhuber concluded that the present time is a golden opportunity for science. Young people are interested, and it is important to get them involved. McNutt added it is also important for scientists to address the problem of misinformation that spreads online. Schmidt urged fellow scientists to figure out how they can help find "action at scale now." Lee shared his vision of harnessing technology to go beyond the goal of increased consumption. Bierbaum closed by saying that science is not always the loudest voice, but it is a very important voice. "We must all be civic scientists to explain the importance of these issues," she urged.

FROM THE SCIENCE SESSIONS: Breakthroughs in Technologies and Social Innovation for Resilient Societies and Global Sustainability

Leena Srivastava (International Institute for Applied Systems Analysis) facilitated a discussion with **Sir Richard Roberts**, **Jennifer Doudna** (University of California, Berkeley), **Karen Seto** (Yale University), and **Frank Geels** (University of Manchester). Srivastava introduced the session by stating:

We are experiencing and expecting many exciting opportunities for human progress driven by innovations. Technological innovations are leveraging and combining developments in artificial intelligence, biotechnology, nanotechnology, and other areas, whereas social innovations are being driven by a much more informed, demanding, and doubting society, contributing to both co-creation and consensus-based innovation. The growth of citizen engagement and activism are also leading to innovations in planning and policy making. If harnessed effectively, they can counterbalance the negative effects of technological developments, increasing the possibilities for global sustainability. However, inequality will have to be addressed squarely and up front to ensure resiliency.

BREAKTHROUGHS

Important Innovations

Roberts drew from the COVID-19 crisis to laud biotechnology-driven advances in the development and improvement of rapid testing and messenger RNA vaccines. However, he said, the testing methods took a long time for regulatory approval, and he called for a way to get groundbreaking biotechnology innovations into the hands of the public sooner. The vaccines are an example of the need for support of critical science at early stages, he added. A decade ago, the researchers who developed the technology had scant funding and support. Many other aspects of biotechnology have been useful, and he singled out the need to respond to climate change by growing plants that are more resistant to changes, especially in the developing world.

Doudna briefly explained the CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats) technology that she pioneered⁹ and its capability to alter DNA sequences in cells so that it is now a globally accepted technology to alter genetic material in any organism. It has been a transformational opportunity and meant that scientists can study the function of sets of genes in a targeted fashion, she explained. Importantly, she added, it is an example of the value of fundamental research, as the early work that she, Emmanuelle Charpentier, and others undertook was motivated by understanding fundamental biology of a bacterial immune system. Now it is having an impact on therapeutic intervention, such as with sickle cell disease, but it remains very expensive. Doudna noted that her institute has the goal to innovate but also make innovations affordable. Genome technology can also help with climate change, she added, but she stressed the need for responsible use and appropriate regulation.

Seto noted that some of the issues discussed at the summit have another issue at the center: the urbanization of societies. Every day, she explained, an area equal to about 20,000 American football fields becomes urbanized, including biodiverse ecosystems and agricultural lands. Urban areas generate about 70 percent of fossil fuel greenhouse gas emissions, and the global population of cities and towns grows by 1.3 million people every week. Looking back into history, she said the microscope, telescope, and camera were technologies that allowed for new ways of seeing. Today, widespread satellites are transforming the way to see the planet from new perspectives. Remote sensing enables a way to see and understand grand challenges of urbanization across countries and can be a central element to transition societies to be healthier, more equitable, and more sustainable. She singled out NASA's Black Marble product, developed from the Suomi National Polar-orbiting Partnership satellite, which is the only satellite primarily looking at human activity.¹⁰ Analyses and applications from the data collected range from economic activity to changes in energy use to wildfire and hurricane effects. Satellite imagery and analysis is transforming understanding of the world, especially of vulnerable populations, she said.

Geels spoke of transitions in governance, drawing from the field of systems transitions research. Many sustainability innovations related to mobility, food production, and energy exist, but most are not yet diffusing at sufficient speed to address global problems, he noted.

9 See https://www.nobelprize.org/prizes/chemistry/2020/press-release.

¹⁰ See https://blackmarble.gsfc.nasa.gov and Román et al., 2018.

He explained transitions happen through interactions at three levels: emerging novelties at a micro level face uphill struggles against entrenched systems at a meso level in the context of exogenous macro-level trends (Geels et al., 2017). Radical innovations may diffuse when macro-level pressures on existing systems create tensions and windows of opportunity. Diffusion is also affected by investments, consumer enthusiasm, and other variables. Incumbent firms may resist radical change when this threatens their business models. Policy makers can address this resistance by forcing incumbents to change (through regulations), helping companies and workers adapt to the change (through subsidies or retraining programs), or circumventing incumbents by supporting new entrants.

Mobilizing Political Will and Trust in Science

As Geels noted, public support plays a big role in getting policy makers to support innovations. Small businesses, consumer preferences, and a positive cultural narrative can start small and then scale political will. Seto commented on the power of images in public perceptions. She reminded participants of a famous photograph taken of Earth from Apollo 8, which she noted many have been called the most influential environmental photograph ever.¹¹ Remote sensing can play a similar role, when people can see their home, community, or region affected by sea-level rise and other impacts. Roberts pointed out, however, that images are used for good and for bad purposes.

Public mistrust of science was raised by several speakers throughout the session, and the panelists urged scientists to confront this issue directly, despite the difficulty. Doudna said availability of information is great, but it can also be manipulated or confused. She urged scientists to discuss their work publicly and demonstrate the value of science in society. Education and everyday conversation should weave science into people's daily lives far more than in recent decades. Roberts said scientists must talk in language that people understand. Geels said mistrust of science is part of a large sense of public anger and fear.

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¹¹ See https://www.nasa.gov/image-feature/apollo-8-earthrise.





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Throughout the Nobel Prize Summit, presenters discussed the emergence of humanexacerbated challenges facing the planet and of human-created innovations to solve these challenges. "Science across disciplines and across borders can help solve the planet's pressing problems at the speed and scale required," Vidar Helgesen said, calling for the need to look forward and take action. Referring to comments made the previous day by John Kerry (see Chapter 3), science has established a "baseline of truth" about the state of the planet, but "advancing from that baseline is the domain of political decision makers."

Progress in the future requires the involvement of policy makers and others, including artists, spiritual leaders, and business leaders. Helgesen reminded participants that the Nobel Prize recognizes not only science but also literature and peace. The humanities, including the "inspirational power of storytelling," are critical in providing a "shared language to discuss important issues in new ways."

This chapter highlights voices from these different domains, including President of the European Commission Ursula von der Leyen, Nobel Prize laureate His Holiness the Dalai Lama, and performing artists in different genres. Highlights from the Solution Sessions and from panels on lessons from the pandemic and on equity and stewardship are also included in this chapter. A Call for Action and concluding comments shared at the end of the Academic Science session close the chapter.

MAIN STAGE: A View to the Future

European Perspective

"Every Nobel Prize celebrates one leap forward for humanity," said **Ursula von der Leyen**, (President of the European Commission) and she particularly recognized the laureates who

conduct "science in the service of humankind." While the pandemic has reinforced the value of science, international cooperation is needed to fight the virus in all corners of the world.

Von der Leyen focused her remarks on three reasons why and three ways how governments need science. The reasons why, she elaborated, are that (1) science is needed to make sense of the world around us, (2) science is needed as a guide, and (3) science finds new solutions to challenges and fuels innovation for a healthy planet. Prior to the pandemic, she pointed out scientists had warned that human health, animal health, and the planet's health are unified in a One Health concept. They documented how contacts between wildlife and humans have increased with the destruction of forests, how loss of biodiversity has meant that buffering species are disappearing, and how new pathogens are crossing over between animals and humans. She also referred to the concept of planetary boundaries developed by Johan Rockström and others: that is, nine limits or boundaries that humanity should not cross to avoid setting off irreversible and devastating consequences.

Regarding how governments are basing decisions on science, von der Leyen first described the European Green Deal. This set of policy initiatives commits Europe to cutting carbon dioxide (CO_2) emissions by at least 55 percent and protecting at least 30 percent of the land and sea in this decade. "We now want to broker the same ambition at a global level at the next United Nations (UN) biodiversity summit in Kunming," she stated.

Second, Europe is working with three panels that bring scientists to policy making: the Intergovernmental Panel on Climate Change, Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, and International Resource Panel on the circular economy. "Their advice has been essential to build an international consensus on our planet's state of health," she noted, and she urged more coordination and joint efforts across the panels "for more effective multilateralism guided by science."

Third, for science to innovate and find solutions, scientists must have the resources to do their jobs. Governments must support pure science and basic research as the foundation for human progress, von der Leyen said. Alongside pure science, translational science is needed to connect researchers with business, customers, and civil society. She described Horizon Europe as the world's largest publicly funded translational research program. It aims to transform the way people live and do business through five innovation missions: beating cancer, making Europe climate resilient, restoring oceans and waters, developing 100 climate-neutral cities by 2030, and caring for soils. Each tackles a grand challenge in a participative approach with citizens.

Besides technological transformation, cultural transformation is needed. "We need to be much better at bringing science into every home and community," she urged. This includes investments in scientific education, including climate education, at all levels. She asked Nobel laureates and other scientists to communicate to reach the public in their homes through television, social media, and other platforms. "A new enlightenment begins there," she concluded.

Connecting Science and Engineering

With widespread recognition about the need to cut carbon emissions by half by 2050, the question is *how*, stated **James Liao** (Academia Sinica). Some paths forward are known, such as increasing energy efficiency through renewable energy infrastructure. However, deep decarbonization is not possible everywhere, and in some sectors, such as aviation and heavy industry, complete electrification is not yet possible.

To reach net zero by 2050, Liao said, carbon management is a key technology. The challenge for carbon management encompasses capturing CO_2 immediately after it is formed, capturing CO_2 already in the air, and avoiding CO_2 formation entirely. Next-generation technology inspired by photosynthesis must be developed to convert CO_2 to chemicals, materials, and fuels. Once CO_2 is captured, it must be stored or utilized through some combination of physical, chemical, and biological techniques, he added. Chemical agents and materials may also be promising, but they cannot currently be used at scale. He urged investments in research, development, deployment, and commercialization and for scientists, engineers, and others to collaborate to realize these ideas and generate new ones.

MAIN STAGE: Lessons from the Pandemic

Science journalist **Laurie Garrett** facilitated a discussion on how confronting the pandemic can provide a guide to solving sustainability problems with science. She posed a series of questions to a panel that consisted of Nobel Prize laureate **Jennifer Doudna** (University of California, San Francisco), Nobel Prize laureate **Peter Doherty** (University of Melbourne), and **Anthony Fauci** (National Institutes of Health).

The first issue Garrett raised was the seeming lack of preparation in anticipating and quickly responding to the pandemic. Fauci identified several challenges, including logistical issues with testing and the overall political and social context. "The common enemy was the virus, yet we were fighting each other," Fauci said. The U.S. federal-state structure further complicated development of consistent guidelines. "We were acting like we could act independently with a virus that spreads everywhere," he said. Despite these missteps, Garrett commented, science delivered vaccines in record time. This success was due to decades of investment in biomedical research, Fauci clarified. "If we are ever going to make an argument to the general public about the value of investment in basic research, I think this is exhibit number 1," he commented.

Doherty lauded the speed with which highly efficacious vaccines were developed. However, he said, "a lot of work needs to be done in the long term to understand the disease in depth, rather than react to what it is doing to us. We are, whether we like it or not, part of an enormous global experiment." He stressed that "what will be really important is that as we come out of this or continue through it, we look at every part—from the economic perspective to the social perspective to the medical research perspective—and see what lessons we've learned and take those lessons on board."

CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats) represents a particularly promising new area of science, but the advances have heightened public

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expectations that this field will yield great results, Garrett commented to Doudna. She asked Doudna how to temper the excitement with the reality of the scientific process. "CRISPR is an ancient bacterial immune system that scientists began studying 10 or 15 years ago because of fundamental curiosity," Doudna responded. Like the research that led to vaccines, it is another example of an advance in science that built on decades of experimentation. Fewer than 10 years elapsed from the initial publication of papers about how it can be used in genome editing to results from clinical trials, such as with sickle cell disease, she pointed out. Pandemic-related research using CRISPR includes work on potential diagnostic tools that can be deployed in real time.

