Proceedings of the 2022 Geneva Science and Diplomacy Anticipation Summit

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Geneva Science and Diplomacy Anticipator

Proceedings of the 2022 Geneva Science and Diplomacy Anticipation Summit
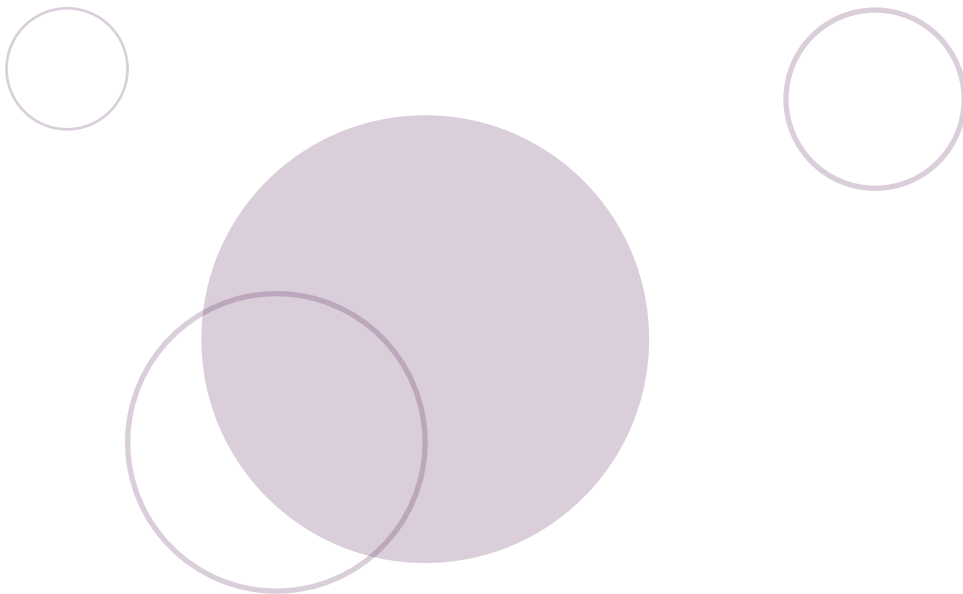
12-14 October 2022

Campus Biotech Geneva

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These Proceedings of the 2022 Geneva Science and Diplomacy Anticipation Summit are based on numerous sources, which are easily accessible via the digital PDF version of this document (as indicated in the "More information" boxes), as well as through the GESDA website (www.gesda.global), directly accessible with the QR code below. These sources include the full video recordings of the speeches and the sessions of the 2022 GESDA Summit, hyperlinks to external information indicated in the texts with underlined words, interviews of the GESDA Summit speakers and participants at the dedicated television booth, twitter threads produced during the sessions, as well as material related to the announcement made by GESDA during the Summit (press releases, images, etc.). To easily navigate that content and replay the recordings of the 2022 Geneva Science and Diplomacy Anticipation Summit, please simply scan the following QR with your smartphone.

Executive summary

THE SUMMIT IN A NUTSHELL

The GESDA Foundation's second annual gathering – the Geneva Science and Diplomacy Anticipation Summit, or GESDA Summit – took place on 12-14 October 2022 in Geneva, Switzerland, at Campus Biotech, where GESDA is headquartered. It consolidated its standing as a new force for global multilateral action based on anticipatory science and diplomacy. This year's hybrid event expanded participation from among all of GESDA's collaborative avenues – including a first high-level political assessment and a youth cohort.

The four main objectives were to provide a yearly update of the GESDA Science Breakthrough Radar® produced in partnership with the Fondation pour Genève; introduce GESDA's Pipeline of Solution Ideas, the prototypes of possible avenues of action to accelerate the humanity-benefiting use of emerging scientific and technological trends; gain a preliminary assessment by political authorities on whether and how these actions could be politically endorsed and set in motion at the global diplomatic level; and start to set up innovative impact funding instruments that can provide the needed resources to incubate the solution ideas.

By the Numbers

The GESDA Summit drew a diverse crowd from across five continents and four communities: academic, citizen (including youth), diplomatic and impact. Its 1,267 participants marked a 40% increase from the more than 900 participants at the inaugural summit in 2021, making for a rich, varied and inclusive exchange of knowledge, ideas and viewpoints. A total of 152 speakers, 55% male and 45% female, and a youth cohort of 12 contributed to 21 sessions over three days.

The speakers and moderators came from 46 nations on five continents. Community-wise, 37% of the speakers and moderators were academic; 27% were diplomatic; 23% were citizens (including youth); and 13% were impact (finance, philanthropy, business). Among the participants, the community breakdown was roughly similar: 32% academic; 30% diplomatic; 21% impact; and 17% citizen (including youth).

The Programme

The 21 sessions featured three primary session styles: Panels, which brought diverse stakeholder representation to a facilitated discussion around anticipatory scientific trends; Debates, which paired experts with diverging views on those trends and were facilitated by an expert moderator; and Solution Ideas, which included a structured update and presentation of GESDA's pipeline of solution ideas followed by an engaging talk on outcomes and plans.

In addition, a Public Plenary session focused on advances in genetic engineering and synthetic biology. Organized in partnership with the Geneva Graduate Institute, it demonstrated the usefulness of the economic, geopolitical, legal, and philosophical tools being developed for working with the GESDA Science Breakthrough Radar®.

HIGHLIGHTS

Opening High-Level Plenary
The summit opened with a demonstration of GESDA's firm support from the Swiss and Geneva governments, including an explanation by Swiss President Ignazio Cassis on why authorities extended GESDA's mandate for 10 years after its successful three-year pilot phase. Speakers cited the need for multilateral governance in a world grappling with climate-linked droughts and flooding, widespread hunger, pandemics, armed conflicts in Europe and much of Asia and Africa, human rights abuses, inflation and disrupted supply chains.

GESDA Board Chairman Peter Brabeck-Letmathe emphasized that GESDA has no time to waste to fulfil its mission. GESDA Board Member Mamokgethi Phakeng, Vice-Chancellor of South Africa's University of Cape Town, oversaw a new Youth and Anticipation Initiative as a partnership between UCT and GESDA to engage young people.

During a high-level panel on the topic of "The New Geopolitical Landscape for Science", GESDA announced a new collaboration with the Geneva Centre for Security Policy (GCSP) and Columbia University that links emerging science to future challenges of war and international security.

The 2022 GESDA Science Breakthrough Radar®
Presented during the Opening High-Level Plenary, GESDA's flagship product involved 774 scientists from 73 countries, a 43% increase in the number of scientists from last year's inaugural edition. The number of emerging topics identified also rose to 37, up from 24 previously. A fifth area of emerging sciences – knowledge foundations – was added to the four main areas in which the scientists anticipate developments: the quantum revolution and advanced AI; human augmentation; eco-regeneration and geo-engineering; and science and diplomacy.

GESDA's Academic Forum expanded its network of participating scientists because "we have to keep engaging with the scientific community," said Martin Vetterli, President of the Swiss Federal Institute of Technology Lausanne (EPFL), who oversaw the forum's development of the Radar for two-and-a-half years with Joël Mesot, President of the Swiss Federal Institute of Technology in Zurich (ETHZ). Since the Radar affects everybody, Phakeng said, the new Youth and Anticipation Initiative will "get the voices of young people into the conversation," helping to reduce inequalities. The Radar's new philosophical and geopolitical lenses also include a "very necessary dialogue" involving social scientists, said Geneva Graduate Institute Director Marie-Laure Salles.

The GESDA Pipeline of Solution Ideas
GESDA presented a new tool for accelerating solution ideas to emerge from the Radar and Summit into concrete actions. This year, those are a pair of proposals to create an Open Quantum Institute (OQI) in Geneva and the first Global Science and Diplomacy Curriculum.

The purpose of the OQI – which drew lengthy discussion and was well-received – is to widen global access to quantum computers and develop use cases for quantum computing that could help accelerate the accomplishment of the UN's 17 Sustainable Development Goals (SDGs) for 2030.

The Global Science and Diplomacy Curriculum is meant to help train current and future science and diplomacy leaders to effectively tackle emerging global challenges through anticipatory science and diplomacy. It is being developed with a large number of partners.

The GESDA Youth Cohort
This year's summit gained fresh perspective from 12 young people whose participation was based on the nominations and support of GESDA partner institutions, including South Africa's University of Cape Town, Swissnex, Swiss Young Academy of Scientists, Villars Institute and XPRIZE Foundation. Among them were three participants chosen from the Youth and Anticipation Initiative led by Phakeng. Throughout the summit, the youths were invited to share their thoughts about what they heard, learned and reflected on during the sessions, and to share their views on the future of science and diplomacy and on GESDA's efforts and vision.

During a panel discussion, several of the young and aspiring leaders, who are just setting out on their chosen educational and career paths, emphasized the need to sustain hard work and hope in the service of science anticipation. "We are constantly reminded that there is a lot that we are struggling to cope with as a society, as a world and as a species. There are a lot of challenges that we have to overcome," said Jordan Naddaf, an American

student at SOAS University of London. "I think that GESDA has left me very hopeful."

In a keynote message, Phakeng congratulated all of the youths for "making it to GESDA" because it meant they are all working hard and doing things that are important for everyone to hear about. "You will inherit the world," she told them. "And so, it is important that you become part of the conversation and you, as young people, become part of leading the action into a better future."

High-Level Political Segment
A new political element was introduced with an inaugural panel that included Swiss President Ignazio Cassis and ministers from Estonia, Mexico, Morocco, Singapore and the United Arab Emirates. It was moderated by Alexandre Fasel, Switzerland's first Special Representative for Science Diplomacy. Cassis said a Western assumption that the world is "automatically increasing towards democracy" no longer seems to be the case, with the rise of authoritarians and wars in Asia, the Middle East and now Europe telling a different story. He emphasized the need for citizens living in democracies to be willing and able to include all viewpoints in public debates, not just those from like-minded people, and "this is a topic where science, science diplomacy can help us to do the right thing."

Cassis also said his dream is for GESDA to become "a powerful tool in enabling a diverse world, through science, to make some steps together in a peaceful way," and for science diplomacy to become the theme of the 21st century among Geneva's hub of international organizations and multilateralism, much like human rights in the 20th century and international humanitarian law in the 19th century.

Launch of the Impact Forum and Fund
With financing for international impact continuing to be a challenge, GESDA confirmed its ambition to launch an Impact Forum and related Impact Fund led by GESDA Board Vice-Chairman Patrick Aebischer, who is President-emeritus of EPFL. Their purpose is to provide the resources necessary to implement the most promising solutions and initiatives using emerging science for the benefit of humanity. They take aim at the same global inequalities and nationalism that hampered recovery from the COVID-19 pandemic.

In a keynote message, Aebischer noted that we're living through an incredible time of scientific disruption at a pace never seen before – and a new Impact Forum and Fund can help us respond better, break down inequalities and bring the scientific community to the table of multilateralism. "Everybody needs to be around the table, and that's what we've decided to do at GESDA," he said. "We're going to rely on innovating new financing, which is going to be public-private by definition."

OUTREACH ACTIVITIES

In the Media Sphere

With the summit marking the end of the GESDA Foundation's three-year start-up phase, there was considerable interest in the media in the start of its new 10-year scale-up with the authorization and backing of Swiss and Geneva authorities. Media coverage reflected that distinction, drawing extensive coverage in the Swiss news media that was equal to if not greater than last year's widespread public interest.

Storylines focused on the addition of a new important institution in Geneva's international ecosystem. International media outlets reported on the biggest news to come out of the summit: the Open Quantum Institute (OQI) proposal for Geneva, Cassis' statements and those of other ministers. Climate change, global health solutions and select interviews also figured prominently, along with articles about the dangers of digital transformation and big data.

A review of the headlines found 163 articles written about the summit in print and online media, radio and TV, as well as on social media, between September 26 and October 31, 2022, reaching an estimated 366 million people.

Social Networks

GESDA made a strong impact on social media, where its following grew by 53% during the past year as of 1 November 2022. Virtually all of the summit sessions were live tweeted and made available as convenient threads with key quotes on Twitter Moments.

Videos explaining complex topics, interviews with people during the summit and session recordings were published on YouTube. Daily wrap-ups were posted on LinkedIn. The hashtag #GESDAsummit was tweeted almost 600 times with a potential reach of more than 4.25 million users. The hashtag #ScienceDiplomacy was tweeted 720 times, with a potential reach of more than 4.78 million users.

Summit as a Magnet

GESDA's Summit relevance as a magnet platform was demonstrated by the number of organizations that held events in Geneva that coincided with the summit. Among them was XPRIZE Foundation, which has its European headquarters beside GESDA in Geneva. It held its ESG Leadership Summit for global innovators. The FIRST Global Challenge, an Olympics-style, international robotics competition at Palexpo Geneva, attracted teams from more than 180 countries competing in STEM activities.

The Foreign Ministries Science & Technology Advice Network (FMSTAN), a global web of science advisers, organized their annual gathering in Geneva in parallel with the GESDA Summit. The Swiss Polar Institute held a side-event to present Swiss scientific activities in polar and alpine research. Finally, the Square Kilometre Array Observatory (SKAO) held its advisory board meeting alongside the GESDA Summit.

KEY TAKEAWAYS

Closing the summit, Chairman of GESDA Peter Brabeck-Letmathe summed up the key takeaways. The first day was dedicated to presenting GESDA's main product, the GESDA Science Breakthrough Radar®, which summarizes the work of scientists around the world and provides insight into the most important trends over the next quarter-century. The second day presented solutions that GESDA's task forces and forums are working on, notably the OQI and Global S&D curriculum. The third day featured a political assessment and the voices of young people.

Need for Honest Brokering

Brabeck-Letmathe said: "It is extremely important for GESDA, in the first two parts of its work, to be as independent, neutral, transparent and honest as we can, because that's the only way we create respect from the science community and the diplomatic community. But GESDA cannot be a substitute for political decision-making. So when it comes to the third phase, which is a phase of implementation, that's the moment when we need that the political sphere comes into this phase."

Depth in Participation

The biggest difference Brabeck-Letmathe said he saw between the first and second GESDA Summits was how much participation deepened in just one year. "We were overwhelmed with the amount of people who want to participate," he said. "Three years ago, the founders of our organization, the Swiss government and authorities of the city of Geneva, trusted us with one mission. That was to develop an instrument of anticipation and action in the service of humanity, to widen the circle of beneficiaries of advances in science and technology. And – on the other hand – that's also very important, especially for Geneva – to strengthen Geneva as a leading hub for multilateralism. This mission we have transformed in three years into a recognized institution, well-suited to achieve its objectives and its purpose."
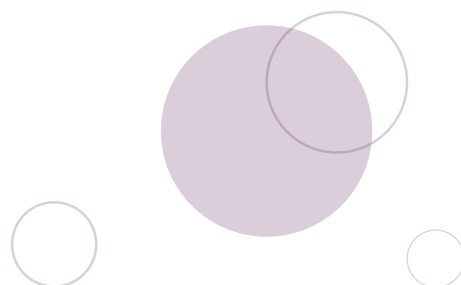
Numbers and figures

Programme

Total number of sessions: 21 (over 4 half-days, spread over 3 days):

Opening High-Level Session: 1

Science Anticipation Sessions: 10

Solutions Pipeline and Initiative Sessions: 4

Solution Idea Sessions: 2

Public Session: 1

Youth Session: 1

High-Level Ministerial Political Assessment Session:1

Closing Session: 1

Speakers' Community Overview

- Diplomatic: 27%
- Citizen (including Youth): 37%
- Academic: 23%
- Impact: 18%
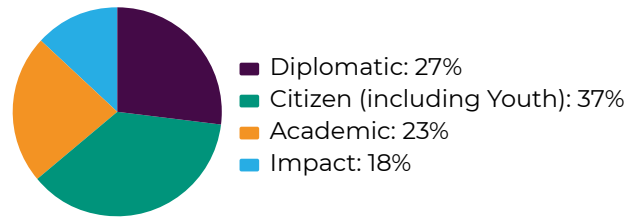
Geographical Origin of Speakers

- Africa: 11%
- North America: 11%
- Latin America: 5%
- Asia & Middle East: 13%
- Europe: 57%
- Oceania: 3%
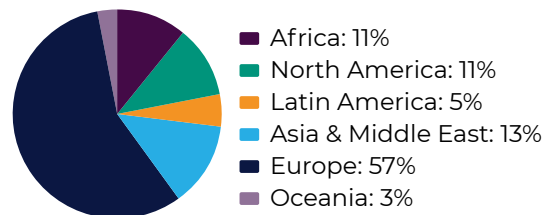
Invited speakers

Number: 152 (Male: 84, or 55%/Female: 68, or 45%) Including a Youth Cohort of 12 (Male: 3/Female: 9)

Onsite: 133

Online: 19

Speakers and moderators came from 46 countries from the 5 continents (see map below)

Participation

Participants including speakers and media, staff excluded: 1267

- On-site registrations: 685 (no show rate – 18%)
- Online registrations: 582
- Media registrations: 52
- Invitee conversion rate: 42,7%

Distribution of Participants among GESDA's Four Communities

- Academic – 32%
- Diplomatic– 30%
- Impact – 21%
- Citizen – 17%
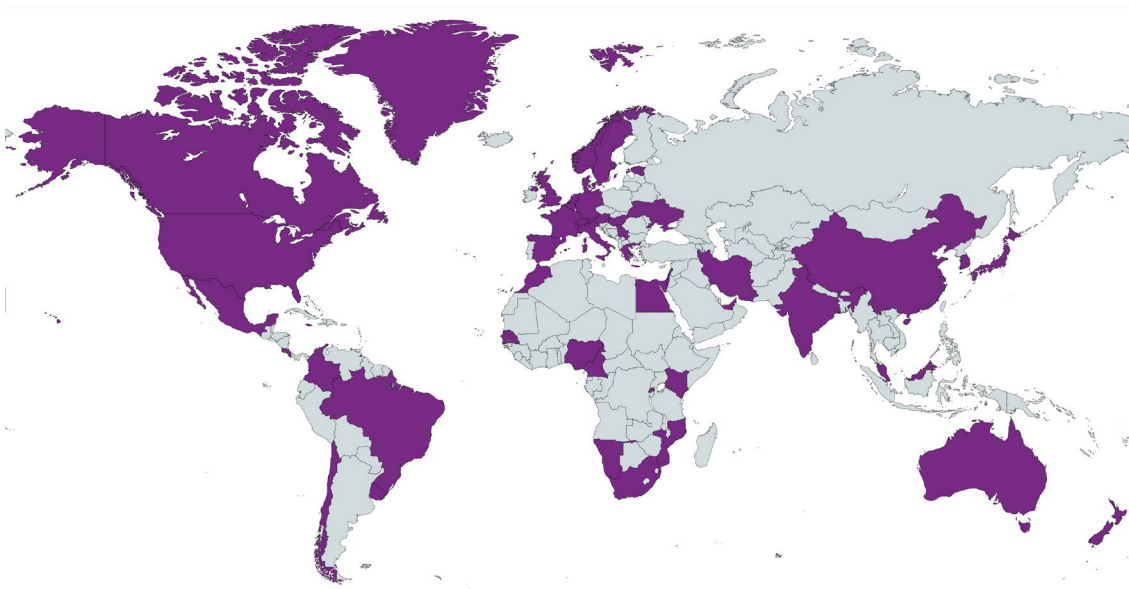
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UN Habitat

Sarah Al-Amiri
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United Arab Emirates

Alberto Anfossi
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Anousheh Ansari
Chief Executive Officer
XPRIZE Foundation

Azeem Azhar
Founder
Exponential View

Vivian Balakrishnan
Minister for Foreign Affairs
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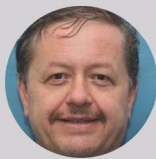
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Swiss Federal Office of Justice

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Climate Economist
Columbia Business School

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Alexandra Xanthaki

UN Special Rapporteur in the field of Cultural Rights
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President
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Director, Smart City Projects Office, Smart Nation and Digital Government Office
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Press conference and press review

Press conference

Geopolitical unrest and growing international support for GESDA's leading initiatives, particularly its proposal to create an Open Quantum Institute (OQI) in Geneva, were the main focus of questions at a press conference that, for the second year in a row, preceded the opening of the annual summit. After GESDA's three-year start-up phase, reporters also wanted to know how the Swiss foundation would evolve as it begins its next 10 years with the authorization and backing of Swiss authorities. Some questions examined a new feature of the summit this year – its inclusion of a high-level political panel with foreign ministers to solicit their assessment and support.