Increased risks from pathogens are connected with climate change, Doherty said. As the planet warms, species are moving to new locations and catastrophic events are becoming more frequent. Infectious disease threats related to climate change include flooding, overwhelmed sewage systems, and mosquito-borne diseases, with the most severe effects on the poor. He noted that change relating to climate change will involve economic imperatives, such as those related to energy production, which will be difficult. "One of the hardest things for humans to do is once they have gained what they see as an advantage, to give it up or contemplate a change in the way they do it," Doherty lamented. The Innovative Genomics Institute, a partnership between the University of California (UC), Berkeley, and UC San Francisco, is applying CRISPR to climate-related problems, Doudna said. Rice is the first focus with a comprehensive approach to work toward net-zero carbon farming by modification of rice to be drought and pest resistant, as well as more sustainable in terms of external fertilizers that would otherwise be necessary and use of microbes that can benefit fertility and carbon sequestration in the soil.



Climate change involves an interface between science and politics, Garrett commented. Fauci reflected on his experience working with U.S. presidents and members of Congress since the 1980s. "The most important thing is to maintain your integrity of sticking with the science," Fauci said. "Sometimes the science leads to truths that make people very uncomfortable." He recalled advice given to him that he should not be awestruck when talking to political leaders or he might temper his message. The overall lesson for scientists, he said, is "speak the truth, stick with the science, and don't deliver happy talk."

Victor Dzau (National Academy of Medicine) shared reflections as he listened to the panel. He noted how during the session, and throughout the summit, the role of science has been stressed and the need for investments in basic research to pave the way for breakthroughs and responses. Lessons from the pandemic include the recognition that climate change is a public health crisis, he added. To enable society to realize the benefits of science, science must reach the public and policy makers through translation and communication.

MAIN STAGE: Reaching Beyond Science: Spirituality and the ARTS

As Helgesen stated in welcoming remarks on the Main Stage, going beyond the boundaries of science is essential to work toward a sustainable future. Throughout the summit, in informal networking and conversation sessions, participants from around the world engaged with the presenters and each other as a way to build community. Spiritual and Indigenous wisdom were honored. In addition, musical and dramatic performances showed the power of the arts in providing inspiration and motivation for action.

Paying Attention to "Inner Science"

Johan Rockström and Marcia McNutt interviewed His Holiness the 14th Dalai Lama of Tibet, recipient of the Nobel Peace Prize in 1989. In welcoming His Holiness to the stage, Rockström said, "Your moral leadership and active advocacy for humanity's future on Earth is recognized across the entire world. You stand up for people and planet, always clear about the urgency of the current climate emergency while being equally passionate and hopeful of a peaceful future for all people on Earth." Rockström asked him to elaborate on the message of human-nature interdependence articulated in his book *Our Only Home: A Climate Appeal to the World* and in other teachings.

"The Buddhist tradition is based on a logical approach that goes very well with modern science," the Dalai Lama replied. In addition to his reliance on faith, he noted he often has discussions with scientists. "The gap between the rich and poor at a global level is not only morally wrong, but practically, in the long run, the source of problems. Therefore, we have to pay more attention to equal distribution," he said.

McNutt asked His Holiness how science could support his vision, especially when many people dismiss both science and spirituality. He suggested that scientists should pay more attention to the "inner science" of the mind and emotions. To maintain peace of mind and

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reduce anger, hatred, and jealousy, he noted that scientists are studying Buddhist psychology, or what he termed the "hygiene of emotions," alongside concerns about physical health.

Rockström commented that the Nobel Prize Summit was organized to recognize the interdisciplinarity between the social and natural sciences, and the concept of "hygiene of emotions" is part of what stewardship entails. He noted that a recent, large-scale opinion poll (conducted by the United Nations Development Programme) showed 60 to 70 percent of people are concerned about the undermining of life support on Earth and want climate action. Rockström asked about how to accomplish a transformation to a more harmonious relationship with the planet. "Scientists are saying global warming is getting more serious decade by decade. We need the concept of oneness: We all live on one planet and share the same basic way of life. According to that reality, we should no longer emphasize *my* nation, *my* country. We should think of *our* humanity," the Dalai Lama replied.

McNutt commented that the pandemic drives home the importance of his message. "If we consider only people's physical well-being and do not consider mental well-being, we will find people fare poorly," she said. "And when you speak of oneness, it is nonsensical for any nation to think they can address the pandemic within their borders without dealing with it on a global basis. No nation is so isolated that it can wall itself off for the indefinite future."

She then asked about how to balance the push for climate and nature protection with closing the wealth gap. "Is it possible to maintain an equitable climate and protect nature while reducing inequality?" she asked. How can people be motivated to act in accordance with these principles, given that so many take the short-term view. To these concerns, the Dalai Lama stressed that education is key.

Messages within Music

Nobel Prize laureate **Robert W. Wilson** (Harvard-Smithsonian Center for Astrophysics) spoke of linkages between science and art. He and Arno Allan Penzias were awarded the Nobel Prize in Physics for their discovery of cosmic microwave background radiation using a large horn antenna as a radio telescope. Many years later, he collaborated with artist and innovator **Beatie Wolfe** when she used the antenna to transmit her music into space. "My work is about reminding people about the value of art for our humanity and also the value of nature. Both art and nature are core to our humanity," she said. She presented her work From Green to Red, an environmental protest piece that combines music, images, and 800,000 years of historic data, specifically atmospheric CO2 levels. She explained her goal in the piece was to transform data into something that everyone can absorb.

Later in the Summit, **Tara Houska**, a member of the Couchiching First Nation and Indigenous rights activist and attorney, introduced musician and activist Gingger Shankar. Shankar premiered a piece titled *Promises of Our Grandmothers*¹ with an international group of musicians. The piece explored the roles of grandmothers, and their relationship to the land and environment.

¹ To view the performance at the Nobel Prize Summit, see https://www.youtube.com/watch?v=VZV19fPEA2Y.

Greek Tragedy with a Modern Lesson

Nobel Prize laureate and physicist **Saul Perlmutter** (UC Berkeley and Lawrence Berkeley National Laboratory) spoke with **Bryan Doerries** (Theater of War Productions) before the performance of the *Oedipus Project*, which Doerries conceived of and directed. Perlmutter noted he is involved in an education project to teach students critical thinking, and he wondered whether Greek tragedy offers an opposite message about shaping one's future and trust in science. Doerries countered that ancient Greek tragedy serves as a valuable framework for scientific truth. He said while characters are often depicted as "learning too late," the effect on audiences is to raise awareness of the possibility of change *before* it is too late. As they watch characters make choices, according to Doerries, they are brought into consciousness about what it takes to change when the stakes are high. "Watching characters make choices that are about life and death seems like an appropriate thing to be doing right now at this juncture in our planet's history and our humanity," he posited.

"Tragedies are also plays in which everyone believes they are justified, yet someone is going to die," Doerries explained. "That's also an appropriate lens to look at our current predicament. Can we step back from the roles we are playing and from our sureness, and acknowledge our fallibility and mistakes? That's what tragedy does." He observed that Perlmutter had offered, in an earlier conversation, that making mistakes also stands at the heart of scientific discovery. "The fun and heart of science is often the hunt for what we have misunderstood or gotten wrong, whether large or small," Perlmutter agreed. "In the end, if you are going to trust science, it's because you're watching people try to make mistakes to then take the next step." And yet, Doerries noted, this scientific ideal takes place in a broader context that often devalues learning from mistakes.

Doerries asked Perlmutter about a common perception that scientists are trained not to express emotion. Perlmutter agreed that along with teaching scientists the tools of rationality, it is vital for them to know how to consider values, fears, and desires. "If you don't come up with a principled way to weave all this together, the part that will be left behind is the rationality," Perlmutter said.

The discussion led into the performance of scenes from Sophocles' *Oedipus the King* and a discussion open to all attendees. "One of the reasons we perform an ancient Greek tragedy to talk about science, to talk about the environment is to bring emotions into a rational and ethical discussion," Doerries said. He noted at most of their events, the post-performance discussion lasts longer than the performance itself.

SOLUTION SESSIONS

An important goal of the summit was to turn discussions into practical solutions. On April 28, summit partners convened 12 sessions on interrelated topics encompassing education, corporate investment, collaboration and empathy, and more (see Box 4-1).²

² For videos of the solution sessions, see https://www.nobelprize.org/our-planet-our-future-day-three.

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BOX 4-1

Solution Sessions

On the third day of the Nobel Prize Summit, concurrent sessions, hosted by a range of government, private sector, and civil society partners, suggested ideas to turn knowledge into action.

The 12 sessions are summarized here and can be viewed online. The topics were as follows:

- 1. Transformational Economics
- 2. Empathy as a Collective Responsibility
- 3. Sustainable Industry Solutions
- 4. Sustainability Education
- 5. Social Enterprise Startups
- 6. From the Lab to the Ground
- 7. Online Disinformation and Human Rights
- 8. Smart Cities
- 9. Governance for the Information Environment
- 10. Comprehensive Design Models
- 11. Corporate Commitments
- 12. The SDGs and International Collaboration

Transformational Economics: Valuing Our Future

The Club of Rome held a session to explore new economic thinking that will contribute to building fairer, resilient societies on a resilient planet and the role of philanthropy in funding transformation. **Sandrine Dixson-Declève** (Club of Rome) opened the session with **Johan Rockström** (Potsdam Institute for Climate Impact Research), who introduced the EarthforAll project,³ and **Andrew Steer** (Bezos Earth Fund), who discussed the need for a new measure to fit for purposes of the future. Per **Espen Stoknes** (Norwegian Business School) moderated a panel with **Carlota Perez** (University College London), **Jayati Ghosh** (Jawaharlal Nehru University), **Sharan Burrow** (International Trade Union Confederation), **Ilona Otto** (University of Graz), and **Jennifer Hinton** (Stockholm Resilience Centre), which called for a new, post-COVID-19 Marshall Plan.⁴ Dealing with inequality between the Global North and South is urgent to promote a paradigm shift; a greener, more sustainable and inclusive recovery; and global solidarity. The session emphasized the need for a new economic model, global standards and digitalization, universal social protection, preparedness, diversity and inclusion, and long-term thinking to protect future generations.

³ The project, led by the Club of Rome, the Norwegian Business School, and Potsdam Institute for Climate Impact Research, will explore transformational political and economic solutions for the 21st century along five pathways: energy, food, inequality, poverty, and population (including health and education). See https://www.clubofrome.org/impact-hubs/reframing-economics/new-initiative-on-transformational-economics-earth4all-launched. ⁴ The Marshall Plan was a post–World War II U.S. government funding initiative to help rebuild war-torn Western Europe. See, for example, https:// www.archives.gov/exhibits/featured-documents/marshall-plan. 41

Leslie Johnston (Laudes Foundation) facilitated a discussion on the role of philanthropy to promote structural transformation, with **Ellen Dorsey** (Wallace Global Fund), **Felicitas von Peter** (Active Philanthropy), and **Tom Steinbach** (Sea Change Foundation). Five principles were laid out: (1) radically collaborate at scale, (2) fund and advocate an intersectional approach, (3) support disruptive movements, (4) align investments with priorities, and (5) spend more during a climate emergency. Participants urged philanthropies to ensure public investments drive equity and create high-quality jobs by understanding communities' needs.

Roots of Change: Empathy as a Collective Responsibility

DICCE, GenZ Girl Gang, and Project LETS hosted a session to explore individual actions to increase empathy. This youth-led session began with a guided meditation with three students, **Phoebe Omonira** (GenZ Girl Gang), **Lyne Odhiambo** (DICCE), and **Zoë Jenkins** (DICCE), followed by an introduction to the importance, and lack, of empathy in policy and society at large. **Julie Fratantoni** (University of Texas at Dallas) and **Gary A. Hoover** (Tulane University) discussed new ways of measuring social progress.

The session highlighted reasons a lack of empathy in policy and society at large affects everyone. For example, Citigroup estimates that the U.S. economy has lost \$16 trillion from racism against African Americans over the past 20 years. Policies are created without consulting affected stakeholder groups, such as the Keystone XL pipeline and Native American communities, while at the individual levels, people are increasingly feeling lonelier.⁵ The facilitators emphasized the importance of active listening, defined as nonjudgmental listening with entire focus on the speaker, as a first step for participants to increase their own empathy. Panelists closed the session by discussing different types of empathy and how empathy affects their research. The session defined empathy as "a faucet, not a switch" and referenced the Interpersonal Reactivity Index to understand different types of empathy.⁶ A participant cautioned about approaching data without empathy, reminding the group that real people are behind the numbers that inform policy making. The session concluded that no matter one's field, there is room for more empathy in places of work and education.

Our Planet: From Human Impact to Climate Action and Sustainable Industry Solutions

The Embassy of Sweden in the United States, in collaboration with the Royal Swedish Academy of Engineering Sciences, hosted a session on the role of science for industries' ongoing sustainability efforts. **H. E. Karin Olofsdotter** (Ambassador of Sweden to the United States) opened the session with **Johan Rockström** (Potsdam Institute for Climate Impact Research). **Tuula Teeri** (Royal Swedish Academy of Engineering Sciences) facilitated a discussion with **Carl Folke** (Stockholm Resilience Centre), **Cristian Samper** (Wildlife Conservation Society), **Emma Nehrenheim** (Northvolt), and **Florian Schattenmann** (Cargill), which emphasized the importance of "togetherness" for addressing the climate emergency, biodiversity loss, rising

⁵ Other examples relating to a lack of empathy resulting in impacts on society could include loss of health and life. See https://www.physiciansweekly. com/nonwhite-patients-get-less and https://www.bbc.com/news/world-us-canada-55009228.
⁶ See https://www.eckerd.edu/psychology/iri.

inequalities, and the COVID-19 pandemic, and for creating a more sustainable future. Sweden has set a goal of becoming the world's first fossil-free welfare state by 2045, and the industry is taking a leading role, such as through the Fossil Free Sweden initiative. A systems approach is crucial for a carbon-neutral, nature-positive, and more equitable future, participants stated. Corporate biosphere stewardship,⁷ a broader concept than corporate social responsibility, is needed, they said, as is portfolio management, education and public awareness.

Gayle Schueller (3M), **Theodor Swedjemark** (ABB), **Heather Johnson** (Ericsson), and **Lena Hök** (Skanska Group) discussed the importance of embedding sustainability across value chains, partnering with a wider range of organizations, and scaling up existing partnerships by identifying clear goals. **Anna Sjöström Douagi** (Nobel Foundation) emphasized the urgent need for global collaboration. The session also presented a photo exhibition titled "Dreamland" by Swedish artist Helene Schmitz, which is on display at House of Sweden in Washington, DC.⁸

"The lesson: speak the truth, stick with the science, and don't deliver happy talk." —Anthony Fauci

The Future of Sustainability Education

The National Academies of Sciences, Engineering, and Medicine organized a session that highlighted its 2020 report *Strengthening Sustainability Programs and Curricula at the Undergraduate and Graduate Levels.*⁹ **Marcia McNutt** (National Academy of Sciences) and **Marilu Hastings** (Cynthia and George Mitchell Foundation) provided opening remarks, with **Vaughan Turekian** (National Academies) as moderator. **Anne Kapuscinski** (University of California, Santa Cruz) summarized insights from the report on the role of U.S. higher education institutions in research, collaborative action, and workforce development.

Arun Agrawal (University of Michigan) facilitated a discussion on the future of sustainability education with **Shamila Nair-Bedouelle** (United Nations Educational, Scientific, and Cultural Organization [UNESCO]), **Ellen Stofan** (Smithsonian Institution), **Dan Higgins** (Ernst & Young Global Ltd.), **Sajitha Bashir** (World Bank), **Jeffrey Sachs** (Sustainable Development Solutions Network), **Zohra Yermeche** (Ericsson), and Nobel Prize laureate **Sir Richard Roberts** (New England BioLabs, Inc). Their perspectives included the need for accelerated capacity building in higher education in South Asia and Sub-Saharan Africa, the role of universities in achieving the UN's Sustainable Development Goals (SDGs), the importance of digital learning, and creative pathways and K-12 pipelines in sustainability education. A dialogue on young people focused on the need to teach truth versus misinformation on social media, encourage youth to take action, and reduce a digital gap in developing countries. Participants discussed how to support teachers, with the use

⁷ See http://www.bluepearl.green/wp-content/uploads/2020/01/biosphere-stewardship-SRC.pdf.

⁸ See https://www.swedenabroad.se/en/embassies/usa-washington/current/calendar/exhibition-dreamland-by-helene-schmitz.

9 See https://www.nap.edu/catalog/25821.

of UNESCO's microscience kits as an example.¹⁰ The session concluded that it is essential to involve women and children to support sustainable education for sustainable development as one of the most important global agendas for the 21st century.

Startup Solutions: How Social Enterprises Are Addressing 21st Century Challenges

Halcyon and the S&R Foundation hosted a session with social enterprise founders who have integrated both profit and purpose into their business models. **Joshua Mandell** (Halcyon) moderated the session with **Svanika Balasubramanian** (rePurpose Global), **Sam Teicher** (Coral Vita), **Phil Wong** (Misfit Foods), and **Sandhya Murali** (Solstice). He noted startups provide nimble, adaptive, and fast-paced business solutions to many environmental and sustainability challenges. rePurpose Global is a plastic-credit platform that reduces waste and restores nature's balance through accessible, circular innovation in South America, Africa, and Asia. Coral Vita aims to preserve the coral reefs and restore coastal ecosystems, while Misfit Foods focuses on a healthier planet through reduced meat consumption and more plant-based diets. Solstice expands community solar panels in the Boston, Massachusetts, area, including underserved communities.

Participants pointed out consumers are increasingly aware of companies that are doing the right things for the environment and societies. Regarding barriers to scaling up, they said fundraising is a challenge for early-stage social entrepreneurs, and there is a need for streamlined business processes. They also stressed the importance of engaging young people and populations of color. While the COVID-19 pandemic has prompted a business model shift, they concluded that focusing on what is going right and leveraging partnerships with municipalities, larger corporations, and other companies would be useful to bring about needed changes.

¹⁰ See http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/sc_bes_microscience_EN.pdf.



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From Results in the Lab to Results on the Ground

The Global Solutions Summit hosted a session to focus on how to translate cutting-edge scientific innovations into tangible change.¹¹ Alfred Watkins (Global Solutions Summit) moderated the session with Maurizio Vecchione (AdAstral and Washington Global Health Alliance), Ramesh Mashelkar (formerly Council of Scientific and Industrial Research and Indian National Science Academy), and Theresa Kotanchek (Evolved Analytics). They discussed new methods to translate science into marketable innovations and new ways of partnering with the private sector. Speaking from slightly different vantage points and professional experiences, the three panelists discussed the following:

- Developing moonshot solutions to planetary problems will entail the shift to an interdisciplinary, problem-oriented approach to scientific inquiry. This reverses the business-as-usual process of inventing something first and then searching for a market.
- The resulting high-impact innovations will be good for the world and an outstanding business opportunity. As a result, the private sector will be more likely to finance, adopt, and deploy at-scale solutions to well-defined, carefully curated problems.
- This is true for solutions pertaining to global health and planetary sustainability, solutions addressing the needs of the billions of people at the bottom of the pyramid, and new industrial processes and materials.

Online Disinformation and Human Rights

The National Academies Committee on Human Rights hosted a chat to examine the role of digital disinformation and media manipulation in entrenching societal inequalities, driving polarization, and eroding public trust. **Sam Gregory** (WITNESS) moderated the session with **Safiya Noble** (University of California, Los Angeles) and **Kate Starbird** (University of Washington). The session began with definitions for disinformation, media manipulation, and misinformation, and it examined examples of these harms. Documents discussed included the UN *Guiding Principles on Business and Human Rights: Implementing the United Nations "Protect, Respect and Remedy" Framework* and the UN report *Disinformation and Freedom of Opinion and Expression: Report of the Special Rapporteur on the Promotion and Protection of the Right to Freedom of Opinion and Expression, Irene Kahn (see OHCHR, 2011, and Kahn, 2021, respectively).*

Gregory emphasized that human rights provide a globally recognized framework for grappling with the competing claims at play when considering the phenomenon of online disinformation, and participants considered possible rights-based approaches to addressing this problem. Noble noted that reforming online platforms will be a challenge due to current business models, and alternative models are needed to differentiate propaganda from research and informed journalism. Globally, disinformation has been employed as a tool by regimes perpetrating rights abuses. At the same time, Starbird emphasized, authoritarian regimes sometimes use accusations of disinformation to shut down oppositional voices. Participants emphasized the importance of linking discussion of online disinformation

¹¹ For a summary and synthesis of the discussion, see https://www.globalsolutionssummit.com/nobelprize.html.

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and human rights with examination of structural issues such as climate change, global inequality, and problems with access to education and information, rather than just focusing on technological issues.

Smart Cities and New Green Solutions

The Embassy of Italy in the United States hosted a session on urban sustainability inspired by the three pillars of the Italian G20 Presidency ("People, Planet, Prosperity"), the 160th anniversary of diplomatic relations between the United States and Italy, the Italian copresidency of the UN Climate Change Conference of the Parties (COP26) in Scotland in November 2021, and Italian Research Day in the World (celebrated on April 15). **Alexander Kaufman** (Huffington Post) moderated the session that began with **Marcia McNutt** (National Academy of Sciences) and **Armando Varricchio** (Ambassador of Italy to the United States). Other participants included **Maria Cristina Messa** (Minister of Universities and Research, Italy), Nobel Prize laureate **Stanley Whittingham** (Binghamton University [National Academy of Engineering]), **Chris Greer** (National Institute of Standards and Technology), **Debra Lam** (Georgia Institute of Technology), **Carlo Ratti** (Massachusetts Institute of Technology), and **Paola Malanotte-Rizzoli** (Massachusetts Institute of Technology).

Participants outlined European urban sustainability efforts, such as achieving 100 climateneutral cities by 2030, and discussed the multidisciplinary challenges to create smart, sustainable cities. An estimated 90 percent of reported COVID-19 cases are connected to cities, so local governments play a critical role in crisis response, recovery, and rebuilding (see UN, 2020). Main sectors to consider include smart grid, microgeneration, mobility, information management systems, e-teaching, e-learning, telemedicine, and home automation and artificial intelligence. Participants discussed the need for collaboration across disciplines and cultures, localized supply chains, and recycling. They emphasized the importance of an interdisciplinary approach, smart governance and leadership by understanding local context, and citizen empowerment.

A Call for an Intergovernmental Panel on the Information Environment

PeaceTech Lab hosted a session to explore creation of an Intergovernmental Panel on the Information Environment (IPIE), modeled after the Intergovernmental Panel for Climate Change, to analyze the global information environment and provide governments with science-based recommendations for a healthy global information environment. **Sheldon Himelfarb** (PeaceTech Lab) moderated a discussion with **Vint Cerf** (Google), **Phil Howard** (Oxford Internet Institute), **Ian Goldin** (University of Oxford), Nobel Prize laureate **Tawakkol Karman** (journalist and human rights activist), and **Katherine Maher** (Wikimedia Foundation and Wikipedia) to address threats posed by false information across online and offline media.

Participants described the severity and complexity of the issues (Howard, 2020). In the midst of a paradigm shift, new governance is needed to support internet norms and standards, improve trust in institutions by identifying credible actors and incentives, and promote citizen engagement. A Wikipedia model was offered as an unbounded network that enables people to self-organize based on priority areas. Panelists also emphasized the

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need for a regulatory framework and suggested the IPIE could encourage actions through a cross-sector, cross-discipline, and cross-national approach. They noted the need to incorporate social, neurological, and psychological components to address the challenge while engaging industry to support implementation. Panelists agreed that the proposal for an IPIE is a sound idea worth pursuing further.