"Would you say that this second summit marks the real start for GESDA?" asked Laurent Sierro, a Geneva-based international journalist and editor for the Swiss News Agency Keystone-ATS. "You talked a lot about science and diplomacy. What about the appetite of other foreign governments? Is there trust or distrust towards GESDA? And then, lastly, when you look at what's at stake for the Ukrainian war now, and you launched today that forum, could GESDA as an honest broker also in the future play a role to gather, for instance, scientists from Ukraine and Russia in order to find solutions, whereas Track One (Diplomacy) and the political leaders cannot find solutions?"

GESDA's Board Chairman Peter Brabeck-Letmathe said the first summit in 2021 was "a proof to our founders that we were able in two years of work to bring forward a Summit and Radar, which was a base for their willingness to prolong the life of GESDA" – and the second summit marks the start of the "long-term GESDA". But the power of science and GESDA cannot help the world bridge a conflict like Russia's war in Ukraine, he noted. "This can only happen if there is a political will to use science. And I haven't seen this political will. I have seen just the contrary," he said. "I think it is a big, big mistake by politicians to use science, art and even economy as a political weapon. Because you are destroying bridges and, afterwards, it will take a long, long time to build them back. So as long as there's no political will, GESDA cannot be very helpful in this conflict."

When it comes to integrating a high-level political component into the summit, he said, GESDA's aim is not to become a political decision-maker but rather simply to engage political leaders in talking about solutions. "We will not be able to make any solution if we don't have the backing from political decision-makers," said Brabeck-Letmathe. "So, if the President of the Confederation invites this year for the first-time political actors, ministers, it is because he wants to present to those political decision-makers what GESDA is doing, and to see whether the political decision-makers have an interest or they feel we are on the right thing or we are not on the right thing,

or whether they will be in the future a supporter for solutions that we might be bringing forward."

GESDA Board Member Michael Hengartner, who has been an adviser on the Science Breakthrough Radar, said the 2021 edition identified expected developments in 18 topics, but this year's version "significantly enlarged" both the number of scientists involved and number of topics, now at 28. It also expanded the four main areas of interest – quantum revolution and advanced AI; human augmentation; eco-regeneration and geo-engineering; and science and diplomacy – to include a fifth, knowledge foundations. "In a similar vein, we have included two analyses for our 2022 Radar that look at technological developments, which, on the one hand, are philosophical and, on the other hand, introduce a political lens," he said. "Finally, we introduced a new section that tries to map roughly both current discussion and social action within society with regard to these topics."

The press conference also included GESDA Board Member Michael Møller, former Director-General of the UN Office at Geneva; Jean-Marie Guéhenno, inaugural Kent Visiting Professor in Conflict Resolution at Columbia University and former UN Peacekeeping Chief; and Tobias Vestner, who leads the Research and Policy Advice Department and Security and Law Programme at the Geneva Centre for Security Policy (GCSP).

Next year's Radar will include a geopolitical view produced through a strategic collaboration between Guéhenno, GCSP and GESDA. Guéhenno said it will "precisely address" areas that are not systematically connected between diplomats and scientists, while Vestner said it will "open up new doors, new insights, and also, obviously at this stage, force us to have the courage to look into 25 years" of the future. "We are cresting a wave in a sense with this initiative, and hopefully we'll come up with something really useful," said Møller, adding that it will sponsor two workshops next year in Geneva and New York.

GESDA's Marketing and Communications Director Jean-Marc Crevoisier moderated the press conference, where more details about OQI, including which scientists and institutions might eventually become involved with it, were requested by Stéphane Bussard, a journalist with the Swiss daily newspaper Le Temps, where he is in charge of the Geneva International section. "What are your short-term, middle-term goals?" he asked. "The second question is, how do you measure actually the appeal that GESDA has on the international scientific scene?"

GESDA Board Member Fabiola Gianotti, Director-General of the European Organization for Nuclear Research (CERN), noted that OQI already has drawn "huge interest" and potential partnerships from

more than 30 academic, diplomatic and business institutions. GESDA's main partner is the XPRIZE Foundation for a quantum competition to solicit proposals. "The idea is to launch an incubator just to prototype. A kind of prototype. So, you know, in particular a physicist likes to proceed by prototypes. First try, and then you see, and then you go on step by step," she said. "The prototypes will also have the goal and objectives of refining the goals of the institute, but also looking at the funding mechanism, the governance mechanism. And then on the time scale, we hope around 2025 to be able to launch the institute itself."

There's excitement around OQI, observed GESDA Board Vice-Chairman Patrick Aebischer. "Every big institution that relates to high performance computing has asked to be part of it," he said. "There have been now more than 12 or 14 countries that have spontaneously expressed interest." But he explained that OQI is "not there to develop the super quantum computing. We're there to try to learn how to use it – for the use case, for the good of mankind. And I think that's really a part of the DNA of what we are."

Brabeck-Letmathe said GESDA has drawn the interest of thousands of scientists, including 774 who participated in this year's Science Breakthrough Radar, up from 543 one year ago. "For me, the sign of whether we can keep up the interest of the scientists will be how many of them are continuing to work with us and whether this reflects also, geographically, the world and not only coming from one part of the world. If you look at the Radar, you will see that we are really spread all over the world, and we have participation from all over the world."

Philippe Mottaz, Founder of the Geneva Observer and former Washington Bureau Chief for Swiss broadcaster RTS, pressed Aebischer on the broader appeal of GESDA's DNA – the "international cooperation or rules-based multilateralism, multistakeholder models, which are exactly the models that China, for instance, is actively dismantling in various member organizations in town."

"Now we live in a techno-polar world. Science and tech are at the very heart of the great powers' rivalry. How do you expect China and the US, for instance, to share the values and wishes – indeed of GESDA to work for the betterment of mankind – when there is fierce rivalry into those countries?" Mottaz asked. "I do not doubt the interest in the scientific community, but it is slightly different than the national interest that we see today being played out on the scene."

Aebischer said that what's been missing in multilateralism is having scientists at the table and, in Geneva, international organizations can help set rules and resolve questions such as those

surrounding intellectual property rights. "A lot of those countries still obey some of those rules," he said. Gianotti noted that China and the US both continue to participate in Geneva-based CERN using its "rules of the game" for open science and open education. "Institutions like CERN or GESDA or the Open Quantum Institute cannot solve directly geopolitical conflicts, as Peter mentioned, but they can show the way," she said. "They can show a different way for humanity to work together."

Impact investor Mariana Bozesan asked Gianotti whether technology needs to be sustainable to help fulfil the United Nations' 17 Sustainable Development Goals for 2030. "The main thing," Gianotti replied, "is to make sure that the new technologies are developed in a more sustainable way in terms of sharing. And this means being able to share them for free, free of charge with people who do not have the possibility otherwise to access them. Education, open education and training free of charge for everyone is absolutely essential. So, we need to bring more and more scientists, more and more people from the developing countries ... I hope that will be done more and more in particular with this Open Quantum Institute. But it's very important – it looks like a little drop in a big ocean but, you know, the ocean is made of many drops."

Valérie Wacker, Radio SRF's West Switzerland correspondent, asked if GESDA is working with industry titans like Google, Apple, Microsoft or Meta. Aebischer pointed out that Matthias Troyer, a Technical Fellow and Corporate Vice-President at Microsoft, is one of the two co-chairs of GESDA's

Quantum Task Force along with XPRIZE Foundation Chief Executive Officer Anousheh Ansari. "Technology now is not only in universities and so on, it's also in big corporations, certainly in the AI and quantum," said Aebischer. "So, we need to work together on it."

GESDA Board Member Mamokgethi Phakeng, Vice-Chancellor of South Africa's University of Cape Town (UCT), emphasized the importance of getting young people involved. She is leading the GESDA-UCT Youth Anticipation Initiative to involve African youth in the use of the Science Breakthrough Radar. "If we want anything to be successful in this world," she said, "you've got to get young people on board and you've got to hear what they're saying."

Sarah Sermondadaz, a science journalist and Deputy Editor-in-Chief of Geneva's Heidi News, asked whether OQI could serve as a stand-in for Switzerland and the European Union to work together on some scientific research projects. Switzerland, which is not a member of the EU, has been blocked from fully participating in the EU's €95.5 billion Horizon Europe research and innovation funding programme from 2021 to 2027. "So, my question is: do you feel that the Quantum Institute will bridge part of that gap and allow all the key players to work on these matters together?" she asked. Aebischer said Switzerland has its own funding system to do quantum research. Gianotti said it might serve as a "tool" for Swiss-EU cooperation but, in principle, it is "above" politics and should be "a platform where people can access the technologies regardless of their background or the political situation of their countries."

GESDA Board Members: Michael Möller, Fabiola Gianotti, Peter Brabeck-Letmathe, Mamokgethi Phakeng, Patrick Aebischer

Press Review

The second Geneva Science and Diplomacy Anticipation Summit and GESDA Science Breakthrough Radar® in October 2022 marked the end of the 2019-2022 pilot phase of the Geneva Science and Diplomacy Anticipator Foundation.

The GESDA Foundation's new 10-year scale-up elicited strong media curiosity about what it will mean for one of Geneva's newest institutions with a global outlook.

Swiss and Geneva authorities gave GESDA, a public-private foundation launched by the Swiss and Geneva authorities in 2019, a new 10-year lease on life with authorization and financial backing in March 2022. Board Chairman Peter Brabeck-Letmathe called it the start of "long-term GESDA".

Media coverage of the second annual Geneva Science and Diplomacy Anticipation Summit reflected that distinction. GESDA drew extensive coverage in the Swiss news media that was equal to if not greater than last year's widespread public interest.

Two press releases (opening and closing) and four backgrounders during the summit were released (GESDA in a nutshell; Open Quantum Institute; Global Science and Diplomacy Curriculum; and The 2022 Science Breakthrough Radar®). Articles on climate change, the search for futuristic health solutions or topics directly related to GESDA and its members were also published.
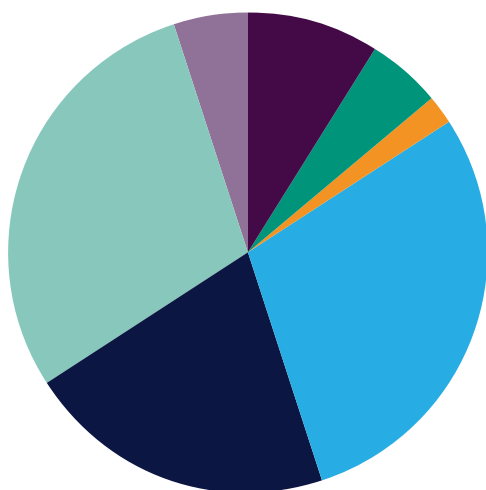
Much of the focus reflected the addition of a important new institution in Geneva's international ecosystem. That storyline garnered more limited coverage among international media outlets than in the previous year, in part because the top headline coming out of GESDA in 2022 had a more solutions-oriented feel to it than last year.

This year, the biggest news was GESDA's proposal to create an Open Quantum Institute (OQI) in Geneva and Swiss President Ignazio Cassis' statements. By comparison, the dominant 2021 headline was Cassis' pronouncement as foreign minister that GESDA was needed to try to prevent another Cold War from being fought over new uses for science and technology.

A review of the headlines by Adwired of Zurich, the agency mandated to accomplish the press screening, found 163 articles written about the summit in print and online media, radio and TV, as well as on social media, between 26 September and 31 October 2022, reaching an estimated 366 million people – or about 5% of the world's population.

The largest proportion of articles focused on the OQI proposal, which could make Geneva a global hub for research into quantum computing starting in 2025. The next biggest coverage was generated by Cassis' speeches and comments during the opening and closing high-level sessions.

The dangers of digital transformation and big data also loomed large on the news agenda

Several interviews featured some of GESDA's prominent members, such as Board Chairman Peter Brabeck-Letmathe; Board Member and University of Cape Town Vice-Chancellor Mamokgheti Phakeng; and a new GESDA collaborator, Jean-Marie Guéhenno, inaugural Kent Visiting Professor in Conflict Resolution at Columbia University and former UN peacekeeping chief.

Swiss News Agency Keystone-ATS, the Swiss Broadcasting Corporation's SWI swissinfo.ch and Swiss daily newspaper *Le Temps* in Geneva showed the most interest in the second GESDA Summit, with original content published for most subject areas.

Among the media highlights were the following:

- **Keystone-SDA:** "Genf könnte in einigen Jahren ein Quanten-Institut erhalten" – the article was picked up by 12 other publications, including Blick, Die Südostschweiz and MSN.

- **Keystone-ATS:** "Le GESDA veut un institut sur le quantique à Genève d'ici 3 à 5 ans" – This article was picked up by seven other sources and garnered almost 6 million views in terms of reach.

Topics

- Climate Change: 9%
- Digital Geneva: 5%
- Futuristic Health Solutions: 2%
- Geneva: Global Centre for Quantum Technology: 29%
- GESDA Summit: 21%
- Ignazio Cassis statements: 29%
- Interviews: 5%

- **Keystone-ATS:** "Le GESDA permet d'oeuvrer pour le bien commun selon Cassis" – This article also appeared in seven other Swiss sources.

Most articles written by swissinfo.ch were picked up in other languages, e.g. "Die Schweiz sollte das 'digitale Genf' stärken" was covered in four other languages.

Russian media covered Cassis' statements calling for Russian scientists not to be ostracized due to the Kremlin's invasion of Ukraine. Unlike last year, Cassis' statements gained interest mainly in Europe instead of the United States, which focused last year on threats to science and technology.

The perpetually understaffed ranks of international journalists at the Palais des Nations in Geneva were thinned out by a transport strike in the city and the demands of Ukraine's war coverage.

Media fatigue from other events in Geneva also appeared to detract from international coverage of the GESDA Summit. Although it deals with different subjects, the Building Bridges summit – which advances sustainable finance in Switzerland and around the globe – was held just one week earlier.

Last year, the two summits were separated by almost two months. The Director-General of UN Geneva Tatiana Valovaya, who spoke at GESDA's 2021 summit, participated in Building Bridges this year. In addition, the Forum des 100, a platform for French-speaking Swiss personalities sponsored by *Le Temps* in Geneva, occurred only a day before the GESDA Summit began.

The Swiss Media Database, which measured coverage of both events, found 50 mentions of Building Bridges and 29 of GESDA during the 2021 summits. It cited 64 mentions of Building Bridges and 47 of GESDA – 37 in French, 10 in German – during the 2022 summits. The gap narrowed, despite Building Bridges' summit lasting a day longer than GESDA's. GESDA is also more present in the media of German-speaking Switzerland.

Reports by top-tier media led the media coverage of GESDA's summit, however, according to Adwired of Zurich. The articles were mainly written in a positive tone, with some neutral coverage, it noted. An article in Keystone-ATS led with Cassis' calls not to ostracize Russian scientists. Pakistan's UrduPoint headlined Cassis' message that no conflict could stop the development of science and should not do so now. Significant media coverage of the 2022 Summit was dedicated to climate change and futuristic health solutions.

Another Keystone-ATS report said that data control can be "a 21st-century weapon of mass destruction," quoting Guéhenno; still another of Keystone-ATS' reports noted that OQI was one of "eight concrete solutions GESDA unveiled this year based on the 2021 analysis of GESDA's Radar."

Swiss daily newspaper *Neue Zürcher Zeitung* said GESDA "aims to benefit from the ecosystem of international Geneva" and its summit "aims to promote multilateral action – also against the backdrop of geopolitical challenges – while giving a voice to 'young leaders.'"
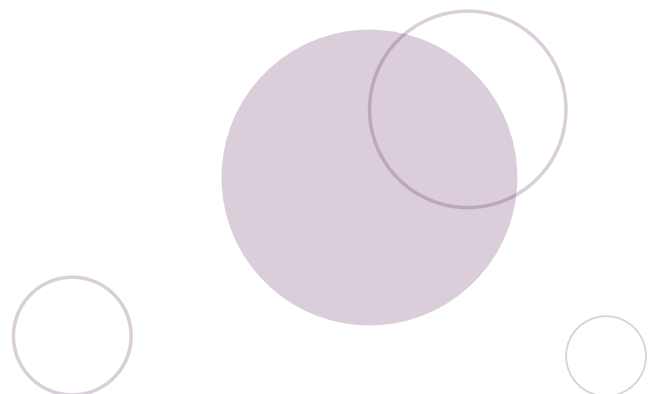
Social media

GESDA made a strong impact on social media in the run-up to and during its summit on 12-14 October 2022. As of 1 November 2022, GESDA had 8,242

followers and subscribers a 53% growth year-on-year.

Year-on-year growth

4,277   19% more followers on Twitter

3,508   122% more followers on LinkedIn

306   84% more followers on Facebook

151   185% more subscribers on YouTube

The GESDA Summit made a strong impact on Twitter. The hashtag #GESDAsummit was tweeted 596 times with a potential reach of more than 4.25 million users. The hashtag #ScienceDiplomacy was tweeted 720 times with a potential reach of more than 4.78 million users.
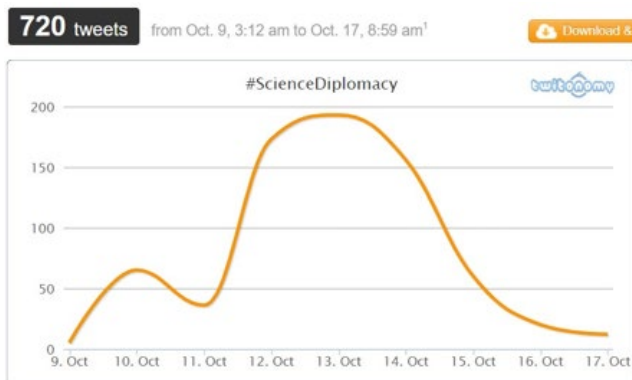
Tweets mentioning the #ScienceDiplomacy from 9 to 17 October 2022
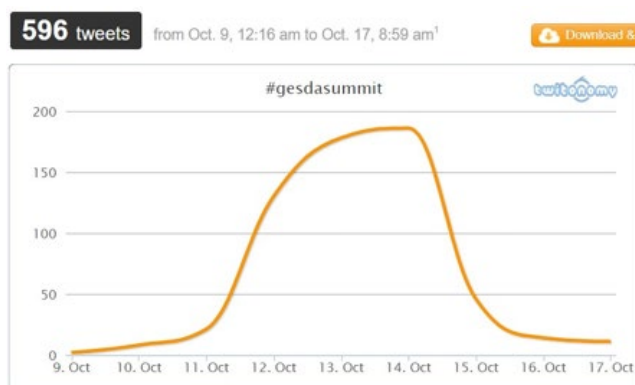
Tweets mentioning the #GESDAsummit from 9 to 17 October 2022

More information

Press conference recording on YouTube

Twitter Moments related to the summit

Wednesday 12 October, 13.00–14:30 CET

Opening High-Level Plenary

Peter Brabeck-Letmathe

**Chairman,
GESDA Board of Directors,
Austria**

Welcome Address

Mesdames et messieurs; ladies and gentlemen; dear representatives of GESDA founders; Ambassador Alexandre Fasel, Swiss Special Representative for Science Diplomacy, who is representing today the Swiss President and Minister of Foreign Affairs, Mr Ignazio Cassis; Swiss State Secretary for Education, Research and Innovation Martina Hirayama; State Councillor of the Republic and Canton of Geneva, Nathalie Fontanet; Mayor of the City of Geneva, Marie Barbey-Chappuis; dear representatives of the United Nations, Mr Amandeep Singh Gill, the Secretary-General's Envoy for Technology; Dear President de La Fondation pour Genève, Monsieur Marc Pictet; representatives of the academic and diplomatic world, and all GESDA guests who are here in Geneva and online throughout the world.

I also would like to give a special welcome to our board members, to the chairs of the different Forums and to our team.

On behalf of the Geneva Science and Diplomacy Anticipator (GESDA), I am pleased to welcome you all to the opening of the second Geneva Science and Diplomacy Anticipation Summit. Three years ago, the founders of our organization, which are the Swiss government and authorities of the city of Geneva, trusted us with one mission. And that was to develop an instrument of anticipation and action in the service of humanity, to widen the circle of beneficiaries of advances in science and technology. And on the other hand – that's also very important, especially for Geneva – to strengthen Geneva as a leading hub for multilateralism. In just three years, we have transformed this mission into a recognized institution, well-suited to achieve its objectives and its purpose.

But we also realize that we have no time to waste if we want to deliver the objectives which have been laid out in front of us. Geopolitical conflicts abound around the world. At the same time, millions of people in the Horn of Africa are on the edge of famine; food and fertilizers are in critical supply; energy is not sufficient; and prices are soaring. The planet is overheating and the most vulnerable suffer the most. Many people think that progress towards the UN Sustainable Development Goals is in serious doubt now. The international community, at the same time, seems to be gridlocked by all these global crises.

So, one of the questions we have to ask ourselves is: "How can advances in science and technology help? What can science diplomacy do? How can we best serve the world?"

As the UN Secretary-General António Guterres said, "These crises threaten the very future of humanity and the fate of our planet." But, he also pointed out that no major global challenge can be solved by a coalition of the willing alone. We , a coalition of the world. So, let's get to work together.

What have we at GESDA done in the last three years? We acted as an honest broker in full transparency. First, our Academic forum had to access, had to scout and discover what is going on in the laboratories of this world. Second, our Diplomacy forum had to better understand all the political and social implications of those breakthroughs. And, in accordance with our mission, we have established several complementary instruments.

For carrying out this work, we have started with an anticipatory instrument, which is the GESDA Science Breakthrough Radar. It offers an open-source overview of scientific disruptions in the making over the next quarter-century.

Along with this, we have established an instrument for action; and this is the Geneva Science and Diplomacy Anticipation Summit, which brings together this year more than 1,000 participants and speakers from more than 46 countries. Thank you all for your huge interest in participating in this second, 2022 edition and being with us today, whether it's physically here or whether it is online. At this summit, we will have a preliminary assessment by political authorities, which will happen on Friday morning [14 October 2022]. And this is exactly why GESDA was created – for multilateral science diplomacy.

New this year, we have GESDA's Pipeline of Solution Ideas, which is also a new product that we are presenting. And, if they are today's ideas, we hope that, after the summit, they will become our working orientation – what we are going to do and work for – the first prototypes of possible actions to accelerate the use of emerging trends, such as quantum computing for sustainable development, new technology for decarbonization or the subject of science and diplomacy.

We already have four big ideas for solutions in the works and, thanks to the work that began with our first GESDA Radar and Summit last year, the first two of them – the creation of an Open Quantum Institute for the co-development of quantum computing applications, and the development of a global science and diplomacy curriculum for the next generation – are well underway.

During these three days, we will examine some of the most promising scientific descriptions presented in this regard. It should make all of us proud to do this work, to help bring forward solutions, initiatives and projects that should benefit everyone. And, as we do this, we also contribute to the UN Sustainable Development Goals.

For a sustainable future, we must maximize benefits and minimize the risks. And, fulfilling the potential we have here in Geneva – drawing on resources we have here in Switzerland – together, we can bring hope, bridge worlds, support multilateralism and find a path out of these dark times to, hopefully, a brighter future. And, ladies and gentlemen, it is your critical input that will be extremely important. It will be channelled into a third GESDA Science Breakthrough Radar for next year, and the third summit in 2023.

So, as we begin the three days of conferences, let me repeat: we have no time to waste. The world is filled with deepening challenges, divides and inequalities. It urgently needs our research; it urgently needs our patience; it urgently needs our care. It needs all of us. And, most of all, it needs our solutions. With this in mind, ladies and gentlemen, welcome to Geneva. Welcome to our second Geneva Science and Diplomacy Anticipation Summit. And, as we have the saying at GESDA, let's all – together – use the future to build a better present.

Thank you very much.

More information

Session recording on YouTube

Twitter Moments related to the summit

Opening High-Level Plenary

Ignazio Cassis

**President of the Swiss Confederation and
Head of the Federal Department of Foreign Affairs,
Switzerland**

Welcome Address

GESDA – Sharing with Everyone the Benefits of Scientific and Technological Advancement

Mister President of the GESDA Foundation, Lieber Herr Peter Brabeck-Letmathe;

State Councillor of the Republic and Canton of Geneva, Chère Madame Nathalie Fontanet;

Mayor of the City of Geneva, Chère Madame Marie Barbey-Chappuis;

Director-General of the United Nations Office at Geneva, Chère Madame Tatiana Valovaya;

United Nations Secretary-General's Envoy on Technology, Professor Amandeep Singh Gill;

Dear members of the GESDA Board of Directors,

Your excellencies,

Dear guests,

Ladies and gentlemen,

It is with great pleasure that I welcome you on behalf of my government, the Swiss Federal Council, to the second Geneva Science and Diplomacy Anticipation Summit here at the Campus Biotech in Geneva.

Last year, I was pleased to present to you the Geneva Science and Diplomacy Anticipator – known as GESDA – as a Swiss initiative operating in Geneva for the benefit of all the actors of global governance in Geneva and beyond, thus making the universal ambition of our endeavour very clear. That is, to anticipate scientific advancement and to harness its benefits for them to be shared by everyone around the world. It was in this spirit that I invited you all to embark together on the journey of anticipatory science diplomacy.

Today, I know that we have already covered considerable ground, and I am happy to report that the federal and cantonal authorities, having evaluated the progress made by GESDA in its pilot phase, have decided to extend its lifespan and give it a 10-year perspective, running until September 2032. Moreover, the Federal Council has decided to triple the federal contribution to GESDA – good news.

We have based our decision:

- First, on the quality of GESDA's early products, such as the GESDA Science Breakthrough Radar and last year's summit;

- Second, on the promise of the rich conversations GESDA has conducted with many of you around concrete ideas and initiatives on how scientific breakthroughs and technological evolutions can be best captured for the benefit of humankind, notably the attainment of the Sustainable Development Goals; and finally

- Third, on the early success of GESDA as a public-private partnership, as the founders have intended it to be, engaging with business and philanthropy, diplomacy and policymakers, as well as the many manifestations of civil society.

With the second summit, GESDA is now scaling up its efforts. And I appeal to all the communities here to do the same.

The challenge and the ambition are clear. What we are attempting to do here, and what the United Nations Secretary-General sets out in his report, *Our Common Agenda*, for the international community to do, is very much convergent and geared towards the same objective: How can we invigorate multilateral governance in the light of the urgency and acceleration of the global challenges and against the background of a geopolitical reality that risks driving us apart? Scientific advancement and the benefits that are to be drawn from it are key. Let us together capture, frame and share them, in an inclusive and equitable manner! Starting now.

Thank you.

Opening High-Level Plenary

Amandeep Singh Gill

**Envoy on Technology, United Nations, representing
UN Secretary-General António Guterres,
India**

Welcome Address

Excellencies, ladies and gentlemen,

It's an honour to attend the second GESDA Summit. It's also a pleasure to be back in Geneva and see so many friends and colleagues in the room.

Distinguished participants, this is a time of bewildering change. Geopolitics is back with a vengeance. Rapid developments in science and technology are having a profound impact on our societies and our economies. Policymakers run the risk of being reduced to bystanders. We need to anticipate and to act with wisdom and discrimination.

This is where, within a short period of time, GESDA has built a niche for itself. It has honed its focus through extensive consultations and brought practitioners from academia, diplomacy, finance and civil society together on innovative platforms. GESDA's choice of quantum revolution and advanced AI, eco-regeneration and geo-engineering, human augmentation and science and diplomacy – as its initial areas of focus – reflects an astute assessment of policy dilemmas today.

And the GESDA Science Breakthrough Radar is an impressive tool to help policymakers stay abreast of cutting-edge scientific and technological developments. The solutions that are being presented today will add to this repertoire of tools.

Excellencies, ladies and gentlemen, last month, the United Nations General Assembly decided to hold the Summit of the Future in September 2024. This will be an unprecedented opportunity to reboot multilateralism and renew international resolve to address the challenges we face now and which you, Mr President, outlined so well, now and into the future. The Global Digital Compact – nourished by multistakeholder consultations and proposed for adoption at the summit – will be one of the critical outcomes. I invite all of you and the institutions you represent to visit our website and consider making a contribution to shape this outcome.

There are two other issues that I wish to address today, and these are power and history.

Why should scientists and technologies think about power? Isn't that for politicians and policymakers? Alas, we have known since the dawn of the Atomic Age that we cannot do this in silos. Power has many faces, some less obvious than others. There is power over in a form of domination and guiding others, and there is power, too, to take decisions and solve problems. There is power with – to come together for common purpose and defend group interest. And then there is power within – our identity, our self-esteem and the ability to influence our own lives. Science and technology have a bearing on all of them. Even benign formulations, such as problem owners and solution owners, sometimes heard even in this town, betray these asymmetries of power.

As we pick problems and devise solutions, we need to reflect about power differentials. Who's making the choice, and for whom? Who has fewer choices and is, therefore, more vulnerable to abuse and exploitation? These are critical reflections, not unfamiliar from previous generations of scientific developments, and not boxes to be ticked as we develop powerful technologies and policies around them.

This brings me to my second point: history. It is striking how ahistorical current approaches to science and technology can be – as if the past did not exist, and those who lived earlier were not as smart as we are today. Listen to this quote from a 2018 interview with a computer scientist of a certain notoriety: "The only thing that matters is the future. I don't even know why we study history. It is entertaining, I guess – the dinosaurs, the Neanderthals and the Industrial Revolution, and stuff like that. But what's already happened doesn't really matter. You don't need to know that history to build on what they made. In technology, all that matters is tomorrow."

Really?! There is a line we can draw through Friar Roger Bacon's Brazen Head to C3PO in Star Wars and to IBM Watson. It is part magical thinking and part science. And it's very important to know which is which. History matters and ontology matters. Science is, after all, a human paradigm. It does not sit outside of the space-time continuum.

As we gather in this city, with its great humanist tradition, let us remember the nature of power, the importance of context, and the lessons of the past, even as we use the future to build the present.

I thank you for your kind attention and, on behalf of the UN Secretary-General, I wish you all success at the summit.

Opening High-Level Plenary

Nathalie Fontanet

State Councillor of the Republic and Canton of Geneva, Switzerland

Welcome Message

As the formal greetings have already been given, I would like to greet you all, ladies and gentlemen, briefly in your titles and functions.

I am very happy to be with you today for the second GESDA Annual Summit. This magnificent event is an opportunity for me to recall some of the fundamentals concerning International Geneva. When we look at our canton, we are contemplating nearly 160 years of experience in international cooperation. The first Geneva Convention dates back to 1864. The ecosystem that has, since then, been developed on our territory with more than 600 stakeholders is truly unique and contains an immense potential for synergies.

However, we will also have noticed that multilateralism is currently in bad shape. The impetus that emerged after the two World Wars is no longer the same. Today, the world is more fragmented. The tendency is to turn inward. Moreover, the role of the international institutions created after 1945 is being questioned. Their effectiveness, too. The existing institutions must adapt or even reinvent themselves. The paradox is that, in an increasingly independent world, International Geneva is more necessary than ever. Migration, climate, trade, pandemics, the internet, taxation and equality are issues that cannot be dealt with by one country alone, however powerful it may be. International cooperation is not an option; it is part of the solution.

Adapting and strengthening global governance is a complex task. In the current context, we need safe space – space for dialogue and cooperation – and Geneva wishes to continue to play this role. But, we also need to integrate the voice of science into global governance. And the work of the GESDA Foundation is of critical importance. Being a locally elected politician, I know how difficult it is to take into consideration long-term anticipation in every day's political decision-making. We need help to understand the future challenges, their impact and how we can address them. This is what GESDA is about.

This year's summit will not only bring anticipation, but also focus on the development of solutions in evaluating the first prototypes of possible avenues of actions to accelerate the use of some of those emerging trends, such as quantum computing for sustainable development, neural technology, decarbonization and science diplomacy.

GESDA's vocation is to catalyse these solution projects that could be politically endorsed and furthered at the global diplomatic level.

As co-founder, the state of Geneva is particularly proud to support this solution-oriented mission. We use the expertise of the ecosystem. Geneva can be seen as a laboratory for developing and testing solutions to solve global issues.

The State Council, which I represent today, intends to pursue this support to International Geneva as well, willing to strengthen it with the innovative and effective approach brought by GESDA's Foundation in anticipating global issues and finding solutions to the universal challenges that surround us.

Thank you for your attention and I wish you all a very successful summit.
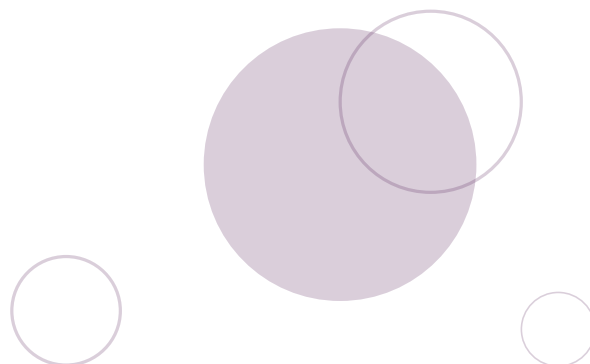
Opening High-Level Plenary

Marc Pictet

**President, Fondation pour Genève,
Switzerland**

Welcome Message

Ladies and gentlemen,

It is a great pleasure to be with you this afternoon for the opening of the second GESDA Summit. As it has been said, we are gathering at a time when geopolitical tensions are severely damaging multilateralism. So, what are the implications for our city? As everyone in this room knows, Geneva has, over the years, established itself as one of the main centres of global governance, with expertise in fields such as peace, security, humanitarian action, health, labour, trade and, of course, environmental protection – just to name a few. The world we live in is changing rapidly. Scientific breakthroughs and technological advances, of course, are occurring at an ever-increasing pace – and these represent a tremendous opportunity to improve the well-being of billions of people around the world.

But they also carry a risk of potential misuse. Take artificial intelligence, AI, for example. On the one hand, it is revolutionizing education – as we all know. On the other hand, however, if misused, AI can tarnish reputations and harm state security through the use of, for instance, deepfake technology. This is where the GESDA Foundation comes in. The foundation aims to anticipate the technological developments over the next five, 10, 25 years and to suggest new solutions to meet those challenges with a unique method, an instrument: the GESDA Science Breakthrough Radar.

The Fondation pour Genève, an entirely private organization, is proud to have supported GESDA since its inception three years ago, alongside the Swiss and Geneva authorities. In my opinion, GESDA is an example of a successful public-private partnership fostering a dynamic and forward-looking International Geneva. I also would like to stress the exceptional work of the more than 500 scientists and diplomats who contributed to this second edition of the GESDA Radar. I also would like to highlight the commitment of the private sector in the Geneva region, which is actively contributing to this ambitious project in many ways.

We strongly believe that the GESDA Science Breakthrough Radar has the potential to transform International Geneva and shape the future of modern multilateralism. By bringing together the different communities – scientists, diplomats, business leaders, civil society, the public and private sectors – GESDA will accelerate the implementation of the SDGs and help to build a more harmonious and secure world. GESDA's anticipatory science, alongside the unique features of Geneva ecosystem, are an ideal combination to build this future.

Since 1976, the Fondation pour Genève has been working alongside the Swiss and Geneva authorities to ensure that Geneva continues to play its part in delivering solutions to global challenges. It is clear that science diplomacy has a unique potential, we are all convinced here in this room, but that the general public is largely unaware. As a result, over the coming weeks, we will be launching a report and a series of public events in Switzerland to explain what science diplomacy is and its potential.