Critical Pathway: Implementing Comprehensive Design Models for People and Planet

The Peace Department hosted a session focused on how economic, political, and social sectors can collaborate to address climate change and systemic inequality. **Bobby Kia** (Peace Department) opened the session. **James Sternlicht** (Peace Department), **Martin Wainstein** (Open Earth Foundation), **Aude de Montesquiou** (BRAC Institute), **Pierre Ferrari** (Heifer International), **Richard Zimmerman** (WE Family Offices), **Zoe Knight** (HSBC), **William Sonneborn** (International Finance Corporation), and **Mary Robinson** (former President of Ireland) discussed pathways that included sustainably focused research and scientific theory to craft deployable solutions. **R. P. Eddy** (Ergo) moderated a final discussion.

Participants outlined activities addressing Goal 1 of the SDGs to end poverty, such as the Graduation Approach from extreme poverty to sustainable livelihood¹² and the importance of digital innovation. They also discussed the current state of impact investing with the need for clear, overarching principles,¹³ performance management, and public-private partnerships to support sustainable investing. Other topics discussed included financing a low-carbon transition, environmental, social, and governance (ESG) and institutional investment, risk reduction, and global initiatives such as the Net-Zero Banking Alliance. Solutions that mobilize private capital can create new and stronger markets at significant scale in developing countries, a participant noted. Participants emphasized five layers of injustice in addressing the climate crisis: (1) social inequality, (2) gender dimension and racial injustice, (3) intergenerational injustice, (4) inequality between developed and developing countries, and (5) injustice to nature. There is a need to "build forward" with equality, justice, and sustainability while making the climate crisis personal by increasing recycling and reducing waste, a participant suggested.

Acting Today for an Ambitious Tomorrow

3M hosted a session on how corporate commitments are a driving force toward a brighter future. **Gayle Schueller** (3M) facilitated the session with **John Banovetz** (3M), **Chris Coulter** (GlobeScan), and **Peter Lacy** (Accenture) to discuss more ambitious commitments, action grounded in data, and broader cross-sector collaboration. They stressed that clarity and simplicity around strategies, goals, and science-based targets, aligned with investments, are critical. Stakeholders include employees, communities, investors, and customers. While customers are key stakeholders, they noted it is essential to understand diverse stakeholders' views and understand changing expectations through surveys, studies, and performance reviews. Other examples discussed included ESG communications with investors and engaging customers on reducing carbon footprint in supply chains.

¹² See https://www.ultra-poverty.org/blog-post/the-graduation-approach-within-social-protection-opportunities-for-going-to-scale.

¹³ A panelist suggested that the United Nations Principles for Responsible Investment and the International Finance Corporation's Operating Principles for Impact Management are two excellent guidelines. For more information, see "What Are the Principles for Responsible Investment" at https://www. unpri.org/pri/what-are-the-principles-for-responsible-investment and "The 9 Principles" at https://www.impactprinciples.org/9-principles.

Participants pointed to proven technologies to deliver the SDGs, but the configuration of those technologies and their interaction across domains are key to achieve innovation and better business outcomes for sustainability. The session also discussed opportunities to accelerate the transition to a low-carbon economy around COP26, examples of public-private partnerships such as the World Economic Forum's circular economy initiative, and the importance of embracing disruptors (e.g., entrepreneurs and start-ups) into the mainstream to create scale and speed in sustainability.

The Sustainable Development Goals and International Research Collaboration

The National Academies and Arizona State University (ASU) hosted a session on international research collaboration for achieving the SDGs by 2030. **Peter Schlosser** (ASU) opened the session, and **Andrew Steer** (Bezos Earth Fund) moderated a discussion with **Tateo Arimoto** (Japan Science and Technology Agency and National Graduate Institute for Policy Studies) and **Daya Reddy** (International Science Council and University of Cape Town).

While the pandemic has demonstrated the ability of effective scientific collaboration, lessons learned include a lack of capacity in research and development in developing countries and limited scientific capacities for international organizations to develop effective and timely responses, they said. The speakers discussed a need for partnerships and networks beyond traditional disciplinary and sectoral boundaries, to include the financial sector. They also discussed a need for a science-policy interface, effective governance, integrated approaches with more communications with diverse sectors, and localization of the SDGs through local knowledge, advanced technologies, and open science. Harnessing science, technology, and innovation is crucial for achieving the SDGs and for building capacity.

Amanda Ellis (ASU) facilitated a dialogue with Nobel Prize laureate **Ada Yonath** (Weizmann Institute of Science) on the need for more attention relating to antibiotic resistance in developing countries, science education at an early age, and providing opportunities for young people. They described the need for transdisciplinary approaches to predict and prevent the next pandemic crisis and innovative partnerships, such as the SDG 5 Training for Parliamentarians and Global Changemakers between ASU and international organizations on gender equality.¹⁴

FROM THE SCIENCE SESSIONS: Toward Sustainable Futures: Governance, Inclusivity, and Stewardship

A message throughout the summit was the need to reduce inequality in order to create a sustainable future. Science and technology alone will not create the necessary conditions for transformation, stressed Rosina Bierbaum. She returned to facilitate a panel on governance, inclusivity, and stewardship with Nobel Prize laureate **Joseph Stiglitz** (Columbia University), **Gretchen Daily** (Stanford University), **Eduardo S. Brondizio** (Indiana University), and **Jane Lubchenco** (advisor to the U.S. president, Oregon State University).

14 See https://globalfutures.asu.edu/sdg5-training.

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Stiglitz began by stressing that issues of international equity are relevant within countries, between countries, and, particularly in a sustainability context, across generations. This cross-generational equity issue is behind a lawsuit by 21 children against the U.S. administration that is based on the public trust doctrine and due process provisions of the U.S. Constitution.¹⁵ Similar suits have been brought in other countries. Bierbaum drew from a statement issued at the UN that youth constitute 25 percent of the population but 100 percent of the future.¹⁶

Brondizio identified three enabling conditions for biosphere stewardship: recognition of the scale of the problem, empathy and equity to address injustices, and cooperation to face the complexity of current issues. In terms of recognition, the IPBES (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services) global assessments report (2019)¹⁷ shows that humans have reconfigured the biosphere and become the main force behind the deterioration of nature and the decline in nature's ability to support human wellbeing. Those suffering the most have contributed the least to these problems, so that the benefits and burdens are very unequally distributed within and across countries, and such burdens are projected to increase. "Cooperation, from local to global levels, is necessary because individuals and communities are coevolving within an inescapable lattice of interdependence on our common-pool resources," he said, quoting Elinor Ostrom. "The lattice is now global, but our institutions are still working at specific levels of governance, many times undermining each other." The social and ecological complexity in front of us calls for governance approaches that are integrated and polycentric; able to deal with policy incoherencies, uncertainties, and abrupt changes; and able to address social-environmental issues in cross-sectoral, adaptive, and inclusive ways.

Daily said the move from knowledge to action requires methods that value ecosystem goods and services. She noted two promising revolutions. The first is the development of engaged science codeveloped with other users, including decision makers, communities, financial institutions, corporations, and nongovernmental organizations. This science is shining a light on humanity's place in the web of life, and on our dependence and impacts on nature, she said. Second, new ways to collect and share data are making the science more accessible and actionable for decision makers. Through a global partnership inspired by work at the Royal Swedish Academy of Sciences, hundreds of scientists are contributing to an open-source global data and software platform supported by the Natural Capital Project. The platform's InVEST software reveals where, how, and how much nature benefits people—in cities, along coastlines, and across regions and countries.¹⁸ Together with about 300 implementing partners, it has been used in more than 185 countries to illuminate how to achieve environmental and social goals, harmonize conservation and regeneration of ecosystems with improved livelihoods, and track progress. These two revolutions offer great promise for accelerating transformations, Daily suggested, and are already having an impact.

¹⁵ Juliana et al. v. United States of America et al. Doc. 369, U.S. District Court for the District of Oregon, Case No. 6:15-cv-01517-AA. For information on the lawsuit, see https://en.wikipedia.org/wiki/Juliana_v._United_States. For information on the public trust doctrine, see https://www.law. cornell.edu/wex/public_trust_doctrine.

¹⁶ See https://www.unicef.org/press-releases/world-leaders-unite-under-new-initiative-provide-quality-education-and-training.

¹⁷ See https://www.ipbes.net/system/files/2021-06/2020%20IPBES%20GLOBAL%20REPORT%28FIRST%20PART%29_V3_SINGLE.pdf.

¹⁸ See https://naturalcapitalproject.stanford.edu.

Lubchenco reflected on progress since 1997, when she called for "20 by 2020," that is, to protect 20 percent of the ocean by 2020. Protected areas have been used for centuries by people around the world to protect and regenerate nature. They are recognized as important today, but, she said, a tension has developed that focuses attention on protected areas but loses sight of larger spaces not in those areas. A dual focus is needed to conserve protected areas but also to ensure more sustainable use outside the protected areas. Science is showing that not just quantity but also quality of the protected areas matters in the level of protection and enabling conditions under which the areas are created or managed. Equal attention must be given to social and economic outcomes so there is recognition that protected areas bring not only biodiversity benefits but also benefits to people through ecosystem services and through climate adaptation and resilience. Lubchenco referred to new methodology showing the multiple benefits from protected areas that can spill over to adjacent areas.

Bierbaum noted place-based initiatives are important, but scaling is needed, which may require different theories of change. To scale up during this decade, Brondizio called for mutually supportive actions at three levels. First, in the here and now, thousands of sustainability-oriented initiatives at the local level are making a difference in people's lives and the environment. Supporting these initiatives, as well as implementing existing national policies and international agreements will contribute to start shifting our current trajectory of unequal environmental degradation. Second, we have a decadal challenge to implement both structural and regulatory changes as well as new societal narratives recognizing and addressing a fast-evolving environmental and climate crisis. New narratives, in society, government, and businesses, are already recognizing that moving away from our current destructive development trajectory offers opportunities for more inclusive and sustainable development. He noted the UN meetings scheduled this year, particularly the post-2020 biodiversity agreement and on climate change, are key elements to promote an enabling framework for more sustainable futures. Third, on a longer time frame, reverting these trends calls for a commitment toward a deeper transformation of social norms and our economic systems, so that we acknowledge and internalize our inescapable dependence on nature and moral obligations toward both nature and future generations.

Daily commented on the capacity for nature-based solutions across different international agreements. Nature-based solutions, she explained, provide a lens through which to strengthen action for ecosystems, undertake conservation and regeneration at scale, and target investments in an integrated way. Citing Belize's green and inclusive development plan as an example, nature-based solutions also open cross-sector, nontraditional partnerships and new financing. She added that public-facing multilateral banks stand out as leading many of these innovations at scale but cofinancing from private-sector institutions is urgently needed.

Public-private partnerships are needed because public money is not enough, Bierbaum observed. For scaling up, the leading role of government is still needed in public investment, regulations, incentives, and price signals, Stiglitz said. To motivate to scale, integrated assessment models that bring together economics and the environment must be improved; he said the most commonly used models were a step forward but do not

fully account for costs, projected temperature rises, or values for future generations. Lubchenco commented COVID-19 provides a potentially transformation moment in time, and "we dare not squander it." She suggested using economic and social incentives to change behaviors to take advantage of the current situation and scale. Complex adaptive systems in the oceans that pay attention to feedbacks are important, she said, noting that governments have used changes of incentives that have led from overfishing to sustainable fisheries. Incentives matter, and understanding how to use them to get to more sustainable practices and policies.