Ladies and gentlemen, international Geneva has to pivot. Our future is uncertain on so many fronts. What I would like to say is that it is crucial that we team up to anticipate and act now. And as the GESDA community puts it so nicely, actually here, use the future to build the present. Thank you.
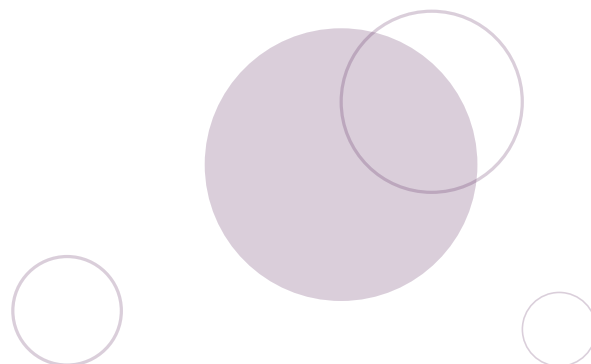
Wednesday 12 October, 13.00–14:30 CET

Opening High-Level Plenary

Presentation of the 2022 GESDA Science Breakthrough Radar®

Participants

Mamokgethi Phakeng, Vice-chancellor, University of Cape Town; Board Member, GESDA, South Africa

Marie-Laure Salles, Director, Geneva Graduate Institute; Member, Science Breakthrough Radar® Advisory Board, GESDA, France

Martin Vetterli, President, EPF Lausanne; Co-chair, Academic Forum, GESDA, Switzerland

Highlights

The second edition of GESDA's flagship product, the GESDA Science Breakthrough Radar®, drew the participation of 774 scientists from 73 countries – a 43% increase in the number of scientists who were involved in the inaugural Radar. The momentum carried through to the number of emerging topics identified – 37 – up from 24 previously. New this year was the addition of a fifth scientific platform, Knowledge Foundations, to the four main areas in which the scientists anticipate major advances: the quantum revolution and advanced AI; human augmentation; eco-regeneration and geo-engineering; and science and diplomacy.

Several new chapters were added to cover not only what citizens are saying (through an analysis of social network feeds, like in 2021), but also what they are doing, the opportunities identified during the 2021 cycle, and links to philosophy and geopolitics. The GESDA Radar not only fuels the summit by providing fodder for panel discussions, but also drives the task forces that oversee work on solution ideas likely to accelerate the implementation of particularly promising innovations. The quantum revolution, for example, was a major topic in the 2021 GESDA Radar and Summit, leading to this year's proposal for an Open Quantum Institute. It also helps the diplomatic community and the general public to better understand these emerging sciences and potential innovations.

GESDA's Academic Forum expanded the network of participating scientists by branching out to thousands of scientists from academic institutions in Switzerland and other nations until it grew into a network of more than 700 people who "truly engaged," said Martin Vetterli, President of the Swiss Federal Institute of Technology Lausanne (EPFL) and Co-Chair of the Academic Forum, who oversaw the development of the Radar for two-and-a-half years with Joël Mesot, President of the Swiss Federal Institute of Technology Zurich (ETHZ). "Many, many people answered and actually worked quite hard to come up with the result we see now," Vetterli said. "It's an evolving product. There is still a lot of work – and we have to keep engaging with the science community."

The GESDA Radar affects everybody, so it also "has to go to the people, so the people on the ground can engage with it," said GESDA Board Member Mamokgethi Phakeng, Vice-Chancellor of the University of Cape Town (UCT), who developed and oversaw a new partnership between GESDA and UCT. The idea behind the joint Youth Anticipator Initiative "is to get the voice of young people into conversation," Phakeng told participants at the summit. "The GESDA Radar is a resource; it's a teaching and learning resource. But there are a lot of people in the world who might not get access to it. And we don't want to commit the same errors that we made in the past by excluding some of the voices."

More than 100 young people participated in the Initiative's challenge by examining the Radar and submitting potential solutions. Three participants were selected to go to the summit and engage in discussions. "This is important," said Phakeng, "because if we do not get the voices of young people into the conversation, we increase the inequality, but also their resentments about science, scientists and how exclusive these discussions are, and who is included and who's not included. My hope is that this kind of work will go on to include other citizens and not just young people."

The GESDA Radar's new philosophical and geopolitical lenses also provide an important step of including a "very necessary dialogue" that includes social scientists so new technologies are used as tools for doing good instead of being turned into weapons, said Geneva Graduate Institute Director Marie-Laure Salles. "It's the notion that the tool is the technology as a way in which to reach the good life," she said, "and the weapon is the way in which technology can derail."

[Find the 2022 GESDA Science Breakthrough Radar here](#)

Wednesday 12 October, 13.00–14:30 CET

Opening High-Level Plenary

The New Geopolitical Landscape for Science

Participants

Moderated by:

Alexandre Fasel, Special Representative for Science Diplomacy, Switzerland

With:

Jean-Marie Guéhenno, Kent Visiting Professor of Conflict Resolution, Columbia University; Former UN Under-Secretary-General for Peacekeeping Operations, France

Amandeep Singh Gill, Envoy on Technology, United Nations, representing UN Secretary-General António Guterres, India

Lydie Hakizimana, Chief Executive Officer, AIMS-The Next Einstein Initiative, Rwanda

Highlights

The scientific and diplomatic work behind the 2022 GESDA Science Breakthrough Radar® — which anticipates the most important advances in science and technology over the next quarter century — does not occur in a vacuum. "We have to face a geopolitical reality," observed Swiss Ambassador Alexandre Fasel, Switzerland's Special Representative for Science Diplomacy, while introducing a panel that he moderated on the complex aspects of GESDA's forward-looking work. "This must of course be an inclusive exercise. Everybody must participate in it."

The COVID-19 pandemic, climate change, food and fuel crises, inflation, and wars and conflicts in Africa, Asia and Europe are contributing to geopolitical conflict and unrest around the world. Anticipatory science diplomacy must somehow navigate those turbulent seas.

"At a time of geopolitical uncertainty, when so many things are shifting, we need to find those deeper anchors in our shared human values, whether it's Ubuntu; it's the concept of harmonia in Greek philosophy; the human flourishing — Tikkun olam in the Judaic culture; fixing the world — héxié shèhuì — in the Chinese culture of social harmony; or in the Indian culture, the need to preserve that centeredness. We need to dig down deeper at this time," said Amandeep Singh Gill, UN Secretary-

General António Guterres' Envoy on Technology. Like Fasel, Gill considers inclusiveness to be the topmost priority in the "constellation of values" that must be considered in service of the United Nations' 17 Sustainable Development Goals for 2030, which will be difficult to achieve because of the pandemic, global conflicts, and economic downturns.

"The slogan really is, 'Leave no one behind.' And this is regardless of the level of development. These are goals that are important for every country, every society on planet Earth," said Gill, citing the need for "better stewardship in terms of the guardrails and the common rules and also in terms of the use of these commons. If only a few people can use them, then they are not commons, they are clubs. So how can we be truly inclusive in these areas?" GESDA's proposed Open Quantum Institute is a step in the right direction, he said.

Connectivity and access to health care are key, as the pandemic showed; vaccine inequity is a serious threat to public health and to the global economy. In the Asia-Pacific region, for example, nations' economic and health recovery hinges on the rapid and equitable deployment of safe and effective COVID-19 vaccines, according to health experts. Some 60% of the region's population has been fully vaccinated, but a wide variation is found among countries. As of March 2022, vaccination coverage in high-income countries was 80% compared to 10% in low-income countries. The same dynamics occurred in other continents. "And if you don't address it now, we'll have a vaccine type of situation here 10 years from now," Gill said. "The inequity in vaccine distribution really made it clear to most countries around the world that you have to look after yourself. So, when geopolitics is back, it means geography is back. Where you are matters."

To Lydie Hakizimana, CEO of the African Institute of Mathematical Sciences (AIMS), "the world today is a complete mess. I hope you all realise that. With the war in Ukraine, the floods everywhere, the hypocrisy in vaccine distribution: the world is a mess. We've forgotten the importance of being human. We've forgotten that we're all the same. If you are not doing well, I cannot do well. We have to work together." One of the main challenges of accomplishing that, however, will be to build a community of scientists around the world that can work with policymakers to translate all their research and development into scalable solutions. "But to provide a solution to the problems, you have to work

with the people who are facing those problems. Right? You have to work with us. You have to include us," she noted.

"And the last part for me is really the funding. Funding is important. Funding is so important for us to advance our science across the globe," said Hakizimana, who lamented that African nations get such paltry percentages of the proceeds from the continent's vast mineral reserves. "This is a joke. This is really a joke. So, what can we do? How can we use the platform of GESDA to make sure that institutions like AIMS and others in Africa can have access to funding to do more on the continent. We need to stop talking and really going into actions." To propel that kind action, Hakizimana suggested, greater efforts must be made to cultivate and sustain students' sense of creativity and curiousity. She recalled astronomer Carl Sagan's saying: "Everybody starts out as a scientist. Every child has the scientist's sense of wonder and awe."

Science is an extraordinary multiplier, accelerator and disruptor, said Jean-Marie Guéhenno, the inaugural Kent visiting professor in conflict resolution at Columbia University and former UN peacekeeping chief, who compared the impact of the internet revolution with Johannes Gutenberg's invention of the movable-type printing press around 1440 and the Industrial Revolution from about 1760 to 1840. "We see that between the rapid advance that it has created and the political institutions, there is a widening gap. And frankly, I often think that if GESDA had been created 25 years ago, maybe we would be in a better situation now because we would have thought about all the governance issues that we are now having to address a bit too late. And it's much more complicated, because we have to deal with giant corporations, we have to deal with massive, entrenched interests. It's much more complicated."

Jean-Marie Guéhenno

Guéhenno emphasised a need to anticipate now coming revolutions in artificial intelligence, biogenetics and other fields of science and technology, including how those revolutions interact. To that end, GESDA announced a new collaboration linking science to future challenges of war and international security with the Geneva Centre for Security Policy (GCSP) and Columbia University. "If we do not reflect on the impact that they are going to have on societies, if we do not try to think through what kind of institutions will be needed to maintain a measure of accountability — if we do not do that, then we are going to have more and more problems as we have now with the internet revolution, with the polarisation of societies, with the fragmentation of societies. So, the time to think through those issues is now. It's not tomorrow. And that's, I think, how we should address it. And that's why I'm very happy with Columbia University to start this collaboration with GESDA and the Geneva Centre for Security Policy."

Alexandre Fasel
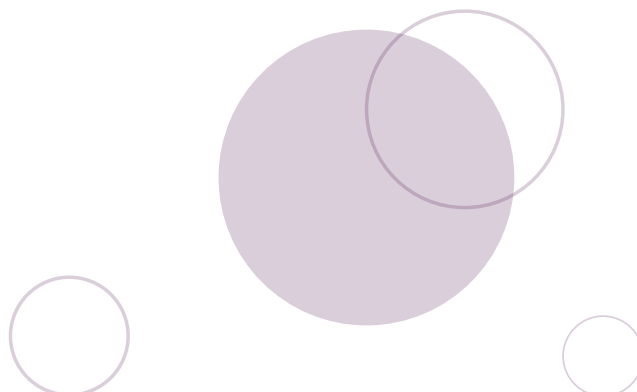
Takeaway Messages

The scientific and diplomatic work behind the 2022 GESDA Science Breakthrough Radar® needs to be put into a geopolitical context to be fully understood.

Anticipatory science diplomacy must be an inclusive exercise that finds the deeper anchors in our shared human values.

The Earth needs better stewardship – more guardrails and common rules to protect the global commons.

The global inequities that have been evident with vaccine distribution during the COVID-19 pandemic are a serious threat to public health and the global economy.

One of the main challenges of being able to work together is building a global community of scientists that can work with policymakers to translate R&D into scalable solutions.

Science is an extraordinary multiplier, accelerator and disruptor, and to avoid more polarization and fragmentation we must reflect on its impact and what kind of institutions are needed for accountability.

Funding is an important consideration in advancing science across the globe.

More information

Explore this topic in the 2022 GESDA Science Breakthrough Radar®

Session recording on YouTube

Twitter Moments related to the summit

Wednesday 12 October, 13.00–14:30 CET

Opening High-Level Plenary

Presentation of the 2022 GESDA Pipeline of Solution Ideas

Participants

Anousheh Ansari, Chief Executive Officer, XPrize Foundation, Iran/USA

Marga Gual Soler, Founder, SciDipGLOBAL; Academic Moderator and Solution Co-chair, GESDA, Spain

Michael Møller, Chair, Diplomacy Forum, GESDA; Former Director-General, UNOG, Denmark

Daria Robinson, Executive Director Solution Accelerator; Deputy of CEO, GESDA, Switzerland

Mathias Troyer, Technical Fellow; Corporate Vice President, Microsoft, Austria

Highlights

The 2022 Geneva Science and Diplomacy Anticipation Summit featured GESDA's Pipeline of Solution Ideas for the first time – a new tool for turning what emerges from the GESDA Science Breakthrough Radar® and Summit into concrete actions. Academic-diplomatic task forces develop the most advanced ideas, which this year are a pair of proposals to create an Open Quantum Institute (OQI) in Geneva and the first Global Science and Diplomacy Curriculum.

"The first task was to create the right environment where we could bring all of us together from science, diplomacy, business and society at large, as we're doing today. In doing so, GESDA's ambition goes beyond mere reflection. Beyond being just a think tank, our ambition is also to be an impactful do tank," said GESDA Board Member

Michael Møller, inaugural Chair of the Diplomacy Forum and former Director-General of the United Nations Office at Geneva.

"We have the ambition to propose concrete solutions emerging from our accumulated knowledge and work on the anticipated science," Møller said. "We start by creating a common understanding of these complex issues and carefully designed ideas with dedicated science and diplomacy task forces, then curate the development with coalitions of partners into sustainable and impactful solutions for the world. This is what we're very pleased to present here to you for the first time."

OQI's purpose is to widen access to quantum computers and develop an open repository of use cases for quantum computing that benefit all of humanity by accelerating implementation of the UN's 17 Sustainable Development Goals (SDGs) for 2030. "I've worked on quantum for 20 years and with GESDA for three years, and based on that, we want to start a conversation around open access to quantum technology," said a co-chair of GESDA's Quantum Task Force, Matthias Troyer, a Technical Fellow and Corporate Vice-President at Microsoft.

"We are at an inflexion point in the industry, a point where hype gives rise to clarity," he said. "Clarity on what we can achieve with quantum; clarity on what is needed to achieve it; and clarity on what can be done if access is open. And one thing is sure. The promise of quantum is real. With quantum, we will be able to solve some of the most important problems that face the planet; and many of them are related to the SDGs. What is also clear is that quantum is a hard technology. And to do that, we will need to the collective genius of the planet. We need all people to combine."

Anousheh Ansari

Mathias Troyer

Marga Gual Soler

Michael Møller

Daria Robinson

To develop and crowdsource the use cases, GESDA is partnering with XPRIZE Foundation, a global leader in designing and hosting public international competitions that are intended to encourage the development of new and beneficial technologies. The other co-chair of GESDA's Quantum Task Force, XPRIZE Foundation Chief Executive Officer Anousheh Ansari, said the hope is to prevent more inequities by ensuring quantum technologies don't benefit only powerful corporations or nations.

"At the heart of the OQI," said Ansari, "is collaboration and bringing the talent of the world together and giving them access to technologies that they may not otherwise have access to, surround them by brilliant minds from scientists from all over the world, and give them the tools needed to use these technologies to do good in the world to solve some of our biggest challenges, the SDG-type challenges that are critical for us to solve."

The first Global Science and Diplomacy Curriculum aims to empower the current and next generation of leaders working on global challenges at the interface of science and diplomacy to ensure they are forward-looking, efficient and successful. The curriculum is being developed in close collaboration with the University of Geneva, Swiss Federal Institute of Technology Zurich (ETHZ), Geneva Graduate Institute, University of Zurich, European Organization for Nuclear Research (CERN), Inter-Parliamentary Union and other key diplomatic partners in Geneva and worldwide.

The key question facing GESDA's task force working on this new curriculum is how to build bridges and foster a common mindset between the science and diplomacy communities, according to its co-chairs Martin Chungong, Secretary-General of the Inter-Parliamentary Union, and Marga Gual Soler, GESDA's new Head of Science Diplomacy Capacity Building.

"I saw a unique opportunity to translate all of these 37 scientific topics that you see in the GESDA Science Breakthrough Radar into a training and pedagogical tool and leverage the ecosystem of international Geneva that already has all of the institutions necessary to achieve this global reach, both diplomatically and scientifically," said Gual Soler. "It really is a framework curriculum with all the ingredients."Science"

More information

Learn more about Solutions

Session recording on YouTube

Twitter Moments related to the summit

Opening High-Level Plenary

Marie Barbey-Chappuis

Mayor, City of Geneva, Switzerland

Closing Keynote Address

Excellencies, ladies and gentlemen,

We are here today in this magnificent Campus Biotech, more than a century after Geneva became a centre of multilateral diplomacy. For three days, this summit will be a place of exchange and reflection on the scientific trends that could be endorsed at the diplomatic level to help solve the global problems that humanity is – or will be – facing.

During these three days, you will be anticipating, you will be reflecting, you will be discussing the future of multilateralism and how science can help this. Geneva, as you know, began this voyage to become this respected centre of diplomacy more than 100 years ago.

Did the pioneers of what we now call International Geneva imagine – did they anticipate – the fact that Geneva would become this unique and dynamic ecosystem in which the future of our world is discussed on a daily basis? Perhaps.

But one thing is certain: International Geneva is a magnificent heritage that we, as host authorities, must keep alive. We must even strengthen the ecosystem so that Geneva remains this essential centre of multilateralism. We must maintain the quality of life and the attractiveness of our city, so that this type of summit can take place and people like yourselves can come together to share ideas.

As Mayor of Geneva, I can assure you that it is a real source of pride to host and support an organization like GESDA. It must be said that, in terms of scientific innovation, Geneva – and I would even say the whole of the so-called Arc lémanique – is fertile soil. In this relatively small garden, we have entities such as CERN, EPFL, companies and international organizations active in research and innovation, which make this ecosystem extremely dynamic. Geneva is the perfect host for an organization such as GESDA.

To all of you, I wish you fruitful exchanges during this summit. I look forward to hearing the highlights of your discussion, and to learning about the scientific innovations that may impact our lives in the next five, 10 or 25 years.

Thank you for your attention, and I wish each and every one of you a brilliant and enjoyable conference.
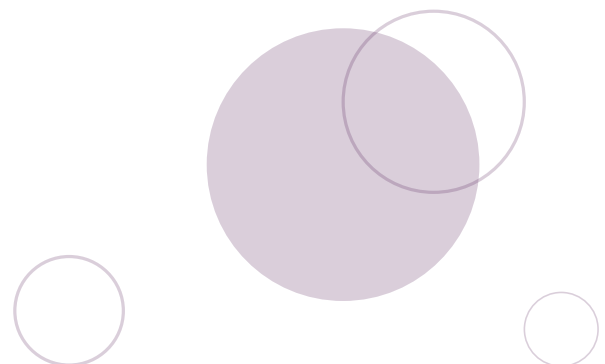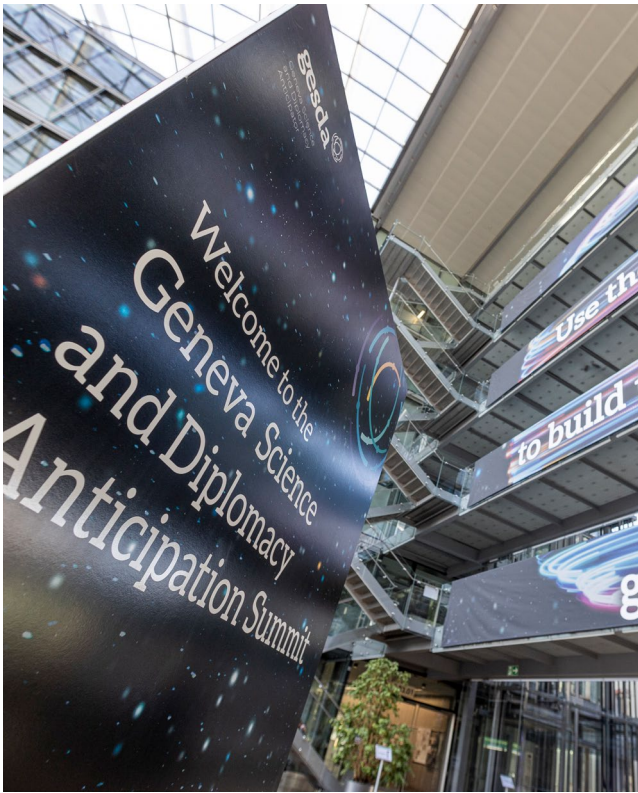
Programme sessions
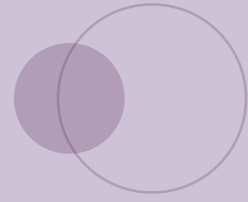
Quantum Revolution and Advanced AI

Human Augmentation

Eco-Regeneration and Geoengineering

Science & Diplomacy

Knowledge Foundations
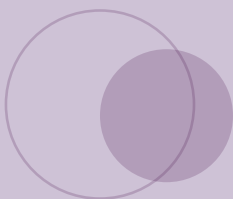
Programme sessions

Scientific Platforms	Scene Setting	What? Science Anticipation	So What? Pipeline of Solution Ideas & Initiatives	Now What?
	12 October	12-13 October	13 October	14 October
Quantum Revolution & Advanced AI		Reshaping Reality in Tomorrow's Society **→ P.55** How can We Prepare for Collaborative Human-Machine Intelligence **→ P.123**	**SOLUTION IDEA PRESENTED AT THE SUMMIT:** Building an Open Quantum Institute & GESDA-XPRIZE Contest **→ P154**	
Human Augmentation		Defining Usage Frameworks for Organoids **→ P.82** Deciphering the Human Immunome with AI for Better Therapeutics **→ P.97**	**SOLUTION IDEA IN THE GESDA PIPELINE:** Navigating the NeuroTech Compass **→ P.134**	
Eco-regeneration & Geoengineering	**Opening Plenary** The New Geopolitical Landscape for Science **→ P.29**	Assessing Solar Radiation Modification **→ P.65** Controlling vector-transmitted Infectious Disease **→ P.71** What is the Future of Polar Research in the Current Geopolitical Landscape? **→ P.77**	**SOLUTION IDEA IN THE GESDA PIPELINE:** Collaborating on a Decarbonisation Accelerator **→ P.141**	**High-Level Political Assessment** The Future of Science Diplomacy **→ P.173**
Science & Diplomacy		Can We Bolster Democracy Through Technologies? **→ P.59** Where are the Limits in the Digitalization of Conflicts? **→ P.102** Enabling Digital Empowerment with Trust and Transparency **→ P.128**	**SOLUTION IDEA PRESENTED AT THE SUMMIT:** Creating a Global Curriculum on Science & Diplomacy **→ P.148** INITIATIVE: Reviving the Human Right to Science **→ P.117**	
Knowledge Foundations		Making the Most of Synthetic Biology's Potential **→ P.88** The Future of Finance for International Impact **→ P.108**		

Science Anticipation

Reshaping Reality in Tomorrow's Society

Abstract

Augmented and extended reality technologies which blend our digital and physical experiences are beginning to transform industry, work, education, and social platforms. With tens of billions of dollars being invested today to lead to a transition in the way people use their smartphones, consume information, and interact with each other, the extended reality ecosystem could be a $1.5 trillion opportunity by 2030. The blurring of boundaries between realities, however, holds enormous implications for how citizens, communities, and leaders comprehend the world around them.

- How will a blended reality existence transform social and economic policies, and how long will it be before these two worlds become indistinguishable?

- What should be done on the multilateral level to prevent undesirable consequences from becoming pervasive and entrenched in our hybrid physical-digital realities?

Join this session to discover the implications of yet another revolution in how people connect, interact, access information, exchange value and experience the world.

Participants

Moderated by:

Azeem Azhar, Founder, Exponential View, United Kingdom

With:

David Chalmers, Author of Reality+; Professor of Philosophy and Neural Science, New York University; Co-director, NYU's Center for Mind, Brain and Consciousness, Australia

Cordel Green, Executive Director, Broadcasting Commission, Jamaica

Sarah Kenderdine, Professor of Digital Museology, EPF Lausanne, Australia

Charlotte Lindsey, Chief Public Policy Officer, CyberPeace Institute, Switzerland

Marc Pollefeys, Professor, Computer Vision and Geometry Lab, ETH Zurich, Belgium

Highlights

As part of GESDA's mission of science anticipation, the prospect of reshaped realities – whether through augmented reality (AR), mixed reality (MR), virtual reality (VR) or the metaverse – looms large in the future. AR and MR are largely synonymous and integrate digital information with a user's real-world environment, while VR creates a totally artificial environment. The metaverse brings experiences to a shared, immersive 3D virtual space. Along with the entertainment value, these digital advances allow us to represent ourselves in different worlds in ways that we couldn't have done previously, introducing new legal, ethical and mental health challenges that might require a retooling of global governance. This begs the ultimate question: Does life in an immersive reality have the same meaning as life in our physical reality?

Many parents of teenagers and younger children know about the popularity of 3D video games like Roblox and Minecraft or social media apps like Instagram, Discord and Snapchat. "It's a complex space. There are perhaps conflicting definitions. We hear phrases like virtual reality and augmented reality, extended reality, immersive technologies, and even the metaverse," said the panel's moderator, Azeem Azhar, an entrepreneur, investor and creator of Exponential View, a newsletter on the future. "Do we mean immersive full-time worlds as science fiction has portrayed in *Ready Player One*? Do we mean new business models where users and organizations can own their experiences, and perhaps why they haven't on platforms like Facebook? Do we mean a set of useful technologies that enter the workplace? A set of series of components rather than a totality?"

Charlotte Lindsey Curtet, the Chief Public Policy Officer at Geneva's CyberPeace Institute, said that trust in these technologies is a critical aspect. "Trust is changing as the sense of digital and virtual is changing," she said. "I think that is really important that we understand what the implications and the drivers of trust for people are, particularly when we're looking at this notion of blending digital and immersive realities. Because we're moving also from one tech era to another tech era without fully understanding the implications and the challenges of the current tech era." But, she said, online gaming is fine as long as kids' online identities are kept in check by their offline identities – and with platforms or games there are government regulations and standards plus societal checks and balances. "We need to avoid remoteness," she said. "There are a lot of promises in this common digital era that this would connect communities, it would build connectedness. It hasn't necessarily done that, and I think we do need to learn from that."

At their best, such technologies can help improve one's work or education, said Marc Pollefeys, who directs the Microsoft Mixed Reality and AI Lab in Zurich, where he leads a team of scientists and engineers that helped build and develop advanced perception capabilities for the Microsoft HoloLens, one of the most successful AR glasses in the world. Pollefeys, a Professor of Computer Science at the Swiss Federal Institute of Technology in Zurich (ETHZ), said the HoloLens – an AR and MR headset with applications meant to improve a user's accuracy and output – is a unique tool that speeds up lessons or handiwork. "People remember, it feels better. For example, for learning anatomy. This is really making a huge difference," he said. "You can bring the expert that's somewhere else – on the other side of the world – and have them assist a person and communicate through three-dimensional information." He said that video games like Roblox and Minecraft emphasize building communities more than social media – like Facebook – that divides people into "echo chambers with like-minded people isolating themselves from others and creating all these micro-communities that can be manipulated and set up against each other."

Sarah Kenderdine, Professor of Digital Museology at the Swiss Federal Institute of Technology in Lausanne (EPFL), has likewise built some breakthrough technologies in curation and cultural heritage. Many of them are "reservoirs of knowledge for people in the future" – essentially digital twins of heritage sites that are no longer available due to lack of access, war, climate change or catastrophe. "We have been designing and building large-scale immersive virtual reality and augmented reality systems for about 20 years now," she said. "We're looking not only at types of cultural materials, but also at scientific data for the museums of the world, for cultural engagement. We've designed 12 large-scale systems at EPFL at the moment. They're panoramic, hemispheric, augmented, panoptic and they offer us strategies for multisensory engagement and give us powerful ways to reformulate narrative."

The idea of virtual reality has antecedents through millennia of philosophy, according to David Chalmers, an author and Professor of Philosophy and Neural Science at New York University, where he also co-directs its Center for Mind, Brain and Consciousness. "In ancient Greece, Plato said, 'Could we be creatures living in a cave, shackled to the cave wall, merely seeing, merely seeing shadows of reality on the screen?' René Descartes said, 'Could we be dreaming now? Could an evil genius be feeding us images of reality?' Well, now, virtual reality technology is doing just that," he said.

Both virtual and augmented reality technology could help people express themselves in ways beyond what's possible now in the physical world.

Sarah Kenderdine

To Chalmers, that means migrating from computers and smartphones to AR glasses that offer "any screen you ever need." Through avatars, people also tend to experiment with new identities, including gender and culture. "For many people, this is actually a way of getting in touch with their deeper selves, not necessarily the superficial self that they were presenting in physical reality," he said, adding that, for "communities of disabled people ... who have limited access to the physical world, I think often the virtual and digital worlds provide new possibilities for accessibility and for expression of identity."

But, according to Chalmers, online gaming communities, like Roblox and Minecraft, are essentially diversions, or entertainment. And there's a real question of manipulation and autonomy – for example, no longer remembering phone numbers or reading maps because we've "offloaded" those brain functions to computers and smartphones. "The meaning in our lives ultimately doesn't come from playing games; it comes from community," he said. "Autonomy is awfully important for us as human beings. We're already manipulated a lot by advertising and so on. But free will has to be at the at the heart of this."

From a government regulator's perspective, Cordel Green, a lawyer and Executive Director of the Broadcasting Commission of Jamaica, said he worries about the impact of electronic media on mental health and memory formation in children. "What, in my view, distinguishes this generation is the potential for deep immersion and for synthetic experiences. And those portend very, very serious problems for the world," said Green, a former Assistant Attorney-General of Jamaica. "The great challenge we have is making the distinction between technologically deterministic hype on the one hand, which seems to be galloping away, and what to me is the more significant question, which

we ought to interrogate: whether it is acceptable in 2022 for a small group of corporations to impose on the world their version of reality without oversight. From a regulatory perspective, that's the fundamental question."

Green said some creators that build platforms without oversight "are not necessarily thinking about the consequences of what it is they create" even when children are exposed to pornography, which illustrates a misconception that regulation destroys innovation – except when governments are complicit in what's going on. "It is when regulation is not innovative that we have the risk of destroying innovation. We need regulatory innovation as well," he said. "For me the deep question is not about the future; it's about what's happening now. There's a dearth of information about the brain and neurological impacts of some of what we're talking about, especially the impacts on children who already have a very difficult time distinguishing reality and fiction ... Educators can't be digitally illiterate in a digital economy and society, and that's precisely the state of affairs. This is crazier than Ukraine and Russia."

Governments today are not organized to effectively regulate or govern these types of challenges, said audience member Anne-Marie Buzatu, Vice-President and Chief Operations Officer of the ICT4Peace Foundation in Geneva. In her frequent work with governments, she noted, she sometimes has to deal with several departments to accomplish a single project because the authority is dispersed among the departments and no single person has ownership. "How are we going to reorganize government, which is also based on the notion of the government having effective control over everything, when in many cases now the control is governed by companies?" she asked. Green said this points to the need for more innovation in governance, because "government must be fit for purpose. Legislation must be fit for purpose. I think that what you are raising is the question of whether the designs that exist now are fit for purpose. For me, the answer is no, they're not. And it's not a bad thing. It is just the fact that the society is changing; and governments also need to adjust. Governance and government – those concepts have to be interrogated."

More information

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Takeaway Messages

At their best, such technologies can improve one's work or education by speeding up lessons or handiwork, for example by bringing in an expert to communicate information in 3D.

Trust in technologies like augmented reality (AR), mixed reality (MR), virtual reality (VR) and the metaverse is a critical aspect as we move from one tech era to another without fully understanding the implications and challenges.

Video games like Roblox and Minecraft emphasize building communities more than social media platforms that divide people into echo chambers of like-minded people isolating themselves from others and creating micro-communities, which can be manipulated.

Large-scale immersive VR and AR systems can help preserve and share reservoirs of knowledge in the form of cultural heritage and materials, including scientific data, for the museums of the world.

The idea of virtual reality has antecedents through millennia of philosophy, but the meaning in our lives ultimately comes from community, not from playing games.

Through avatars, people tend to experiment with new identities, including gender and culture.

For communities of disabled people who have limited access to the physical world, virtual and digital worlds provide new possibilities for accessibility and for expression of identity.

The impacts of electronic media on mental health and memory formation in children are a concern for regulators because of the potential for deep immersion and synthetic experiences.

Regulatory innovation in governance is needed to effectively manage these challenges in a way that keeps pace with how society is changing.

Science Anticipation

Can we Bolster Democracy through Technologies

Abstract

Digital threats to democracy – misinformation, propaganda, political tribalism – are trending toward a future of destabilized political and community coherence. Many experts anticipated that greater connectivity and access to information would help build a broader foundation for democratic values, but political projections of the future no longer easily align with these expectations. As digital tools are increasingly used in democratic systems, the judiciary, and other governmental processes, the operating foundation for many nations and their citizens has never had more at stake.

- Can we employ digital technologies to bolster democracy and embody the values of an integrated and educated public?

- Will increasing digitalization breed divisiveness and threaten the foundations of democratic values?

Join this session to debate how technologies are shifting power, redefining communities, mixing personal and political identities, and what this means for our collective future.

Participants

Moderated by:

Chris Luebkeman, Chief of Foresight, ETH Zurich, Switzerland

With:

Agnès Callamard, Secretary-General, Amnesty International, France

Micheline Calmy-Rey, Former President, Swiss Confederation; Visiting Professor, University of Geneva, Switzerland

Niva Elkin-Koren, Professor of Law, Tel Aviv University, Israel

Aaron Maniam, Deputy Secretary of Industry and Information, Ministry of Communications and Information of Singapore, Singapore

Nanjira Sambuli, Policy Analyst; Advocacy Strategist; Board member, Digital Impact Alliance, Development Gateway and The New Humanitarian, Kenya

Highlights

An alarming picture of democracy in decline emerges from a slew of recent indices and reports issued by organizations that monitor the precarious state of freedom and human rights worldwide. According to Freedom House, democracy and human rights deteriorated in 80 nations since the COVID-19 pandemic began, while 36 nations engaged in transnational repression – tracking down and silencing social activists and political dissidents beyond their national borders.

"Democracy and pluralism are under assault. Dictators are toiling to stamp out the last vestiges of domestic dissent and spread their harmful influence to new corners of the world," said the organization in a 2020 report. Less than half the world lived in a democracy in 2021, according to the Economic Intelligence Unit's annual democracy index in February: Some 44.3% "deteriorated" in their ratings; another 27.5% "stagnated" and just 28.1% showed "improvement".

Against this backdrop, the GESDA panel, moderated by Chris Luebkeman, Director of the Strategic Foresight Hub of the Office of the President at the Swiss Federal Institute of Technology in Zurich (ETHZ), asked how digital technologies might come to the aid of democracy – and whether the Swiss foundation could build a platform to facilitate citizens' greater digital participation in public affairs. Former Swiss President Micheline Calmy-Rey, a GESDA board member, held up the example of Switzerland's decentralized governance

and tradition of direct democracy, including the oldest form, the open-air Landsgemeinde. This tradition lets the Swiss electorate directly express their opinions on decisions taken by the Swiss Parliament and propose amendments to the Federal Constitution. The frequent initiatives and referenda – sometimes an instrument of the people, sometimes an opposition tool against the ruling elite – are a ceaseless push-and-pull between citizens' sense of international obligations and desire for self-determination.

Swiss foreign policy promotes Geneva's aspiration to be an international capital of digital governance, reflecting the Swiss city's long history of multilateralism. "I take the example of Switzerland as an inspiration to explain what I mean by reinventing democracy," said Calmy-Rey, noting that the Swiss have a "fourth institutional power" – the people – to accompany their executive, legislative and judicial branches. But something's missing at the global level: a Digital People's Assembly that could allow everyone from citizens to academics to industry representatives to exchange ideas and "evolve into a real decision-making institution at the global level," she said, adding that GESDA could serve as a perfect venue to consider this because of its credibility and technical knowledge. "We shouldn't think of not using technologies," she urged. "We should focus on how to do it better – how to use it for the good of democracy."

Niva Elkin-Koren, a Professor of Law at Tel-Aviv University Faculty of Law and Faculty Associate at Harvard University's Berkman Klein Center for

Internet & Society, told the panel that she sees a "huge mismatch" between the traditional checks and balances of liberal democratic institutions and new technologies like artificial intelligence that assign traditional societal decisions to the realm of algorithms. She pointed to predictive policing, court assessments of potential offenders, and social media filters as examples.

"All of these decisions are now automatically made by algorithms that are not transparent but are learning from data and therefore changing over time and creating a huge challenge for auditing and for oversight," said Elkin-Koren. "There are some efforts to address this problem, especially in Europe." Computer and data scientists and engineers also have a role to play, she said, particularly when it comes to unintended consequences in technology design. An audience member, Stefan Germann, Chief Executive Officer of the Swiss philanthropic foundation Fondation Botnar, noted that "an essential element of democracy and good governance is something that's very unpopular: that's taxation. Why are we not talking about data taxation as much as we should?" He suggested that the issue could spur change among big tech companies that bill themselves as forces for good.