In closing comments, Brondizio stressed that biosphere stewardship cannot be considered without supporting and including Indigenous Peoples and local communities. "There are almost a half-billion Indigenous Peoples in the world. They manage over 25 percent of the Earth's land surface. That's where the most conserved ecosystems are. That's where almost 40 percent of the protected areas are. Their contributions to agrobiodiversity, to food production, to managing fisheries, and to managing watersheds broadly impact society. Their ways of understanding and interacting with nature are sources of inspiration for the larger society. We need to bring them front and center to this conversation." Daily called attention to Gross Ecosystem Product, recently approved by the United Nations as a metric for global use. Now being deployed in an experimental phase, it can help measure, report, and manage natural capital to connect with policy incentives and other mechanisms to drive investments in nature. Stiglitz reinforced the need for incentives that are transparent and encompass social norms. He also warned about a K-shaped recovery after COVID-19, in which the gap between rich and poor grows wider.¹⁹

FROM THE SCIENCE SESSIONS: Call for Action and Concluding Remarks

"The long-term potential of humanity depends upon our ability today to value our common future. Ultimately, this means valuing the resilience of societies and the resilience of Earth's biosphere." This excerpt comes from a statement signed by more than 125 Nobel Prize laureates and other experts titled "Our Planet, Our Future: An Urgent Call for Action." The statement was not a consensus document issued by the summit, but members of the steering committee drafted it and presented it to Academic Science participants for discussion. It offers proposals in seven areas: policy, mission-driven innovation, education, information technology, finance and business, scientific collaboration, and knowledge (see Appendix D for the full statement).

The sessions closed with remarks from the same representatives who opened the summit on April 26 (see Chapter 1). Vidar Helgesen observed that, from his background in politics, he used to think of science as long term and slow, and governance as short term and more responsive to immediate demands. However, he said, science and innovation are now outpacing public decision-making. "In this time of profound planetary crisis and the complexity of the solutions, we don't have time to waste," he said. Scientific leadership is needed, he said. To him, a takeaway challenge from the summit is the need for a more continuous relationship between scientists and policy makers.

¹⁹ For a description of K-shaped recovery, see, e.g., https://www.investopedia.com/k-shaped-recovery-5080086.

Marcia McNutt agreed with the need for a connection between science and policy, but expanded the point to emphasize a need for a connection between science and the public. "We have seen time and again, politicians are a reflection of their electorate. They will not make decisions that they feel do not have the backing of their constituents," she commented. She echoed the comments made during the summit that scientists must avoid jargon and talk plainly with the public. Without public support, she said, innovation tools that have been developed will not be able to be deployed, citing GMO (genetically modified organism) crops to deal with pests and climate change as an example. "This summit can be a great platform for better communication not just to policy makers but to everyone on the globe that we have big problems, but we also have awesome solutions. If we don't engage with them from the beginning, the narrative will be taken away from us," she stated.

Johan Rockström pointed to the evidence discussed during the summit about the need to reboot humanity's relationship with planet Earth. "Our only way to reconnect with planet Earth is through science," he said. "And we have to do it at speed. That is the challenge. How do we reboot humanity at speed for transformation? The summit has provided some insights." He expressed hope that the partnership among the organizations continues in the future.

Carl Folke thanked the presenters and participants in the Main Stage and Academic Science sessions. He noted the different entry points and perspectives that converged toward a consensus about the big challenges. "That was a breakthrough," he said. "We are clear that some kind of profound transformation in our relation with the planet is deeply required. We as scientists have a critical role to play—not just by delivering the knowledge but as active parties in collaborating and producing it together with other actors. That's a fascinating insight that is emerging and is triggered by the urgency of the situation."

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APPENDIXES

APPENDIX A Main Stages Agenda

The Main Stages consisted of three parts: **Our Planet, Breakthroughs**, and **Our Future**.

April 26–27, 2021 All times cited in U.S. Eastern Time

9:45 am DOORS OPEN TO VIRTUAL MAIN STAGE

SESSION 1: OUR PLANET

10:00 am THE PERFECT HOME

Sir David Attenborough provides a message for our planet via a glimpse into his newest project.

10:20 am WELCOME FROM THE THREE PRESENTING HOSTS Vidar Helgesen, Executive Director, The Nobel Foundation Marcia McNutt (NAS/NAE), President, U.S. National Academy of Sciences

Johan Rockström, Director, Potsdam Institute for Climate Impact Research

10:30 am SETTING THE STAGE: OUR PLANET

Former U.S. Vice President **Al Gore**, Nobel Prize laureate, Co-Founder and Chair of Generation Investment Management, and Founder and Chair of the Climate Reality Project

10:45 am THINK GLOBALLY, ACT LOCALLY A conversation between Sandra Diaz (NAS), Professor of Ecology, Córdoba National University and senior member, National Research Council of Argentina Thomas Lovejoy (NAS), Professor of Ecosystems, Department

of Environmental Science and Policy, George Mason University

11:00 am MUSICAL PERFORMANCE AND ART PIECE: BEATIE WOLFE FEATURING FROM GREEN TO RED

Artist and UN Women campaign role model for innovation **Beatie Wolfe** shares her latest work, built using 800,000 years of climate data. With an introduction by Nobel Prize laureate **Robert Woodrow Wilson**

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11:15 am DYNAMIC DIALOGUES

A fast-paced, interactive exchange centered on the summit's core topics.

Human Rights

Martin Chalfie (NAS/NAM), Nobel Prize laureate, Professor of Biology, Columbia University

With **Connie Nshemereirwe**, independent science and policy facilitator **Gatwal Augustine Gatkuoth**, peacebuilding advocate

Gingger Shankar, musician and activist

Economics of Inequality

Gary Hoover, Professor of Economics and Director, Murphy Institute at Tulane University

With **Simon Levin** (NAS), James S. McDonnell Distinguished University Professor in Ecology and Evolutionary Biology, Princeton University

Zoë Jenkins, education justice activist

Sustainability/Earth Systems

Brigitte Baptiste, biologist, Chancellor of Universidad Ean, Colombia With **Adam Riess** (NAS), Nobel Prize laureate, cosmologist **Klaus von Klitzing** (NAS), Nobel Prize laureate, physicist

Anne Muthoni, climate change enthusiast

Technology

Stanley Whittingham (NAE), Nobel Prize laureate, Professor of Chemistry, Binghamton University, State University of New York

With **David Gross** (NAS), Nobel Prize laureate, Chancellor's Chair Professor of Theoretical Physics and former Director of the Kavli Institute for Theoretical Physics, University of California, Santa Barbara

Beatie Wolfe, artist and UN Women campaign role model

Ahmad Mobayed, digital education advocate, youth leader, and Co-Founder, Syrian Youth Assembly

Hosted by actor, writer, musician, producer, futurist, and science enthusiast **Ahmed Best**

12:10 pm DYNAMIC DIALOGUES BREAKOUT

Choose your own adventure audience Q&A: Which of the dynamic dialogues piqued your curiosity? Join the discussion group of your choice to take a deeper dive with one of our dynamic dialogue scientists.

1:00 pm CLOSE OF FIRST SESSION AND BRAIN BREAK

Join a relaxing, 30-minute yoga and sound bath session with Phyllicia Bonanno, work on a fun puzzle challenge with puzzle master David Kwong, network with fellow attendees, catch up on personal business, or take a walk.

SESSION 2: BREAKTHROUGHS

- 3:00 pm SESSION OPENS
- 3:05 pm WELCOME

Johan Rockström, Director, Potsdam Institute for Climate Impact Research

3:15 pm PAY IT FORWARD: ENVISIONING NEXT STEPS WITH OUR LEADERS OF TOMORROW Xiye Bastida, climate activist and youth leader

•

3:25 pm EVIDENCE OF URGENCY: AN ISLAND NATION'S CALL TO ACTION

David W. Panuelo, President, Federated States of Micronesia

3:40 pm MUSICAL PERFORMANCE: GINGGER SHANKAR AND SPECIAL GUESTS

"Promises of Our Grandmothers" is an original musical piece by Gingger Shankar exploring the roles of our grandmothers and their relationship to the land and environment.

3:50 pm MANY AVENUES FOR ACTION: A PANEL DISCUSSION

Sir Richard Roberts, Nobel Prize laureate and Chief Scientific Officer, New England Biolabs

Tamar Krishnamurti, Assistant Professor of Medicine and Clinical and Translational Science, University of Pittsburgh and CEO, Naima Health Rana el Kaliouby, Co-Founder and CEO, Affectiva Moderated by Nisha Anand, CEO, Dream Corps

4:10 pm GIVING POWER TO SOLUTIONS

A conversation between

Steven Chu (NAS), Nobel Prize laureate and Professor of Physics and Molecular and Cellular Physiology, Stanford University **Natalia Kanem**, United Nations Under-Secretary-General and Executive Director, United Nations Population Fund

4:25 pm A COMMITMENT TO COOPERATION

A conversation between **John Kerry**, Special Presidential Envoy for Climate **Marcia McNutt** (NAS/NAE), President, U.S. National Academy of Sciences

4:30 pm CLOSING REMARKS

Marcia McNutt (NAS/NAE), President, U.S. National Academy of Sciences

4:40 pm NETWORKING SESSIONS: CONNECTING & COLLABORATING TO CREATE CHANGE

Meet someone new or connect with a colleague. Collaborate with fellow attendees.

5:00 pm CLOSE OF DAY 1

DAY 2: APRIL 27, 2021

SESSION 3: OUR FUTURE

1:00 pm COFFEE OR COCKTAILS Hosted by leading mixologists, attendees will be led through a coffee and cocktail mixology demonstration to prepare a beverage to enjoy during the session.

1:30 pm OPENING REMARKS

Vidar Helgesen, Executive Director, Nobel Foundation

1:50 pm TOGETHER WE STAND: A VIEW TO THE FUTURE

A message from Ursula von der Leyen, President, European Commission

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APPENDIX A

1:55 pm A PANDEMIC GUIDE TO SOLVING PROBLEMS WITH SCIENCE: A PANEL DISCUSSION

Anthony Fauci (NAS/NAM), Director, National Institute of Allergy and Infectious Diseases, National Institutes of Health

Jennifer Doudna (NAS/NAM), Nobel Prize laureate and Professor of Biochemistry and Biophysics, University of California, Berkeley Peter Doherty (NAS/NAM), Nobel Prize laureate and patron of the Doherty Institute, University of Melbourne

Moderated by author and policy analyst Laurie Garrett

2:20 pm LISTENED: LEARNED

Key themes and messages from the previous panel shared by **Victor Dzau** (NAM), President, U.S. National Academy of Medicine

2:30 pm HARD PROBLEMS: SCIENCE SOLUTIONS

A message from James Liao (NAS/NAE), President, Academia Sinica

2:40 pm WE ARE THE WORLD: HIS HOLINESS THE 14TH DALAI LAMA

An interview with His Holiness the 14th Dalai Lama of Tibet

2:55 pm NETWORKING

Seek out fellow attendees to connect or join a roundtable discussion on summit topics created to foster discussion and action.

3:15 pm TOOLBOX OF TRUTH

A conversation between **Saul Perlmutter** (NAS), Nobel Prize laureate and Professor of Physics, University of California, Berkeley, and **Bryan Doerries**, Artistic Director, Theater of War Productions, The Oedipus Project

3:30 pm THE OEDIPUS PROJECT: A SPECIAL PERFORMANCE AND GLOBAL DISCUSSION

The Oedipus Project presents acclaimed actors reading scenes from Sophocles' Oedipus the King as a catalyst for powerful, constructive, global conversations about climate change, ecological disaster, and environmental justice. Sophocles' ancient play, first performed in 429 BC just after the first wave of a plague that killed nearly one-third of the Athenian population, is a story of arrogant leadership, ignored prophecy, intergenerational curses, and a pestilence and ecological collapse that ravages the archaic city of Thebes. Seen through this lens, Oedipus the King appears to have been a powerful tool for helping Athenians communalize trauma and loss, while interrogating their own complicit role in the suffering, not just of those around them but also of generations to come. This performance will be presented on Zoom.

Featuring performances by **Bill Murray** (*Lost in Translation*), **Frances McDormand** (*Nomadland*), **Jeffrey Wright** (*Westworld*), **Frankie Faison** (*The Wire*), **David Strathairn** (*Good Night, and Good Luck*), **Marjolaine Goldsmith** (Company Manager of Theater of War Productions), and **Jumaane Williams** (New York City Public Advocate), and a Chorus of Nobel Prize-awarded scientists, including **Elizabeth Blackburn** and **Harold Varmus**.

Translated, directed, and facilitated by Bryan Doerries.

5:30 pm CLOSE OF DAY 2

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APPENDIX B Academic Science Sessions Agenda

Our Planet, Our Future—Global Sustainability The Science Sessions

April 26–27, 2021 All times cited in U.S. Eastern Time

Purpose: These sessions are designed as a scientific discussion on global sustainability challenges in the context of a global pandemic. The sessions will explore the leadership role of science as we enter a critical "decade of action."

Main audience: Nobel Prize laureates and invited experts.

APRIL 27 ACADEMIC SCIENCE SESSION 1: OUR PLANET

2:30-4:30 pm EDT

WELCOME

- Setting the stage (**Göran K. Hansson**, Karolinska Institute and the Royal Swedish Academy of Sciences)
- Remarks by HRH Crown Princess Victoria of Sweden

Keynote presentation – Setting the stage (40–45 min., 10 min. each)

- White Paper's key messages for global sustainability (**Carl Folke** [NAS], Royal Swedish Academy of Sciences)
- NAS workshop main points (Pamela Matson [NAS], Stanford University)
- The economics of biodiversity (Partha Dasgupta [NAS], University of Cambridge)
- Ocean stewardship (Jane Lubchenco, NAS)

Response – Comments on the keynotes (10–15 min.)

- Richard Horton (NAM), the Lancet
- Magdalena Skipper, Nature
- Holden Thorp, Science

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Moderated Panel Dialogue (45 min.)

SCIENCE SUPPORTING TRANSFORMATIONS TOWARD GLOBAL SUSTAINABILITY

Moderator:

Rosina Bierbaum (NAS), University of Michigan and University of Maryland

Panelists:

Brian Schmidt (NAS), Australian National University; **Yuan Tseh Lee** (NAS), University of California, Berkeley; **Marcia McNutt** (NAS/NAE), U.S. National Academy of Sciences; and **Hans Joachim Schellnhuber** (NAS), Potsdam Institute for Climate Impact Research

Nobel Summit statement - a call for action (15 min.)

- Introducing the plan with and draft of the call for action
- · Steering Committee of the summit followed by comments from invited participants

APRIL 28 ACADEMIC SCIENCE SESSION 2: OUR FUTURE

2:00-4:00 pm EDT

Moderated Panel Dialogue (45 min.)

BREAKTHROUGHS IN TECHNOLOGIES AND SOCIAL INNOVATIONS FOR RESILIENT SOCIETIES AND GLOBAL SUSTAINABILITY

Moderator:

Leena Srivastava, International Institute for Applied Systems Analysis

Panelists:

Richard Roberts, New England Biolabs; Jennifer Doudna (NAS/NAM), University of California, Berkeley; Karen Seto (NAS), Yale University; and Frank Geels, University of Manchester

Moderated Panel Dialogue (45 min.)

TOWARD SUSTAINABLE FUTURES: GOVERNANCE, INCLUSIVENESS, AND STEWARDSHIP

Moderator:

Rosina Bierbaum (NAS), University of Michigan and University of Maryland

Panelists:

Joe Stiglitz (NAS), Columbia University; Jane Lubchenco (NAS); Gretchen Daily (NAS), Stanford University; and Eduardo Brondizio, Indiana University

Next steps with the Call for Action (20 min.)

Summit Steering Committee followed by comments from invited participants

Closing remarks (10 min.)

Vidar Helgesen, Nobel Foundation; Marcia McNutt (NAS/NAE), U.S. National Academy of Sciences; Johan Rockström, Potsdam Institute for Climate Impact Research; and Carl Folke (NAS), Royal Swedish Academy of Sciences

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Appendix C Solution Sessions Agenda

April 28, 2021 All times cited in U.S. Eastern Time

On day three of the Nobel Prize Summit, our partners hosted events that put our discussion themes into practice.¹

TRANSFORMATIONAL ECONOMICS: VALUING OUR FUTURE

Hosted by The Club of Rome

8:00-10:00 am EDT

Humanity is now the largest driver of change on Earth. To minimize risk of climate change and biodiversity loss, this next decade must see the fastest economic transformation in history and at a global scale. How does economic thinking accommodate these facts? How do economists make sense of this new responsibility for our planet? Ultimately, if we are to value our future we need to value resilience in societies and in nature. This Solution Session explored new economic thinking that will contribute to building fairer, resilient societies on a resilient planet; introduced the EarthforAll project; and discussed the role of philanthropy in funding the change we need. In two parts, speakers discussed transformational economic thinking and transformational leadership.

Speakers:

Sandrine Dixson-Declève, Co-President, Club of Rome Johan Rockström, Director, Potsdam Institute for Climate Impact Research Andrew Steer, President and CEO, Bezos Earth Fund Per Espen Stoknes, Director, Centre for Green Growth, Norwegian Business School Sharan Burrow, General Secretary, International Trade Union Confederation Jayati Ghosh, Professor, Centre for Economic Studies and Planning, Jawaharlal Nehru University Ilona Otto, Professor, Wegener Center for Climate and Global Change, University of Graz Carlota Perez, Honorary Professor, Institute for Innovation and Public Purpose, University College London Jennifer Hinton, Researcher, Stockholm Resilience Centre Leslie Johnston, CEO, Laudes Foundation Ellen Dorsey, Executive Director, Wallace Global Fund Felicitas von Peter, Managing Partner, Active Philanthropy Tom Steinbach, Executive Director, Sea Change Foundation

¹Videos of all solution sessions are available at https://www.nobelprize.org/our-planet-our-future-day-three.

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ROOTS OF CHANGE: EMPATHY AS A COLLECTIVE RESPONSIBILITY

Hosted by DICCE, GenZ Girl Gang, and ProjectLets

9:30–11:30 am EDT

We are in an empathy crisis. In a world defined by political ideology, race, and economic status, there seem to be more that divides us than unites us. And this polarization creates barriers, both for mutual understanding and societal problem-solving. Citigroup estimates that the U.S. economy has lost \$16 trillion from racism against African Americans over the past 20 years. The Genuine Progress Indicator (GPI), a measure of well-being, has been stagnant. To move forward, we must acknowledge our collective responsibility in addressing the empathy crisis. In this discussion, we explored the scientific impact of empathy and how we can embed empathy into our science, systems, and individual lives. We heard from leading cognitive behavioral scientists on the sociobiological basis of empathy and from incredible thought leaders and psychologists on how to ground ourselves in revolutionary empathy. In this youth-led session, we explored new ways of measuring social progress and helped explore our own empathy and active listening through some fun speed-friending activities!

Moderators:

Phoebe Omonira, Director of Community Outreach, GenZ Girl Gang

Lyne Odhiambo Zoë Jenkins, Founder, DICCE

Speakers

Julie Fratantoni, Head of Operations, The BrainHealth Project, Center for BrainHealth, University of Texas at Dallas

Gary A. Hoover, Executive Director of the Murphy Institute and Professor of Economics, Tulane University

OUR PLANET: FROM HUMAN IMPACT TO CLIMATE ACTION AND SUSTAINABLE INDUSTRY SOLUTIONS

Hosted by Embassy of Sweden in the United States

10:00–11:30 am EDT

The human impact on nature is undeniable. The never-ending demand for limited natural resources leaves lasting effects on the environment and risks the loss of biological diversity. With a foundation in science, industry is a vital part of the solution by creating efficient resource utilization aiming to reduce the negative impact on the environment. What does science tell us about the human impact on nature and loss of biodiversity? How can science contribute to industries' ongoing sustainability efforts? How do companies incorporate science and industry inspire and innovate sustainable solutions? This event addressed these issues with a foundation in the findings from the Nobel Prize Summit and in collaboration with the Royal Swedish Academy of Engineering Sciences.

Speakers:

H. E. Karin Olofsdotter, Ambassador of Sweden to the United States
Johan Rockström, Director, Potsdam Institute for Climate Impact Research
Carl Folke (NAS), Director, Beijer Institute of Ecological Economics and Chair, Stockholm Resilience Centre
Cristian Samper, President and CEO, Wildlife Conservation Society
Emma Nehrenheim, Chief Environmental Officer, Northvolt
Florian Schattenmann, Chief Technology Officer and Vice President for Innovation and Research and Development, Cargill
Tuula Teeri, President, Royal Swedish Academy of Engineering Sciences
Gayle Schueller, Senior Vice President and Chief Sustainability Officer, 3M
Theodor Swedjemark, Chief Communications and Sustainability Officer, ABB
Heather Johnson, Vice President for Sustainability, Skanska Group
Anna Sjöström-Douagi, Program Director, Nobel Prize Summit

THE FUTURE OF SUSTAINABILITY EDUCATION

Hosted by National Academies of Sciences, Engineering, and Medicine

10:00–11:30 am EDT

This event highlighted the findings and recommendations from the recent National Academies' report Strengthening Sustainability Programs and Curricula at the Undergraduate and Graduate Levels (2020) with a focus on the future of sustainability education. The report provides expert insights for strengthening the emerging discipline of sustainability in higher education in the United States. Presentations and facilitated discussion examined the role of universities in achieving the SDGs, digital learning opportunities and student engagement, and the critical need to build a K-12 pipeline to higher education.

Moderators:

Arun Agrawal (NAS), Samuel Trask Dana Professor, School for the Environment and Sustainability, University of Michigan

Vaughan Turekian, Executive Director, Policy and Global Affairs, National Academies of Sciences, Engineering, and Medicine

Speakers:

Marcia McNutt (NAS/NAE), President, National Academy of Sciences

Marilu Hastings, Chief Innovation and Strategy Officer, Cynthia and George Mitchell Foundation Anne Kapuscinski, Director, Coastal Science and Policy Program, University of California,

Anne Kapuscinski, Director, Coastal Science and Policy Program, University of California, Santa Cruz

Shamila Nair-Bedouelle, Assistant Director-General for Natural Sciences, United Nations Educational, Scientific, and Cultural Organization

Ellen Stofan, Under Secretary for Science and Research, Smithsonian Institution

Dan Higgins, Global Technology Consulting Leader, Ernst & Young Global Ltd.

Sajitha Bashir, Adviser, Office of the Global Director, Education Practice, The World Bank

Jeffrey Sachs (NAM), President, Sustainable Development Solutions Network

Zohra Yermeche, Program Director, Connect to Learn, Sustainability and Corporate Responsibility, Ericsson

Sir Richard Roberts, Chief Scientific Officer, New England BioLabs, Inc. (Nobel Prize in Physiology or Medicine 1993)

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STARTUP SOLUTIONS: HOW SOCIAL ENTERPRISES ARE ADDRESSING 21ST CENTURY CHALLENGES

Hosted by Halcyon and S&R Foundation

10:00–11:00 am EDT

Startups provide the most nimble, adaptive, and fast-paced business solutions to many of the most pressing 21st century environmental and sustainability challenges. In concert with governments, large industry, and engaged leadership, social enterprises have a critical role to play. This event featured three remarkable social enterprise founders who have integrated both profit and purpose into their business models to maximize their impact. Learn the story behind some of the most innovative social ventures in the world and how these enterprises will help to create a brighter future for humans and our planet.

Moderator:

Joshua Mandell, Chief Operating Officer (COO), Halcyon

Speakers: Svanika Balasubramanian, CEO, rePurpose Global Sam Teicher, CEO, Coral Vita Phil Wong, CEO, Misfit Foods Sandhya Murali, COO, Solstice

FROM RESULTS IN THE LAB TO RESULTS ON THE GROUND

Hosted by Global Solutions Summit

11:00 am-12:30 pm EDT

How can we ensure that cutting-edge scientific results enhance sustainability and lead to concrete improvements in peoples' lives? To accomplish these objectives, scientific knowledge has to be embedded in products and organizations that meet three criteria: (1) financial, operational, and environmental sustainability; (2) accessibility to the billions of people at the lower/lowest strata of the income pyramid rather than serving only the economic elites; and (3) deployed at scale to improve the lives of hundreds of millions of people in dozens of countries in thousands of communities around the world. The panelists explained that this daunting task is eminently worth pursuing, but it will require some changes to business-as-usual procedures in the scientific community and elsewhere.