Instead of using American and European experiences as the starting point, Nanjira Sambuli, a Researcher, Policy Analyst and Advocacy Strategist, said she would "flip the question" and start with the experiences of nations like India and Kenya, her home. "In the rest of world, the media gives insights very different from how *The New York Times* and all these other typical news outlets talk about what's happening with technology in our societies and especially in the Global South," she said.

Kenya's presidential election in August offered a recent look into the nation's decade-long experimentation with how to use digital technologies to bolster democracy, civic participation and transparency. The nation is a

Aaron Maniam

digital leader in Africa; its Independent Elections and Boundaries Commission's website for the first time digitally published handwritten result forms that came from thousands of polling stations, allowing anyone with an internet connection to check the results. Still, the paper ballots were verified manually in a bow to previous elections that suffered from a lack of trust and led to violent unrest and the nullification of results by Kenya's top court.

"Each election cycle, it has been an interesting case of lessons learned and what works and what doesn't," observed Sambuli, who works to understand the intersection of information and communications technology (ICT) adoption with governance, media, entrepreneurship and culture through a gender lens. What people are motivated to do matters more than what technology is being used, she told the panel.

"We have to always keep that as a lode star in how we talk about the role of technologies in society today. And technologies will help if the intrinsic motivation is to actually fix something. It will also, similarly, not help if the motivation is to control or to suppress and so on and so forth," said Sambuli. "You have also what you might call some more practical issues about who actually has access to these technologies to engage in bolstering democracy. In Kenya, for example, over the 10 years, I would say, people have exercised – through the use of social media – their democratic rights that have been enshrined in a new constitution, some of which they cannot exercise offline. So, for example, it's increasingly possible if you are online connected and discussing an issue to register a protest, then it may have action taken upon [it] by the authorities. But, if you go to the streets to exercise your right to protest, you could die. So, you start to see the dual nature that starts to emerge about the unfinished business of democracy meeting the emerging and unfolding impacts of technology."

For decades, Singapore has promoted its technological expertise in the region – not just with how to run the island nation's e-government, but also with a host of government-owned industrial and financial enterprises. "We're thinking a lot about how we manage the upsides of tech. But, at the same time, how do we also manage and regulate the inevitable downsides?" asked Aaron Maniam, Singapore's Deputy Secretary for Industry and Information. "We don't want to overregulate because there are so many genuine upsides. But, we also recognize that, if we leave the upsides simply to unfettered market forces, then we have some serious problems to deal with." For example, digital technology is creating jobs, but also a potential dependency. "We are worried about reliance on specific firms and their products, platforms and apps. But, at the same time, we worry about the fact

Agnès Callamard

that standards in areas like AI and data need to be maintained," he said.

"Similarly, with socio-political issues, on the one hand, I think tech is giving us the opportunity to connect, to collaborate and to be creative in more fundamental ways than we've ever had before. These are where the examples of free speech can be so powerfully felt if used well. But, at the same time, there are huge risks in the social political sphere: overconsumption, or just overconsumption either of data, or overconsumption on specific platforms where people become reduced to automatons playing with their digital devices," said Maniam.

Maniam noted that Singapore has laws dealing with "falsehoods", "foreign interference issues and disinformation" and "harassment" and its lawmakers will soon debate new online safety laws dealing with suicide ideation and illicit use of intimate material. "We need experimental, iterative, constant beta testing rather than trying to find a single silver bullet," he said, adding that education both for students and people in the workforce "has to keep evolving."

Amnesty International views the advent of digital technologies as a "double-edged sword" because of their power to help protesters fight injustice in places like Iran and the United States and their potential to be misused as a tool of repression, Secretary-General Agnès Callamard told the panel.

The idea of a new and decentralized iteration of the World Wide Web – known as Web3 – with greater data privacy and security, is something she's "very keen" for her organization to explore "as a form of governance which may be able to escape the scrutiny of governments in places where we are no longer able to be, such as China." The same goes for the potential uses of blockchain technology, a database or chain of digital blocks with records of transactions shared across a network of computers called "nodes" and a decentralized autonomous organization, which uses smart contracts or chunks of code that automatically execute whenever a set of criteria are met.

"There are huge potential opportunities currently and in the future. But, it is also something that can be employed just for the opposite of empowerment. It can be employed for repression and, there, the miracle of digital technology turns into a nightmare. We just need to think of surveillance," said Callamard.

Since digital technologies can be used to bolster either democracy or repression, efforts like GESDA's should focus on those who use, control, regulate and profit from them, according to Callamard, and the goal should be to build up new institutions, norms, behaviours and international laws. "The anarchy of the internet is not necessarily a driver for more voices or more empowerment or more democracy. It is not," she said. "We need to face that fact."

Takeaway Messages

Decisions automatically made by algorithms are not transparent but are learning from data and therefore changing over time; this creates a huge challenge for auditing and oversight.

The element of digital taxation could spur change among big tech companies that bill themselves as forces for good.

New designs to boost democracy might look to the experience of populous nations like India and Kenya, rather than North America and Europe, to include those who live in the Global South.

What people are motivated to do matters more than what technology is being used when we talk about its role and uses in society.

Managing both the upsides and inevitable downsides of technology must include coming to terms with the enormous amount of personal data that is collected.

The advent of digital technologies is a double-edged sword: they have the power to help fight injustice, and yet hold the potential to be misused as a tool of repression.

When designing digital technologies that might come to the aid of democracy, the traditional checks and balances of liberal democratic institutions don't match with new technologies – like artificial intelligence – that assign traditional societal decisions to the realm of algorithms.

The goal of efforts like GESDA's should be to build new institutions, norms, behaviours and international laws.

GESDA could build a platform to facilitate citizens' greater digital participation in public affairs modelled after Switzerland's decentralized governance and tradition of direct democracy.

Nanjira Sambuli

Chris Luebkeman

Micheline Calmy-Rey

More information

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Science Anticipation

Assessing Solar Radiation Modification

Abstract

Solar Radiation Modification (SRM) has been scientifically, politically and societally divisive. Some experts don't even want to discuss proposals to go on with fundamental research in the field. There is fear that future societies could succumb to "techno fix" attitudes, potentially damaging current climate change mitigation policies. Other experts believe that interventions such as cloud brightening, aerosol injection, and creating more reflective surfaces must be part of a possible intervention portfolio, especially if other measures fail. Regardless of position, both sides agree that the planet's future is in peril and people and governments must act.

- With the consequences of climate change rising, should we be doing fundamental research on SRM, or at least verifying the feasibility of these technologies?

- How can we deal with the risks and consequences that some actors will deploy SRM techniques unilaterally?

- How do we create an inclusive multilateral process to make sure that no country is left out of any possible decision on using SRM technologies?

Join this session to explore how disparate communities can address wide ranging ramifications of perhaps humanity's greatest challenge.

Participants

Moderated by:

Milica Momcilovic, Science Journalist, RTS Public television Serbia; President, World Federation of Science Journalists, Serbia

With:

Frank Biermann, Professor of Global Sustainability Governance, Copernicus Institute of Sustainable Development, Utrecht University, Netherlands

Sikina Jinnah, Professor of Environmental Studies; Affiliated Graduate, Faculty of Politics, University of California, USA

Pascal Lamy, Former Head, World Trade Organization; Coordinator, Jacques Delors Think Tanks (Paris, Berlin, Brussels); President, Paris Peace Forum, France

Chukwumerije Okereke, Professor in Environment and Development, AEFUNAI, Nigeria

Janos Pasztor, Executive Director, Carnegie Climate Governance Initiative, Hungary

Gernot Wagner, Climat Economist, Columbia Business School; Columnist, Bloomberg Green, Austria

Highlights

Questions surrounding whether to pursue new technologies that could deflect the sun's rays and prevent more climate-affected droughts or heatwaves have become politically charged. Aside from the potential unwanted effects that such untested technologies, called Solar Radiation Modification (SRM), could have on people, animals and plant species and the rest of the planet, they raise concerns that tinkering with the planet's air to cool the Earth's warming climate might weaken the most important part of the fight that scientists say governments must urgently prioritize to limit the worst effects of global warming: reducing heat-trapping CO2 emissions from fossil fuel burning.

It's already highly doubtful that the world will stick to its obligations under the 2015 Paris Agreement to limit global warming to 1.5° Celsius, which would require a 43% emissions cut since the planet has already warmed by 1.2°C from pre-industrial times. Scientists with the UN's Intergovernmental Panel on Climate Change (IPCC) found that the world is headed for 4.5°C of warming this century compared to pre-industrial levels in roughly the year 1750, but recent efforts by some nations have lowered their global forecast, based on the latest trajectory, down to 2.6°C. That puts the world on a course that scientists say will have it passing the 1.5°C mark in the 2030s.

The GESDA panel raised difficult questions about SRM that, at least in some quarters, are seen as taboo: Should we try to manipulate Earth's climate systems? Would that open the floodgates to actions that potentially weaken our current climate change mitigation policies? Moderated by Radio Television of Serbia journalist, editor and TV anchor Milica Momcilovic, President of the World Federation of Science Journalists, the panel was, as expected, a heated debate in a range between those who said no, we shouldn't open a Pandora's box or discuss anything that could weaken our emissions-cutting resolve and those who said yes, these potential "techno fixes" like cloud brightening, aerosol injection and creating more reflective surfaces just might work and, even if they are not used, should at least be part of the discussion and examined with scientists' eyes. The only firm area of agreement was that more urgent action is needed to keep the planet from overheating, which is why GESDA, a neutral platform for dialogue, invited the panel.

Pascal Lamy, President of the Paris Peace Forum and a former Director-General of the World Trade Organization in Geneva, said he was participating in the panel in his additional role as Chair of the Climate Overshoot Commission. The forum launched the commission in early 2022 to consider the risks of overshooting 1.5°C and prepare options

for addressing those risks "given the unfortunately extremely high likelihood that we'll overshoot 1.5°C with catastrophic consequences," he said.

The global response to climate change generally involves a two-pronged approach. The first is mitigation: reducing emissions and stabilizing the levels of heat-trapping greenhouse gases in the atmosphere. The second is adaptation to what's already a foregone conclusion. Lamy said the commission's willingness to consider all options, including SRM, "doesn't change the fact that the main option remains mitigation and that, of course, we all have to keep pushing on this." Although SRM is "a very divisive topic" for scientists, politicians and citizens, he acknowledged, our dire predicament necessitates that "we should not leave any stone unturned; we have to look at this option."

There are two main arguments against it, said Lamy. The first one, based in science, is the belief that it is too risky, given the possible unintended consequences. The second one, based in politics, is the risk of "trumping" or deflating other, more preferrable options. "We are looking at this under all angles, and with all sides in order, and that's our intention to come roughly a year from now with recommendations," he said, which might set conditions for SRM's "acceptable" use in some places.

Acknowledging the fierce debate between wealthy and developing nations over climate change, Lamy said that when he composed the commission, he made sure that roughly two-thirds of its members came from the Global South, including a large contingent from Africa. "I'm pretty convinced that this commission will make quite radical proposals on the adaptation side of the equation, which for the moment is vastly underfinanced," he said of its efforts to form a governance strategy for removing carbon dioxide from the air, adapting to climate change and possibly lowering temperatures by reflecting sunlight with artificial methods. "As far as SRM is concerned, there is no blueprint from a proper governance of SRM internationally." But, he added, the order of their thinking is Plan A, mitigation. Then Plan B, adaptation. Then Plan C, maybe carbon removal, if it can be scaled up and "maybe SRM if a proper international governance system can be found."

Nations in the Global South are paying the price for a problem largely created by rich nations and the voices of the most vulnerable populations aren't heard enough in the global debate over climate change, according to Sikina Jinnah, Professor of Environmental Studies at the University of California, Santa Cruz, who is researching how to hold a more inclusive debate on SRM. "If you look at maps of climate vulnerability globally, we see that most

countries that are most vulnerable to climate change are those that have contributed least to the problem historically and have least capacity to adapt," she told the panel.

"When you think about who has been contributing to the conversations and research on solar geo-engineering, over 90% of that research has come from North America and Europe. Those countries that are most vulnerable to climate change have been largely – in the academic literature – left out of the conversation, and that is literature looking at everything from philosophy to physics, across disciplines. The project that I'm working on at the moment is trying to think about, how do we expand that tent? … Let's learn a little bit more about this before we make any decisions about what's best for the world's most vulnerable," said Jinnah.

The discussion about SRM causes an "overriding emotion" of fear at the "intellectual domination" of North American scholars but also a "little bit" of anger, acknowledged Chukwumerije Okereke, Professor of Global Climate and Environmental Governance and Director of the Centre for Climate and Development at Alex Ekwueme Federal University Ndufu-Alike in Nigeria. "I feel angry because we have sketched now three baskets of actions that can be taken to enable the poor countries that have contributed the least to climate change to adapt," he told the panel. "We have said that one basket of option is radical mitigation by those who have most caused the transformation. We have identified as a basket, emphasis on climate-resilient development and adaptation. I am not sure why we want to begin to explore the third option when there is still a huge headroom – we haven't done anywhere near those first two options."

Okereke said African nations prepared plans in accordance with the 2015 Paris Agreement on climate change for how to cut carbon pollution and identified $3 trillion of investment opportunities, but they have "received next to nothing of the sort of amount of money that they are required to implement. I have gone around telling African heads of state you have to engage with climate change because it presents an opportunity for you to build climate resilience infrastructure and develop in a cleaner way. They are now turning to me and saying: 'You sold us a lie. We believed you. We prepared the plans. We didn't get the money.' And suddenly the discussion is shifting to some kind of delay tactics, some kind of risky delay tactics that will buy time for more pollution."

On top of that, said Okereke, "Africa has all the sun, all the wind, all the geothermal to develop its energy potential and indeed also supply to the rest of the world. The last time I saw a contingent from Europe coming to Africa in the past five years has now been

to ask Africa to please allow them to invest more in gas. Oh, not gas to supply Africa, but gas to supply Europe. Africa suddenly becomes important again because Europe needs gas. This is not how to do climate diplomacy … Powering ahead with this kind of research [on SRM] will be the most egregious climate injustice that will be done to Africa."

One of SRM's most vocal critics is Frank Biermann, a Research Professor of Global Sustainability Governance with the Copernicus Institute of Sustainable Development at Utrecht University in the Netherlands. Biermann argues that it does not address the core problem of lowering CO_2 emissions. He and Okereke are among 16 scholars who initiated a global petition among experts in January 2022 calling for an international "non-use agreement" on SRM – a moratorium on its study and development similar to international bans on biological and chemical weapons – that has since gained around 1,000 signatures.

The petition was not the first international effort to rein in SRM. In 2019, Switzerland introduced a resolution at the UN Environment Assembly in Nairobi calling for an assessment of how SRM could be used and governed – with the goal of creating firm regulations – but withdrew the resolution for lack of consensus. Biermann said he fears that encouraging more discussion about SRM could derail momentum on more emissions-cutting. "More and more people are accepting the need to reduce emissions. The prices for renewable energies are falling. We see indications that, within the next generation, we can make the transition to a fossil-fuel-free world," he said. "I'm deeply afraid about this particular discussion that is now gaining speed. I think – number one – this discussion will delay and will derail all existing climate policy programmes. It will demobilize politicians, it will demobilize businesses – it might also demobilize citizens."

However, turning to SRM likely is inevitable despite these "moral hazard concerns," said Gernot Wagner, a Climate Economist at Columbia Business School and author of *Geoengineering: The Gamble*. He agreed that emissions-cutting should be the top priority, but it should be followed by adaption, carbon removal and then research into SRM because it is too late to forgo a technology and simply not worry about it. "Everything we do know, I think, points in the direction that it is not a question of if, but a question of when," he told the panel. "Unmitigated climate change is no longer sort of an environmental concern that you put in one bucket of the discussion. It is a national security concern, of course, and there's also an economic question."

Here's how SRM could work: Squadrons of remote-controlled aircraft might fly to the stratosphere, extending to about 10 to 50 kilometres in altitude,

and disperse particles of sulphur dioxide that reflect sunlight into space, similar to what can happen when a major volcano erupts. Such flights could go on for decades. The costs of SRM, including the most-studied method of injecting aerosols into the stratosphere, by 2030 would be an estimated $140 billion to $300 billion a year, according to the United Nations and, by 2050, could rise to $280 billion to $500 billion a year.

Aerosol particles have a cooling effect on the Earth's surface because they scatter and absorb incoming sunlight. For example, after its eruption in 1991, the Philippines' Mount Pinatubo caused a measurable cooling of the Earth's surface by about 0.6°C for 15 months after it injected some 15 million tonnes of sulphur dioxide into the stratosphere, where it reacted with water and created a layer of aerosol particles mainly composed of sulfuric acid droplets. Winds in the stratosphere spread the aerosol particles around the Earth.

In its latest reports the IPCC found "high agreement" among research papers that SRM "cannot be the main policy response to climate change and is, at best, a supplement to achieving sustained net-zero" emissions. That is because it "introduces a 'mask' to the climate change problem by altering the Earth's radiation budget, rather than attempting to address the root cause of the problem, which is the increase in greenhouse gas emissions in the atmosphere." Limited studies of SRM's potential health risks show a possible rise in infectious diseases and more deaths from skin cancer due to depletion of the ozone layer, which would result from blocked sunlight limiting ozone formation at the poles.

Audience member Katarina Gårdfeldt, Director of the Swedish Polar Research Secretariat in Luleå on the coast of northern Sweden, recalled that Harvard University cancelled an experiment in Sweden in 2021 looking at SRM's effectiveness through the release of aerosols. An advisory committee cited a lack of consensus about the research after protests from local inhabitants and the scientific community. "There was a debate, everybody was not happy about it, so those experiments were stopped. However, I'm also chair of a National Commission for the Royal Science Academy, and we are planning a symposium at Luleå University of Technology on this very issue, together with the State Research Council in Sweden. And my first point is that I invite you all," she said. "The problem for me now is that I agree with all of you."

Janos Pasztor, a Senior Fellow of the Carnegie Council for Ethics in International Affairs who serves as Executive Director of the Carnegie Climate Governance Initiative (C2G), argued that SRM should be considered proactively because the reality is that emissions-cutting alone will not save the day.

"There is not sufficient attention being paid to how serious a climate crisis we are in today," said Pasztor, who previously served as the UN Assistant Secretary-General for Climate Change in New York under then-Secretary-General Ban Ki-moon. "We will be overshooting the 1.5°C even under the most optimistic IPCC scenarios."