Moderator:

Alfred Watkins, Chairman, Global Solutions Summit

Speakers:

Theresa Kotanchek, CEO, Evolved Analytics

Ramesh Mashelkar (NAS/NAE), Former Director General of the Council of Scientific and Industrial Research and Former President of Indian National Science Academy

Maurizio Vecchione, Co-Founder of AdAstral and President and CEO of Washington Global Health Alliance

ONLINE DISINFORMATION AND HUMAN RIGHTS

Hosted by National Academies Committee on Human Rights

11:30-12:30 pm EDT

This fireside chat examined the role of digital disinformation and media manipulation in entrenching societal inequalities, driving polarization, and eroding public trust. The panelists discussed possible human rights-based approaches to countering disinformation online.

Moderator:

Sam Gregory, Program Director, WITNESS

Speakers:

Safiya Noble, Associate Professor, University of California, Los Angeles (UCLA) and Co-Founder and Co-Director of the UCLA Center for Critical Internet Inquiry (C2i2)

Kate Starbird, Associate Professor, Human Centered Design & Engineering, University of Washington

SMART CITIES AND NEW GREEN SOLUTIONS

Hosted by Embassy of Italy in the United States

12:00–1:15 pm EDT

Inspired by the motto of the G20 Italian Presidency in 2021, "People, Planet, Prosperity," and on the triple special occasion of the 160th anniversary of Italy-U.S. diplomatic relations, the Italian co-presidency of COP26, and the Italian Research Day in the World, the Embassy of Italy to the U.S. organizes, in collaboration with the National Academy of Sciences, a high-visibility event on April 28. The theme was Urban Sustainability, with a panel of top-notch experts from both sides of the Atlantic, to discuss the global challenge of developing smart, people-oriented and resilient cities that could improve the long-term health of the planet's human and ecological systems.

Moderator:

Alexander Kaufman, Huffington Post

Speakers:

Marcia McNutt (NAS/NAE), President, National Academy of Sciences

Armando Varricchio, Ambassador of Italy to the United States

Maria Cristina Messa, Minister of Universities and Research, Italy

Stanley Whittingham (NAE), Director, NorthEast Center for Chemical Energy Storage and Distinguished Professor of Chemistry, Binghamton University (State University of New York) (Nobel Prize in Chemistry 2019)

Chris Greer, Senior Executive for Cyber-Physical Systems, National Institute of Standards and Technology, Department of Commerce

Debra Lam, Managing Director for Smart Cities and Inclusive Innovation, Institute for People and Technology, Georgia Institute of Technology

Carlo Ratti, Director of Senseable City Lab, Massachusetts Institute of Technology

Paola Malanotte-Rizzoli, Professor of Physical Oceanography, Massachusetts Institute of Technology

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A CALL FOR AN INTERGOVERNMENTAL PANEL ON THE INFORMATION ENVIRONMENT

Hosted by PeaceTech Lab

12:00-1:30 pm EDT

In response to the existential threat posed by the proliferation of false information across online and offline media, leadership at PeaceTech Lab proposes the consideration of the formation of an Intergovernmental Panel on Climate Change (IPCC) equivalent—the Intergovernmental Panel on the Information Environment (IPIE)—to analyze the global information environment in order to provide governments with recommendations, based on science, for arriving at objective, transparent standards for a healthy global information environment and the actions needed to achieve it. With expert voices and thought leaders, this panel explored the practicalities and importance of creating an IPIE in our immediate future.

Moderator:

Sheldon Himelfarb, President and CEO, PeaceTech Lab

Speakers:

Vint Cerf (NAS/NAE), Internet Pioneer and Chief Internet Evangelist, Google
Phil Howard, Director, Oxford Internet Institute
Ian Goldin, Professor of Globalisation and Development, Oxford University
Tawakkol Karman, Nobel Prize laureate, journalist and human rights activist
Katherine Maher, Executive Director, Wikimedia Foundation and Wikipedia

CRITICAL PATHWAY: IMPLEMENTING COMPREHENSIVE DESIGN MODELS FOR PEOPLE AND PLANET

Hosted by The Peace Department

12:00-1:30 pm EDT

This session included as a series of talks shedding light on the challenges we face globally, and the solutions the economic, political, and social sectors can bring to a collaborative effort. Our partners joined us in sharing the roles they play in the global development framework, and from this we focused our discussion on establishing a potential working relationship toward executing the SDG critical pathway: a pathway that includes using sustainably focused research and scientific theory to craft deployable solutions, aligning philanthropic and investment efforts to build new markets, and integrating new local and international policies that seed and cultivate sustainable change. By addressing coordination shortfalls and bringing together experts in global economic systems, carbon emissions research, sustainable climate policy, and international development, the session tackled the challenge and promise of putting innovation and capital to work. Through this panel's collaborations, we began to bridge the gap between intention and action to accelerate progress on the dual global crises of climate change and systemic inequality.

Speakers:

James Sternlicht, Co-Founder, The Peace Department Bobby Kia, Co-Founder, The Peace Department Pierre Ferrari, CEO, Heifer International

Martin Wainstein, Founder and Executive Director, Open Earth Foundation

Zoe Knight, Group Head, Centre for Sustainable Finance, HSBC

William Sonneborn, Senior Director of Technologies and Funds, International Finance Corporation

Aude de Montesquiou, Senior Advisor, Strategy and Digital Innovations, BRAC Institute of Governance and Development

Richard Zimmerman, Partner, WE Family Offices

The Honorable **Mary Robinson**, former President of Ireland, UN High Commissioner of Human Rights, and Founder of Realizing Rights and Climate Justice

ACTING TODAY FOR AN AMBITIOUS TOMORROW

Hosted by 3M

12:00-1:00 pm EDT

Corporations play a crucial role in advancing the health of our planet, protecting its natural resources, and building a better future for its people—and stakeholders increasingly expect them to do so. Addressing our shared global challenges will require more ambitious commitments, action grounded in data, and broader cross-sector collaboration. Through the exchange of insights and ideas, this Solution Session detailed how corporate commitments are driving positive changes, the best approaches for leveraging technology and learning from data, and the crucial role of unified action in driving us toward a brighter future.

Speakers:

Gayle Schueller, Senior Vice President and Chief Sustainability Officer, 3M **John Banovetz**, Executive Vice President, Chief Technology Officer and Environmental Responsibility, 3M

Peter Lacy, Chief Responsibility Officer and Global Sustainability Services Lead, Accenture **Chris Coulter**, Chief Executive Officer, GlobeScan

THE SUSTAINABLE DEVELOPMENT GOALS AND INTERNATIONAL RESEARCH COLLABORATION

Hosted by the National Academies and Arizona State University

1:00-2:00 pm EDT

The pandemic has made the achievement of the SDGs more challenging, with increasing concerns about supply chain disruption, environmental degradation, and persistent inequalities. As the international community slowly adapts to a new normal, the pace of global policy discussions should accelerate to deliver much-needed change. This session highlighted the importance of international collaboration for achieving the SDGs with a timeline of 2030. Presentations and facilitated discussions focused on the role of science, technology, and innovation in support of more effective policies and actions toward sustainability; advancing awareness of the SDGs with a particular focus on the youth, civil society, and the new U.S. administration; and research agendas related to sustainability and the SDGs to inform post-2030 processes.

Moderators:

Andrew Steer, President and CEO, Bezos Earth Fund

Amanda Ellis, Director, Global Partnerships, Wrigley Global Futures Laboratory, Arizona State University

Speakers:

Tateo Arimoto, Principal Fellow, Japan Science and Technology Agency and Visiting Professor and Deputy Director, Science, Technology and Innovation Policy Research Center, National Graduate Institute for Policy Studies (GRIPS)

Daya Reddy, President, International Science Council and South African Research Chair in Computational Mechanics, University of Cape Town

Peter Schlosser, Vice President and Vice Provost, Julie Ann Wrigley Global Futures Laboratory, Arizona State University

Ada Yonath (NAS), Director, The Helen and Milton A. Kimmelman Center for Biomolecular Structure and Assembly, Weizmann Institute of Science (Nobel Prize in Chemistry 2009)

APPENDIX D An Ugent Call for Action

This statement was inspired by the discussions at the 2021 Nobel Prize Summit, issued by the Steering Committee and cosigned by Nobel laureates and experts.¹

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The Nobel Prizes were created to honor advances of "the greatest benefit to humankind." They celebrate successes that have helped build a safe, prosperous, and peaceful world, the foundation of which is scientific reason.

Science is at the base of all the progress that lightens the burden of life and lessens its suffering. — Marie Curie (Nobel Prize laureate 1903 and 1911)

Science is a global common good on a quest for truth, knowledge, and innovation toward a better life. Now, humankind faces new challenges at unprecedented scale. The first Nobel Prize Summit comes amid a global pandemic, amid a crisis of inequality, amid an ecological crisis, amid a climate crisis, and amid an information crisis. These supranational crises are interlinked and threaten the enormous gains we have made in human progress. It is particularly concerning that the parts of the world projected to experience many of the compounding negative effects from global changes are also home to many of the world's poorest communities, and to Indigenous Peoples. The summit also comes amid unprecedented urbanization rates and on the cusp of technological disruption from digitalization, artificial intelligence, ubiquitous sensing, and biotechnology and nanotechnology that may transform all aspects of our lives in coming decades.

We have never had to deal with problems of the scale facing today's globally interconnected society. No one knows for sure what will work, so it is important to build a system that can evolve and adapt rapidly.

-Elinor Ostrom (Nobel Prize laureate 2009)

¹ This statement was released on April 29, 2021, on the National Academies website at https://www.nationalacademies.org/news/2021/04/nobel-prizelaureates-and-other-experts-issue-urgent-call-for-action-after-our-planet-our-future-summit. It was delivered to world leaders ahead of the G7 Summit held in June 2021. See https://www.nationalacademies.org/news/2021/06/our-planet-our-future-statement-signed-by-126-nobel-laureates-delivered-toworld-leaders-ahead-of-g-7-summit.

The summit has been convened to promote a transformation to global sustainability for human prosperity and equity. Time is the natural resource in shortest supply. The next decade is crucial: global greenhouse gas emissions need to be cut by half and destruction of nature halted and reversed. An essential foundation for this transformation is to address destabilizing inequalities in the world. Without transformational action this decade, humanity is taking colossal risks with our common future. Societies risk large-scale, irreversible changes to Earth's biosphere and our lives as part of it.

> A new type of thinking is essential if mankind is to survive and move toward higher levels. —Albert Einstein (Nobel Prize laureate 1921)

We need to reinvent our relationship with planet Earth. The future of all life on this planet, humans and our societies included, requires us to become effective stewards of the global commons—the climate, ice, land, ocean, freshwater, forests, soils, and rich diversity of life that regulate the state of the planet, and combine to create a unique and harmonious life-support system. There is now an existential need to build economies and societies that support Earth system harmony rather than disrupt it.

OUR PLANET

It seems appropriate to assign the term 'Anthropocene' to the present. —Paul Crutzen (Nobel Prize laureate 1995)

Geologists call the last 12,000 years the Holocene epoch. A remarkable feature of this period has been relative Earth-system stability. But the stability of the Holocene is behind us now. Human societies are now the prime driver of change in Earth's living sphere—the biosphere. The fate of the biosphere and human societies embedded within it is now deeply intertwined and evolving together. Earth has entered a new geological epoch, the Anthropocene. Evidence points to the 1950s as the onset of the Anthropocene—a single human lifetime ago. The Anthropocene epoch is more likely to be characterized by speed, scale, and shock at global levels.

Planetary Health

The health of nature, our planet, and people is tightly connected. Pandemic risk is one of many global health risks in the Anthropocene. The risks of pandemics are now greater due to destruction of natural habitats, highly networked societies, and misinformation.

The COVID-19 pandemic is the greatest global shock since the Second World War. It has caused immense suffering and hardship. The scientific response in the face of catastrophe, from detection to vaccine development, has been robust and effective. There is much to applaud. However, there have been clear failings. The poorest and most marginalized in societies remain the most vulnerable. The scale of this catastrophe could have been greatly reduced through preventive measures, greater openness, early detection systems, and faster emergency responses.

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Reducing risk of zoonotic disease like COVID-19 requires a multipronged approach recognizing "One Health"—the intimate connections between human health and the health of other animals and the environment. Rapid urbanization, agricultural intensification, overexploitation, and habitat loss of large wildlife all promote the abundance of small mammals, such as rodents. Additionally, these land-use changes lead animals to shift their activities from natural ecosystems to farmlands, urban parks, and other human-dominated areas, greatly increasing contact with people and the risk of disease transmission.

The Global Commons

Global heating and habitat loss amount to nothing less than a vast and uncontrolled experiment on Earth's life-support system. Multiple lines of evidence now show that, for the first time in our existence, our actions are destabilizing critical parts of the Earth system that determine the state of the planet.

For 3 million years, global mean temperature increases have not exceeded 2 °C of global warming, yet that is what is in prospect within this century. We are on a path that has taken us to 1.2 °C warming so far—the warmest temperature on Earth since we left the last ice age some 20,000 years ago, and which will take us to greater than 3 °C warming in 80 years.

At the same time, we are losing Earth resilience, having transformed half of Earth's land outside of the ice sheets, largely through farming expansion. Of an estimated 8 million species on Earth, about 1 million are under threat. Since the 1970s, there has been an estimated 68 percent decline in the populations of vertebrate species.

Inequality

The only sustainable prosperity is shared prosperity. —Joseph Stiglitz (Nobel Prize laureate 2001)

While all in societies contribute to economic growth, the wealthy in most societies disproportionately take the largest share of this growing wealth. This trend has become more pronounced in recent decades. In highly unequal societies, with wide disparities in areas such as health care and education, the poorest are more likely to remain trapped in poverty across several generations.

More equal societies tend to score highly on metrics of well-being and happiness. Reducing inequality raises social capital. There is a greater sense of community and more trust in government. These factors make it easier to make collective, long-term decisions. Humanity's future depends on the ability to make long-term, collective decisions to navigate the Anthropocene.

The COVID-19 pandemic, the largest economic calamity since the Great Depression, is expected to worsen inequality at a moment when inequality is having a clear destabilizing political impact in many countries. Climate change is expected to further exacerbate inequality. Already, the poorest, often living in vulnerable communities, are hit hardest by the impacts of climate, and live with the damaging health effects of energy systems, for

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example, air pollution. Furthermore, although urbanization has brought many societal benefits, it is also exacerbating existing, and creating new, inequities.

It is an inescapable conclusion that inequality and global sustainability challenges are deeply linked. Reducing inequality will positively affect collective decision-making.

Technology

The accelerating technological revolution—including information technology, artificial intelligence, and synthetic biology—will affect inequality, jobs, and entire economies, with disruptive consequences. On aggregate, technological advancements so far have accelerated us down the path toward destabilizing the planet. Without guidance, technological evolution is unlikely to lead to transformations toward sustainability. It will be critical to guide the technological revolution deliberately and strategically in the coming decades to support societal goals.

Acknowledging Urgency and Embracing Complexity

The future habitability of Earth for human societies depends on the collective actions humanity takes now. There is rising evidence that this is a decisive decade (2020–2030). Loss of nature must be stopped and deep inequality counteracted. Global emissions of greenhouse gases need to be cut by half in the decade 2021–2030. This alone requires collective governance of the global commons—all the living and nonliving systems on Earth that societies use but that also regulate the state of the planet—for the sake of all people in the future.

On top of the urgency, we must embrace complexity. Humanity faces rising network risks and cascading risks as human and technological networks grow. The 2020–2021 pandemic was a health shock that quickly cascaded into economic shocks. We must recognize that surprise is the new normal and manage for complexity and emergent behavior.

OUR FUTURE

A Decade of Action

Time is running out to prevent irreversible changes. Ice sheets are approaching tipping points—parts of the Antarctic ice sheet may have already crossed irreversible tipping points. The circulation of heat in the North Atlantic is unequivocally slowing down due to accelerated ice melt. This may further affect monsoons and the stability of major parts of Antarctica. Rainforests, permafrost, and coral reefs are also approaching tipping points. The remaining carbon budget for a 67 percent probability of not exceeding 1.5 °C global warming will be exhausted before 2030. At the same time, every week until 2050, the urban population will increase by about 1.3 million, requiring new buildings and roads, water and sanitation facilities, and energy and transport systems. The construction and operation of these infrastructure projects will be energy and emissions intensive unless major changes are made in how they are designed and implemented.

In 2021, major summits will generate political and societal momentum for action on climate, biodiversity, food systems, desertification, and the ocean. In 2022, the Stockholm+50 event

marks the 50th anniversary of the first Earth Summit. This is an important opportunity to reflect on progress to meet the United Nations Sustainable Development Goals (SDGs), due to be completed by 2030. Yet a disconnect exists between the urgency indicated by the empirical evidence and the response from electoral politics: the world is turning too slowly.

Planetary Stewardship

We must break down the walls that have previously kept science and the public apart and that have encouraged distrust and ignorance to spread unchecked. If anything prevents human beings from rising to the current challenge, it will be these barriers.

—Jennifer Doudna (Nobel Prize laureate 2020)

Effective planetary stewardship requires updating our Holocene mindset. We must act on the urgency, the scale, and the interconnectivity between us and our home, planet Earth. More than anything, planetary stewardship will be facilitated by enhancing social capital—building trust within societies and between societies.

Is a new worldview possible? To date, 193 nations have adopted the SDGs. The global pandemic has contributed to a broader recognition of global interconnectivity, fragility, and risk. Where they possess the economic power to do so, more people are increasingly making more sustainable choices regarding transportation, consumption, and energy. They are often ahead of their governments. And increasingly, the sustainable options, for example, solar and wind power, are similar in price to fossil fuel alternatives or cheaper—and getting cheaper.

The question at a global systems level today is not whether humanity will transition away from fossil fuels. The question is: Will we do it fast enough? Solutions, from electric mobility to zero-carbon energy carriers and sustainable food systems, are today often following exponential curves of advancement and adoption. How do we lock this in? The following seven proposals provide a foundation for effective planetary stewardship.

POLICY: Complement GDP (gross domestic product) as a metric of economic success with measures of true well-being of people and nature. Recognize that increasing disparities between rich and poor feed resentment and distrust, undermining the social contract necessary for difficult, long-term collective decision-making. Recognize that the deteriorating resilience of ecosystems undermines the future of humanity on Earth.

MISSION-DRIVEN INNOVATION: Economic dynamism is needed for rapid transformation. Governments have been at the forefront of funding transformational innovation in the last 100 years. The scale of today's challenges will require large-scale collaboration between researchers, government, and business—with a focus on global sustainability.

EDUCATION: Education at all ages should include a strong emphasis on the nature of evidence, the scientific method, and scientific consensus to ensure future populations have the grounding necessary to drive political and economic change. Universities should embed concepts of planetary stewardship in all curricula as a matter of urgency. In a transformative, turbulent century, we should invest in life-long learning and fact-based worldviews.

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INFORMATION TECHNOLOGY: Special interest groups and highly partisan media can amplify misinformation and accelerate its spread through social media and other digital means of communication. In this way, these technologies can be deployed to frustrate a common purpose and erode public trust. Societies must urgently act to counter the industrialization of misinformation and find ways to enhance global communication systems in the service of sustainable futures.

FINANCE AND BUSINESS: Investors and companies must adopt principles of recirculation and regeneration of materials and apply science-based targets for all global commons and essential ecosystem services. Economic, environmental, and social externalities should be fairly priced.

SCIENTIFIC COLLABORATION: Greater investment is needed in international networks of scientific institutions to allow sustained collaboration on interdisciplinary science for global sustainability as well as transdisciplinary science that integrates diverse knowledge systems, including local, Indigenous, and traditional knowledge.

KNOWLEDGE: The pandemic has demonstrated the value of basic research to policy makers and the public. Commitment to sustained investment in basic research is essential. In addition, we must develop new business models for the free sharing of all scientific knowledge.

CONCLUSION

Global sustainability offers the only viable path to human safety, equity, health, and progress. Humanity is waking up late to the challenges and opportunities of active planetary stewardship. But we *are* waking up. Long-term, scientifically based decision-making is always at a disadvantage in the contest with the needs of the present. Politicians and scientists must work together to bridge the divide between expert evidence, short-term politics, and the survival of all life on this planet in the Anthropocene epoch. The long-term potential of humanity depends on our ability today to value our common future. Ultimately, this means valuing the resilience of societies and the resilience of Earth's biosphere.

► SIGNATURES²

Peter Agre,* Johns Hopkins Bloomberg School of Public Health Harvey Alter,* National Institutes of Health Hiroshi Amano,* Nagoya University Frances Arnold,* California Institute of Technology Barry Barish,* California Institute of Technology Françoise Barré-Sinoussi,* Institut Pasteur Georg Bednorz,* IBM Zurich Research Laboratory Carlos Filipe Ximenes Belo,* Nobel Peace Prize 1996 Paul Berg,* Stanford University J. Michael Bishop,* University of California, San Francisco Elizabeth H. Blackburn,* University of California, San Francisco Linda Buck,* Fred Hutchinson Cancer Research Center William Campbell,* Drew University

² *Nobel Prize laureate

Mario Capecchi,* University of Utah Stephen R. Carpenter, University of Wisconsin-Madison Franklin Carrero-Martínez, U.S. National Academies of Sciences, Engineering, and Medicine Thomas Cech,* University of Colorado, Boulder Martin Chalfie,* Columbia University F. Stuart Chapin III, University of Alaska Deliang Chen, Gothenburg University Steven Chu,* Stanford University Aaron Ciechanover,* Technion – Israel Institute of Technology Mairead Corrigan-Maguire,* Nobel Peace Prize 1976 Beatrice Crona, Stockholm Resilience Centre at Stockholm University Robert Curl Jr. ,* Rice University Gretchen C. Daily, Stanford University His Holiness the 14th Dalai Lama,* Nobel Peace Prize 1989 Sir Partha Dasgupta, University of Cambridge Johann Deisenhofer,* University of Texas Southwestern Medical Center Peter C. Doherty,* University of Melbourne Jennifer Doudna,* University of California, Berkeley Jacques Dubochet,* Lausanne University Shirin Ebadi,* Nobel Peace Prize 2003 Mohamed ElBaradei,* Nobel Peace Prize 2005 Gerhard Ertl,* Fritz Haber Institute of the Max Planck Society Andrew Fire,* Stanford University Joern Fischer, Leuphana University Carl Folke, Stockholm Resilience Centre at Stockholm University, and the Beijer Institute of Ecological Economics at the Royal Swedish Academy of Sciences Joachim Frank,* Columbia University Jerome Friedman.* Massachusetts Institute of Technology Owen Gaffney, Potsdam Institute for Climate Impact Research, and Stockholm Resilience Centre at Stockholm University Victor Galaz, Stockholm Resilience Centre at Stockholm University Leymah Gbowee,* Nobel Peace Prize 2011 Frank Geels, Manchester University Walter Gilbert,* Harvard University Sheldon Glashow,* Harvard University, Boston University Line Gordon, Stockholm Resilience Centre at Stockholm University Carol Greider,* University of California, Santa Cruz David Gross,* University of California, Santa Barbara Sir John Gurdon,* The Gurdon Institute, University of Cambridge Jeffrey Hall,* Brandeis University, University of Maine John Hall,* University of Colorado Göran Hansson, KVA (Royal Swedish Academy of Sciences) Serge Haroche,* College de France Oliver Hart,* Harvard University Leland Hartwell,* Arizona State University Richard Henderson,* MRC Laboratory of Molecular Biology Dudley Herschbach,* Harvard University, Texas A&M University Avram Hershko,* Technion – Israel Institute of Technology Holger Hoff, Potsdam Institute for Climate Impact Research Roald Hoffmann,* Cornell University Bengt Holmstrom,* Massachusetts Institute of Technology

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"We need the concept of oneness: we all live on one planet and share the same basic way of life. According to that reality, we should no longer emphasize my nation, my country. We should think of our humanity." —His Holiness the Dalai Lama