Because of that likelihood, said Pasztor, "We're getting into a much hotter world, and we need to manage the risk. Now, fundamentally, there are two families of options that the world can do to manage the risk. One is to increase substantially adaptation, resilience and find ways to support communities, countries that are already being impacted and having damages because of climate change. Let's not look further than Pakistan right now [which suffered from dramatic floods in the autumn of 2022]. That's one family of options. Another one is potentially SRM. And there aren't too many other options. Emission reductions and carbon removal is absolutely necessary, number one priority. But we know that simply doing those is not enough to keep the temperature below 1.5°C."

Sikina Jinnah

"Therefore, the question is: How do we have a conversation, an intelligent conversation between those who want this new technique and those who don't want to have this technique? How do we have a conversation where the different perspectives, the different ways of interpreting and living risks can come together and find some kind of a solution? It will be very difficult to do. No question about that. Everything is very difficult in today's world, but the alternative is not to do anything. And there I think we're running into serious trouble," said Pasztor.

Pasztor noted that the panel talked a lot about the moral hazard, but no one raised the moral imperative. "The moral imperative that, if the situation is as bad as it looks, we may actually have to figure this out," he said. "And my granddaughter, who will be an adult when it gets really, really bad – she will look back and say, 'Why didn't you at least research it and find out whether it was really possible or not?'"

Takeaway Messages

Questions about whether to pursue new technologies that could deflect the sun's rays and prevent more climate-affected droughts or heatwaves have become politically charged.

The element of digital taxation could spur change among big tech companies that bill themselves as forces for good.

Among the chief concerns is that tinkering with the planet's air to cool the Earth's warming climate might weaken resolve to reduce heat-trapping CO2 emissions from fossil fuel burning.

Opponents of Solar Radiation Modification (SRM) believe that, from a scientific perspective, it's too risky and could open a Pandora's box; and, from a political perspective, even discussing it could weaken our emissions-cutting resolve.

Without necessarily being supporters, some believe all options, including SRM, should at least be examined with scientific eyes, particularly since emissions-cutting alone won't save the day.

The only firm area of agreement is that more action is urgently needed to keep the planet from overheating, which is why GESDA, a neutral platform for dialogue, invited the panel.

The Paris Peace Forum and its Climate Overshoot Commission believes the pursuit of these new technologies should be the last priority, after first cutting carbon pollution, adapting to climate change and using carbon removal technologies.

The Global South is paying the price for a problem largely created by rich nations and the voices of the most vulnerable populations aren't heard enough in the global debate. The discussion is predominately framed by North American scholars.

African nations, home to vast renewable energy potential, proposed $3 trillion in carbon-cutting investment opportunities in accord with the 2015 Paris Agreement but received little money, leaving their leaders disheartened and more willing to delay curbing pollution.

Milica Momcilovic

Janos Pasztor

More information

Explore this topic in the 2022 GESDA Science Breakthrough Radar®

Session recording on YouTube

Tweets related to the session

Science Anticipation

Controlling Vector-transmitted Infectious Diseases

Abstract

As humans move into previously undisturbed ecosystems, and as climate change broadens areas where vector-transmitted diseases such as dengue fever, Zika, and Chikungunya are present, the need to monitor, detect, contain and, above all, prevent new outbreaks is paramount. Genetic modification of mosquitoes is already being tested to stop disease transmission, but are poorly accepted publicly. The opportunity to constrain disease transmitters with a new biological (non-genetic, hence possibly better accepted) method is within our grasp. This effective method is being evaluated for endorsement by the World Health Organization, while next generation advances in synthetic biology and genetic engineering are looking at even more innovative ways to constrain disease, such as modifying the human microbiome to resist such viruses.

· How should governments use and deploy methods of disease management in a responsible and socially acceptable way?

· What role should scientists and policymakers play in making sure innovative methods are understood and knowledgeably accepted or rejected by populations?

Join this session to explore the collaborations linking disease management and our care of the environment that are needed to fight the next insect-transmitted epidemic wave.

Participants

Moderated by:

Olivier Dessibourg, Head of Science Scouting and Transfer; Curator of the Summit, GESDA, Switzerland

With:

Arnaldo Correia de Medeiros, Secretary-General, Health Emergencies, Ministry of Health, Brazil

Jeremy Farrar, Director, Wellcome Trust, United Kingdom

Scott O'Neill, Chief Executive Officer, World Mosquito Program, Australia

Soumya Swaminathan, Chief Scientist, World Health Organization, India

Highlights

Aedes aegpyti mosquito-transmitted diseases like dengue, Zika and chikungunya have become global health emergencies in recent decades. Other diseases – such as yellow fever – have re-emerged, particularly with the acceleration of climate change, which moves or enlarges areas where those mosquitoes are endemic. Scientists traditionally looked to insecticides, removal of larval habitats and other traditional methods of reducing mosquito populations. But, starting in 1980, Australian scientist Scott O'Neill began looking at other, more effective ways.

O'Neill focused on a small bacterium called Wolbachia, first described in the 1920s, which occurs naturally in almost 50% of all insect species, but not in the Aedes aegpyti mosquitoes, and could be used to infect them and render them unable to transmit disease. The need is particularly acute with dengue fever, which causes millions of infections a year and is the world's fastest-spreading mosquito-borne disease. As a bonus, the technique does not involve the sort of genetic modifications that could alarm the public, such as "gene drive" techniques.

O'Neill, Chief Executive Officer of the World Mosquito Programme, is now poised for an endorsement from the World Health Organization, which could facilitate the technique's adoption across the planet if governments take it up and the financial support to do so is provided. O'Neill said WHO's endorsement would be "hugely important" to encourage more countries to use the technique, particularly those that can't or won't assess the benefits and risks themselves. "WHO is critical for the ones that are holding back," he said.

Enter GESDA's panel discussion, aimed at catalysing global policymakers and scientists at the cusp of a scientific advance that seems ready to be implemented – and could save millions of lives. In early 2022, WHO said the number of reported dengue cases increased more than eightfold over the last two decades, from 505,430 cases in 2000 to more than 2.4 million in 2010 and 5.2 million in 2019.

O'Neill explained the mechanism. "When you take a bacterium called Wolbachia and put it into a mosquito, it lives inside the body of the mosquito and gets passed from one generation to the next in the eggs of the mosquito; the presence of that bacteria stops the dengue virus from growing in the mosquito. It stops replicating. And if [the virus] can't replicate in the mosquito, it can't be transmitted between people," he said. "We grow in our laboratory or in a factory, if you like, mosquitoes that have this Wolbachia bacteria introduced into them. We grow them up in the laboratory and then we release small numbers of them into communities where they mate with the wild mosquitoes and pass that Wolbachia into the mosquito community. It then gets transmitted into the mosquito population and maintains itself without having to be reapplied. And once the mosquitoes have it, they're much less likely to give viruses to people when they bite them."

In his homeland, Australia, all the mosquitoes in the places they tested it had Wolbachia more than a decade later – dengue transmission was virtually eliminated – and it became a model for global projects. Already, some 10 million people have been protected as a result. "The group of us that have developed this believe it has great potential," said O'Neill. "We're on the edge now of wanting to take it from 10.5 million at the present day to it being able

to be scaled globally." But there's still the question of who's willing to pay for it to be used. Either the big foundations will have to shell out the money, he said, or start-ups will have to generate revenue streams in places that can afford it. Communication engagement also will be needed to ensure people accept the idea.

In some countries, there's no clear pathway to regulation. As one of the nations most affected by dengue fever, Brazil has shown a strong interest in the technology and began with two pilot projects in Niterói and Rio de Janeiro. Panel moderator Olivier Dessibourg, GESDA's Executive Director of Science Communication and curator of the 2022 summit, asked why the reduction in dengue at Rio is only 44%. O'Neill acknowledged "some difficulty in getting high levels of Wolbachia frequency in informal communities – favela communities in Rio that are very challenging to operate in." Over the past eight years, however, the government has invested $3.6 million in the methodology, said Arnaldo Correia de Medeiros, Secretary for Health Surveillance at the Brazil Ministry of Health. (According to O'Neill's team, that investment has saved more than $24 million in social and medical costs.)

It has also taken time to adjust to the methods and figure out how to explain it, said Correia de Medeiros. "We are used to killing mosquitoes. And with Wolbachia we are releasing mosquitoes. So, it's quite different to change, to explain it to the population, what is going on," he said. "Because it's quite important to have diverse communities understand what is going on, because we are not killing the mosquito, but we are releasing into an environment mosquitoes with Wolbachia. It is quite simply strange for the population: 'What is this Wolbachia?'" Yet, releasing the mosquitoes

Jeremy Farrar

is only "the middle step," he said, because the community must be engaged to understand the need for more data collection and monitoring once the mosquitoes leave. "The mosquitoes don't have passports. They don't recognize borders."

More evidence is needed before WHO endorses this nature-based solution and supports scaling it up to reduce the rising global burden of dengue disease, said WHO's Chief Scientist Soumya Swaminathan. She added that some sort of recommendation – even a weak one – is likely. A recent study of an Indonesian trial found an 80% reduction in dengue transmission, possibly affected by excessive heat from climate change. The approval process, or "living systematic review", looks at all the evidence, said Swaminathan, but with the Wolbachia mosquitoes so far, "there isn't that much evidence. There's a randomized trial and a few non-randomized studies. But that's fine. You know, all of that evidence is collected and it's graded. A randomized trial is obviously the highest level of evidence now, especially in a situation like this where behaviour of vectors could vary from year to year: it could depend on climatic conditions, the population behaviour could be different, there could be many factors that affect and that might actually affect the results of an intervention study, right? That's why you need a control group and, if it's randomized, it's good. If it's not randomized, then the quality of the evidence perhaps is a little less."

Other factors are the public health impacts and cost-effectiveness, said Swaminathan. "It has to be equitable. We look at many factors before the guideline group actually recommends, and then they make either a strong recommendation, a conditional recommendation, or a weak recommendation based on the evaluation of the evidence." The guideline development group is looking at the data and was supposed to meet before the end of 2022. "So, we expect that there'll be a recommendation," she said. "But whether it will be a strong or a conditional recommendation, we have to wait, wait and see. But the good thing about the living approach is that it's updated. And so, it's possible that, in six months, a lot of data comes out, Brazil, other countries, the recommendation could then be updated as well."

Even with WHO's recommendation, using mosquitoes with Wolbachia more broadly would require money to pay for an integrated approach with community engagement and education, surveillance, monitoring, removal of standing water where mosquitoes lay eggs, and the use of larvicides and insecticides to control mosquito larvae, pupae and adult mosquitoes. In recent years, O'Neill's World Mosquito Programme created an Eliminate Dengue Programme to scale up trials of Wolbachia-carrying mosquitoes in South

America and received funding for this innovative infection control method from the Wellcome Trust, the Bill & Melinda Gates Foundation, the US Agency for International Development and the UK Department for International Development.

Sir Jeremy Farrar, Director of Wellcome Trust and a GESDA board member, said that it's a tribute to O'Neill and the World Mosquito Programme that they managed to navigate not just the scientific community, but also the political system, because "science is political, and you have to do it in the context of the regulatory and the guideline committees and everything else." Their *Wolbachia* approach to mosquito management fits within the Wellcome Trust's portfolio, which tries to push for advances by taking risks at the boundaries of "knowledge spaces," he said, while ensuring that science is put into the context of the society in which it operates. "I think that is the role of philanthropy: risk-taking long term and putting things together that others in relative silos may not see the benefits of bringing – basic lab science, societies, our politics, culture and regulators."

Although O'Neill's dengue project was approved before Farrar took over the trust's direction, the British medical researcher and former tropical diseases professor recalled working on dengue in Viet Nam decades ago, which has led him to consider it an "archetypal disease" of the 21st century: If the world gets dengue right, we will all be better prepared for future pandemics. "When I first went to Viet Nam in 1996, there was no danger in Hanoi, in the North, because it was not tropical. It is now endemic in Hanoi," said Farrar. "It's not in Switzerland, that is true, but it will be in southern Europe. It is across a much wider belt. It's urban. It's not rural. The world is becoming urbanized. The mosquito is beautifully adapted to it. Dengue is a disease that, at the moment, only has potentially one vaccine, which we're not sure quite of its impact. Dengue is a harbinger of much bigger things that are changing in the world around climate, urbanization, trade and travel, which is underlying; and, of course, also epidemics and pandemics. I think to get dengue right would set a precedent for how we get a number of other things right." *Aedes aegypti* mosquito-transmitted

Scott O'Neill

diseases extend well beyond dengue, making the prospect of WHO endorsement's "really critical," he said, and explains why it is a perfect fit for GESDA's attention.

"For me, the bigger take-home message is that technology is coming: Let's think ahead of how we may use it in the communities that are going to be most affected," said Farrar. "GESDA wasn't in existence when Scott started his work. But if it had been, this would have been a case study of why GESDA is important. Because, if you think about it, it was last century when this work started with basic science invested in over years and years that nobody took any interest in. It was high risk; it was difficult; it was difficult to get funding for. Nobody could quite see where it was going. How ever were you going to persuade anybody – from a regulator, from WHO, to a political system, to a society – that you were going to release more mosquitoes in order to control the mosquito-borne disease? I mean, it just made no sense. The lesson to take away from that is: Science that makes no sense today may make huge sense tomorrow. If you don't invest in that basic science, you will not have the breakthroughs tomorrow."

More information

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Takeaway Messages

Aedes aegpyti mosquito-transmitted diseases, like dengue, Zika and chikungunya, have become global health emergencies in recent decades.

A small bacterium called Wolbachia that occurs naturally in almost 50% of all insect species but not in *Aedes aegpyti* can render these mosquitoes unable to transmit disease.

The technique of infecting *Aedes aegpyti* with *Wolbachia* to render them harmless does not involve the sort of genetic modifications that could alarm the public, like "gene drive" techniques.

Brazil has shown a strong interest in the technique, investing $3.6 million in pilot projects over the past eight years; it has produced mixed results because of difficulty in getting high levels of cooperation in some poorer communities.

An endorsement from the World Health Organization (WHO) could facilitate its adoption across the planet if governments take it up and the financial support to do so is provided.

More than 10 million people in Australia have been protected as a result of testing that became a model for global projects.

Even with WHO's recommendation, more government-approved use of mosquitoes with Wolbachia around the world may need philanthropic backing to scale it up.

WHO's chief scientist says more evidence is needed before it will endorse this solution and support scaling it up in an equitable fashion to reduce the rising global burden of dengue, but some sort of recommendation – even a weak one – is likely.

Olivier Dessibourg

Arnaldo Correia de Medeiros

Soumya Swaminathan

Science Anticipation

What is the Future of Polar Research in the Current Geopolitical Landscape?

Abstract

The poles are the most challenging and expensive frontiers on Earth for scientific research and resource acquisition. The current geopolitical situation has put deployed efforts to pursue research in those regions at risk. It is, in fact, accelerating the race to exploit essential resources such as oil, gas, and rare earth minerals. In addition, concerns citing environmental preservation, ecosystem balance, and lack of clear authority or ownership loom over existing approach to the Earth's poles. Alternatively, the poles and their resources are an important contributor to meeting the demand of a more manageable energy transition.

- How can nations and multilateral coalitions move forward with global research programs and tenuous collaborations overshadowed by geopolitical realities?

- What is the right balance between exploitation of resources and exploration of scientific unknowns?

Join this session to examine opportunities for sustainable approaches to scientific research and polar resources acquisition in a changing geopolitical landscape.

Participants

Moderated by:

Doaa Abdel Motaal, Author of "Antarctica, the Battle for the Seventh Continent"; Senior Counsellor, World Trade Organization, Egypt

With:

Alexandra Baumann, Ambassador; Head, Prosperity and Sustainability Division (incl. Polar Affairs), Swiss Federal Department of Foreign Affairs, Switzerland

Rasmus Bertelsen, Professor of Northern Studies, Barents Chair in Politics, The Arctic University of Norway, Denmark

Katarina Gårdfeldt, Director-General, Swedish Polar Secretariat, Sweden

Larry Hinzman, Assistant Director, Polar Sciences, White House Office of Science and Technology Policy, USA

Yeadong Kim, President, Scientific Committee on Antarctic Research (SCAR), South Korea

Highlights

As climate change drastically reshapes the polar regions, geopolitical conflicts likewise are fracturing the polar research landscape, particularly since Russia's invasion of Ukraine on 24 February 2022. Russia holds the presidency of the eight-nation Arctic Council until May 2023 (when Norway is supposed to take over) and its territory extends to 53% of the Arctic Ocean coastline. About 2.5 million Russians live in Arctic territory – almost half of all the people there. In the meantime, a race is on for control of Arctic resources and access.

The situation drastically differs in the Antarctic region, where a 1959 treaty originally conceived as a disarmament regime now provides for a system of sustained international scientific cooperation and tightly regulates the only continent that lacks a native human population – but a possible reversal of its strict ban against mining for mineral resources is not unthinkable in future decades.

Against this complex backdrop of cooperation and competing interests, the panel examined how global research and expeditions can best continue. "I always say whatever happens in the Arctic is a precursor to what may happen in Antarctica. It's warming much faster and its geopolitics are also heating up," said the panel's moderator, Doaa Abdel-Motaal, an international development expert whose book, Antarctica: The Battle for the Seventh Continent, explores how the treaty could change when it comes up for review in 2048.

Adverse impacts from climate hazards and resulting risks are triggering tipping points in sensitive ecosystems and in significantly and rapidly changing social-ecological systems affected by ice melt, permafrost thaw and changing hydrology in polar regions, according to the UN Intergovernmental Panel on Climate Change in its latest comprehensive report. Additional warming of the Earth above 1.5°C during an overshoot period this century, it says, will likely bring about "irreversible impacts on certain ecosystems with low resilience, such as polar, mountain and coastal ecosystems, impacted by ice-sheet, glacier melt or by accelerating and higher committed sea level rise."

About 4 million people live within the Arctic Circle, of which 10% are Indigenous peoples. Since the Antarctic Treaty was signed in 1959 by the 12 countries whose scientists were active there and it came into force in 1961, all territorial claims were suspended and prohibitions against mining were added. But the polar regions, including the more pristine and purely scientific Antarctic territory, are rich in fossil fuels, metals and other resources, including potentially tens of billions of barrels of oil. The Antarctic region is a barometer for the health of our planet, said Yeadong Kim, President of the Scientific Committee on Antarctic Research (SCAR), which oversees the region. "So, when we think about the exploitation of resources, then we have to think about conservation and management first beforehand," he said.

But the Arctic region, including the land and Arctic Sea, lacks similar tight controls over its environment. The Arctic Council provides a loose governance forum for sustainability and science, but not security. Since Russia invaded Ukraine, it has been somewhat dormant, its future uncertain. A week after the invasion, the council's seven members other than Russia suspended their participation in protest. But, in June, the seven agreed to continue for a bit without Russia, and Kim said he is "very optimistic to solve any dispute or any disagreement within the Antarctic community."

Larry Hinzman, Assistant Director of Polar Sciences in the White House Office of Science and Technology Policy (OSTP) and Executive Director of the US

Yeadong Kim

Alexandra Baumann

Interagency Arctic Research Policy Committee, noted the growing importance of the polar regions to national interests and the Arctic's huge influence on global climate dynamics. Fifty years ago, he said, science dictated the policy talks and decisions – and that's still the case to some degree. "Scientific discussions do lead to political realizations and that's a good thing," said Hinzman. But, there is a need for more science diplomacy in the region, like what GESDA practices.

"The current situation – the unprovoked invasion into Ukraine – is having global political ramifications and it also is affecting our scientific collaborations," said Hinzman. "I'm very hopeful that, in the future, we will see again the science leading to opening doors, leading back to the positive relationships." Hinzman said that the Arctic Council has been "diminished" by the war in Ukraine but remains "active to a certain extent" with its future uncertain. Among the complexities is that "the chairmanship is not taken, the chairmanship is given," he said, meaning Russia will have to formally hand it over.

Diplomacy – including science diplomacy – beats violence but still revolves around those who are "pursuing state interests," noted Rasmus Bertelsen, Professor of Northern Studies and inaugural Barents Chair in Politics at the Arctic University of Norway. "It's also important to keep in mind," he said, "I would say that polar science is strategic science. It is very much science with a strategic aim." Norway, for example, has been coal mining in Svalbard, the Norwegian archipelago in the Arctic Ocean, for more than 120 years. It maintains fibre-optic cable from the Norwegian mainland to Longyearbyen, where there's an airstrip, making it convenient for transmitting data from research.

The Arctic region also is "chock full of nuclear weapons," Bertelsen noted. This is because, during the Cold War, it was key to mutual nuclear deterrence between the United States and Soviet Union because it's the shortest flight path for missiles and aircraft. The area around northern Norway and Murmansk, Russia is "excessively militarized," he said, because it's home to the Russian Northern Fleet's Navy and aircraft that are vital to Russian nuclear deterrence. "There's probably no part of the world which is more key to nuclear strategic stability between the United States and Russia than the Arctic," said Bertelsen. "And, in the future, also including China."

In a sign of the growing importance of the polar regions, Switzerland's new Arctic Ambassador Alexandra Baumann took over the nation's long interest in the Arctic, which is based primarily on science. Switzerland, which has consultative status in the Antarctic Treaty and is an observer to the Arctic Council, considers the Alps to be part of "the third or the vertical pole" with interrelated concerns, and believes the future of polar research in both regions will strongly depend on the sort of multilateralism and international cooperation that GESDA promotes.

"The Alpine-Arctic dialogue is, for us, a tool to build an understanding for the larger challenges such as climate change," said Baumann. "Swiss researchers have developed a very strong interest over the years to explore the cryosphere on a global scale." Baumann noted that "what happens in the poles doesn't stay in the poles, so the human change, or the human-induced change and the consequences it has on the ecosystem, on the global climate, are at the forefront of Swiss research." Although it is a neutral nation, Switzerland "never had a passive role in international relations" and still considers the

Doaa Abdel Motaal

Larry Hinzman

Arctic Council to be the leading intergovernmental forum for the region, which will benefit from more science diplomacy.

Pollution spreading to the polar regions is a real problem, said Katarina Gårdfeldt, who as Sweden's top official for polar science is Director-General of the Swedish Polar Research Secretariat. As an environmental chemist, she's been chasing mercury and microplastic as it emerges from industrial sources and shows up in ice cores, seawater and atmosphere of the Arctic and Antarctic. In line with trying to preserve the environment, she said, one of Sweden's top priorities is for researchers to have climate-neutral icebreakers to use while doing climate research at the poles.

Gårdfeldt also called for more international collaboration in laying fibre cable on the sea floor, including one from Japan over the North Pole to northern Norway and on to Sweden. "From our side, we can see that, when it comes to infrastructure, Russia is taking over the central Arctic Ocean with four nuclear-powered icebreakers," she said. "Sweden and Europe have the Swedish icebreaker Oden."

Audience members raised questions about the poor engagement of Indigenous people, the relationships between US, Russian and Chinese scientists, and the prospect of nations renegotiating the treaty's provisions that protect against tapping the vast mineral resources. Some wondered how to support those in the Global South that want environmental protections. For example, Chile's UN Ambassador in Geneva, Frank Tressler, said his nation's interest in the Antarctic is linked to the global challenges of overpopulation, scarcity of minerals and feeding people. "Do you think that, in the Antarctic system, there is a possibility to regulate the exploitation of minerals, for example, like creating a system similar to the Law of the Sea, the seabed mining?" he asked.

The UN Convention on the Law of the Sea, which came into force in 1994, created three international organizations for managing ocean resources, including seabed minerals. It includes 168 parties, but not the United States, the only major nation that does not belong, and it does not cover the high seas – those international waters that are beyond the 370-kilometre (200 nautical miles) jurisdiction of coastal nations.

Kim said that, when the review happens "any country can object" and trigger a discussion on the minerals. "Even so, the protocol says, in that case, some sort of regulatory measures should be made before the mineral excavation starts," he said. As a result, the need for science diplomacy appears likely to arise when the Antarctic Treaty comes up for review in 2048.

More information

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Takeaway Messages

As climate change drastically reshapes the polar regions, geopolitical conflicts are likewise fracturing the polar research landscape, particularly since Russia's invasion of Ukraine.

A race is on for control of Arctic resources and access; the Arctic Council provides a loose governance forum in this regard.

Scientists and diplomats should improve their engagement of Indigenous peoples living in the Arctic region.

The situation is different in the Antarctic region – a barometer for the health of our planet – where a 1959 treaty provides for sustained international scientific cooperation.

When the treaty comes up for review in 2048, nations could seek to reverse its strict ban against mining for mineral resources.

Pollution spreading to the polar regions is already a problem. Mercury and microplastic emerges from industrial sources and shows up in polar ice cores, seawater and the atmosphere.

Polar science has a strategic component. There is a need for more science diplomacy in the Arctic region – this has been key to mutual nuclear deterrence between the US and Russia.

Switzerland, a leader in Alpine research, has a strong interest in polar research and believes its future depends on the sort of multilateralism and international cooperation that GESDA promotes.

Science Anticipation

Defining Health Usage Frameworks for Organoids

Abstract

Organoids are tiny, self-organized three-dimensional cell cultures that replicate the complexity of human organs. They are already providing insights into diseases pathologies, drug development, transplantation options, behavior and genetics, brain research and even learning networks. This rich field of research agendas and commercial needs could usher in a revolution in innovative diagnostics, therapeutics, and commercial ecosystems connected to personalized medicine.

- What challenges affect developing organoids openly and transparently?

- What ethical and moral issues are there, especially around brain and interspecies organoids?

Join this session to learn about the impact organoids will bring to healthcare, biodefense, consciousness, and cyber-physical systems.

Participants

Moderated by:

Effy Vayena, Professor of Bioethics; Founder, Health Ethics and Policy Lab, ETH Zurich, Greece

With:

Matthias Lütolf, Professor of Life Science, EPF Lausanne; VP, Scientific Director, Roche Institute for Translational Bioengineering, Switzerland

Alysson Muotri, Professor, Department of Pediatrics and Cellular & Molecular Medicine, University of California, Brazil

François Rivasseau, Senior Consultant Technology & Diplomacy, World Intellectual Property Organization, France

Highlights

The growing potential uses of human organoids – tiny 3D structures made from stem cells that can replicate the complexity of human organs, but on a much smaller scale – make it possible for scientists to develop new drugs and transplant options, or to learn about cancers, genetic disorders and infectious diseases without the traditional reliance on animal models in biological research.

However, some potential disadvantages loom, namely, the ethical and moral issues around brain and interspecies organoids. These issues should be considered before organoids can be widely used to reduce the traditional need for classical cell line and animal model systems in biomedical research. Experts wonder, for example, how exactly to classify organoids; might they develop feelings or feel pain? What happens if or when chips are combined with living tissues, or species are interbred?

The panel examined these multiple challenges to science, ethics and society, because "that is exactly in the mission of GESDA's mandate," said Effy Vayena, Professor of Bioethics at the Swiss Federal Institute of Technology in Zurich (ETHZ) and expert on medicine, data and ethics, who served as moderator. "The questions that we want to discuss are how we're progressing, how we ought to progress, and what can we do in science and diplomacy to enable these technologies to develop, while at the same time making sure that we're not violating ethical principles, and that we're promoting a version of progress in our society that we agree is the right version of progress."

Animal experimentation can generate data that is of little value to human applications. In contrast, organoids can allow research results to be directly applied to humans, making animal experimentation redundant. Organoids can also be used to perform more complex examinations of human tissue physiology than those from 2D cell cultures; but there is no *in vitro* model that can replace all animal models. "We're in an interesting phase now where we see proof of concept for many applications in translation," said Matthias Lütolf, Scientific Director of the Roche Institute for Translational Bioengineering. His research focuses on the use of cutting-edge bioengineering strategies to guide stem-cell-based development to build novel organoids. He is also Professor of Bioengineering at the Swiss Federal Institute of Technology in Lausanne (EPFL), where he is the principal investigator for the Laboratory of Stem Cell Bioengineering.

"They're really changing the way biologists work, how our life sciences lab operate, and they become almost a commodity," said Lütolf. There's been a correlation between clinical responses in patients treated by chemotherapy and *ex vivo* or *in vitro* measurements, he said, and now cancer centres and academic labs are researching communication between cell types.

Several groups are also working on generating synthetic human embryos in culture, which raises important questions. But cancer is a good case to look at when considering organoids, said Lütolf, because patients are diagnosed through biopsies, histology, histological analysis and genomics, and the only additional step needed is another biopsy to measure the effects of a specific drug or combination of drugs.

But it's expensive – single-cell sequencing can cost tens of thousands of dollars to measure organoids – so research tends to overlook diseases in the Global South, where there's less of a developed market. "We need to find a model where every patient can be can benefit from this advance," said Lütolf. "It's a game-changing development for this technology and it's going to happen." He also said it's easier for researchers to maintain confidentiality if they don't know where the samples came from.

But that doesn't solve the issue of autonomy – whether a patient should have a say in how their samples are used or lingering rights to them in these new applications. The issue of consent looms large with organoids, according to Alysson Muotri, Professor of Paediatrics and Cellular and Molecular Medicine at the University of California, San Diego. His current research examines the development of stem-cell-derived brain organoids. Muotri said organoids are exciting because they offer a chance to study how neurons connect and what goes wrong in neurological disorders, such as Parkinson's, Alzheimer's and dementia. "Most of the biomedical sciences so far have been reliant on animal models, which is, to be honest, unsatisfactory to understand the human brain. So that's the excitement," he said.

Organoids are not seen as morally neutral; tissue donors may perceive enduring personal connections with their organoids, setting

Effy Vayena

"higher bars for informed consent and patient participation," according to a systematic review of ethical issues surrounding brain organoids, chimeras and gastruloids that was published in *Stem Cell Research & Therapy* in July 2022. "It shows that further ethical research is needed, especially on organoid transplantation, to help ensure the responsible development and clinical implementation of this technology in this field," said Muotri. He said he started to worry when his team noticed that organoids were not only forming a tissue that resembled the human brain but were also sending neural oscillations similar to an EEG. "It will acquire some self-aware consciousness," he predicted.

As a result, his team developed what he said may be first consent form ever devised for the use of brain organoids – and he believes more communications outreach is needed to help the public understand what's going on in the labs. Most people consent because they want to find cures for diseases or neurological conditions, he said, but some decline because organoids can become conscious. "We try to be very specific on what are the cells that are going to be used," he said. "And you're going to have

no remuneration to your side."

The issue of remuneration involves intellectual property, and these kinds of problems will be the first issue for global governance to address with discoveries involving organoids because IP and ethics are closely linked, said François Rivasseau, a veteran French diplomat and Senior Consultant on Technology and Diplomacy at the World Intellectual Property Organization (WIPO). "First, we don't have an agreed definition of what an organoid is. When I review the literature, I find almost as many definitions as scientists," he said.

Other issues arise over consent by self-donors – and whether organoids might one day merit their own IP protections if they are seen as a type of sentient being. "We are here in uncharted territory," said Rivasseau. The problem of privacy is another area for consideration, he added, because DNA isn't an invention. "So how do you solve this issue?" he asked. "Very likely we would have different solutions within different jurisdictions. One in China, one in the US, one in Europe. Therefore, with artificial intelligence, we are not unified and in WIPO we are not yet even authorized to talk about trying to unify the solutions. And we should do better. It's divisive to use the word unification."

When considering the GESDA Science Breakthrough Radar's projections for the importance of organoids over the next quarter-century, he said, some "soft regulation" is probably needed and another potential "venue for international governance" for dealing with organoids might be the UN Human Rights Council in Geneva.

UNESCO has a bioethics committee that could be involved in these kinds of governance discussions because it has global reach, Austrian diplomat Claudia Reinprecht told the panel during the question-and-answer segment. The real question is: "How do you get the Global South involved in this kind of discussion?" One of the members of GESDA's youth cohort, Eloise Westfeldt, an American student at Switzerland's Collège du Léman, also recommended generating global discussion by incorporating the research "into school curriculums, into our biology classes."

More information

Explore this topic in the 2022 GESDA Science Breakthrough Radar®

Session recording on YouTube

Tweets related to the session

Takeaway Messages

Most of the biomedical sciences have been reliant on animal models, which is unsatisfactory for understanding the human brain.

Human organoids open a new window in science, including gaining more understanding of the human brain, but they present ethical and moral issues that should be examined. Several groups are working on generating synthetic human embryos in culture, which raises important questions.

High costs mean that research tends to overlook diseases in the Global South, where there's less of a developed market.

Organoids are not seen as morally neutral; tissue donors may perceive enduring personal connections with their organoids.

The issue of patient confidentiality can be easier for researchers to deal with if they don't know where the samples came from.

The issue of autonomy and consent – whether a patient should have a say in how their samples are used or lingering rights to them in these new applications – is a looming problem.

Eventually, organoids sending neural oscillations similar to an EEG may acquire some self-aware consciousness.

More communications outreach is needed to help the public understand what's going on in the labs; a member of GESDA's youth cohort recommends incorporating the research into school curricula.

Some soft regulation may be needed, and the UN Human Rights Council in Geneva and a UNESCO bioethics committee could be involved in governance discussions.

The issue of remuneration involves intellectual property, and these problems may be the first issue for global governance to address with discoveries involving organoids because IP and ethics are closely linked.

Wednesday 12 October, 19.30-21.00 CET

Public Plenary Session

In partnership with the Geneva Graduate Institute

Science Anticipation

Public Plenary Session: Synthetic Biology, towards new geopolitical and economic frontiers

Abstract

Technological advances in genetic engineering and synthetic biology lead to a fast-growing number of purposes such as biofuels, new drugs, replacement organs, and biological threats. The democratisation of such technologies, coupled with the decreasing cost of DNA synthesis, will allow a broader set of actors to generate new organisms, fuelling the need for addressing individual and societal challenges, while raising concerns about the governance of these technology innovations, capacity-building and benefit sharing. The weaponisation of biology could even lead to high-impact biological attacks that would be difficult to defend against. In this context, it is essential that policymakers and regulators explore the social, environmental, economic and geopolitical implications of such technology advances.

· At the cusp of an explosion of uses and products, how can we harness the benefits of synthetic cells, biosensors, synthetic organisms and more?

· What effect will synthetic biology applications have on ethics, geopolitics, science policy and society?

Join this session to hear leading experts present a future significantly shaped by synthetic biology.

Participants

Introductory Remarks by:

Jérôme Duberry, Managing Managing Director, Tech Hub; Academic Advisor, INP Executive Education; Senior Researcher, AHCD / CIES, Geneva Graduate Institute, Switzerland

Moderated by:

Jane Metcalfe, Co-founder, WIRED; Founder, NEO. Life, USA

With:

Peter Gluckman, President, International Science Council, New Zealand

Arancha Gonzalez Laya, Dean, SciencePo Paris School of International Studies, Spain

Andrew Hessel, Chairman, Genome Write-Project; Founder, Humane Genomics, USA

Timothy Swanson, Professor, International Economics; Academic Co-director, Centre for International Environmental Studies, Geneva Graduate Institute, USA

Keynote lecture

Synthetic Biology: Towards New Geopolitical and Economic Frontiers

With Andrew Hessel, Microbiologist and Distinguished Researcher, Autodesk

It is an absolute pleasure to be here. I am many things, but a lot of what I am is a troublemaker because I just enjoy speaking about these life technologies to anyone who will listen: kids, seniors, everyone in between. Because the only thing that we all have in common is life. It's the only thing. And yet it's the thing we think about the least.

Most people haven't heard of this technology called synthetic biology, which is still very much below the radar. And, if you ask them what it is, you'll get essentially no reasonable answer. Even the scientists have not agreed on what it is, only that it makes biology easier to engineer. It's a functional definition.

I'm always completely stunned by what an amazing species we are, and how unique we are. We're the only species that doesn't live in nature. We build our environments around us: our technology supports us; our engineering supports us. And it is a fast-changing world. It has changed so much in the last century – it's hard to even imagine. We've gone from an agrarian society to having cities like Hong Kong that are international, fast-paced. And the evolution of our technologies, cities and environments is only accelerating.

And there's this one technology that we just forget about, called life.

What you see on the screen [an image of a cup of coffee with a text written in the milk foam] is actually a computer-generated image from Dalle 2. I just told

this [AI] software to "show me a cup of coffee with the word 'life' written in foam" – and it produced this image. So, artificial intelligence is starting to get really creative.

But life was the first technology leap. It is a technology that makes us; we didn't make it. So, it's really unfamiliar to us. In fact, it's the only technology that really butts heads with religion. No one thinks their mobile phone was made by a god. Life is so universal. Ubiquitous. Everywhere. The deepest hole we drill. Bacterial colonies thrive in clouds. It is surrounding us everywhere. It's on every surface. It's in every breath we take. It's in our bodies. It makes our bodies. We are completely blind to it, like the air we breathe.

The only time we really notice it is when we're creating a new life. I don't get to share in that role that much. I had two children. I was totally fascinated by the process, in part because they started off in labs; they're both in vitro fecundation things. I spent more time in the lab than most dads. We also notice it mainly when it starts to fail, when we get sick, when our friends and family get sick, or they die. It's just because life is so reliable and so robust. We are just blind to it.

And all life is built on this incredible technology, this building block that we call the cell. The cell is my favourite machine. It's the only machine I really want to study anymore because it's mysterious. It's the Lego brick of all living things. And plant, animal or microbe: the machinery inside the cell, the low-level machinery, is conserved.
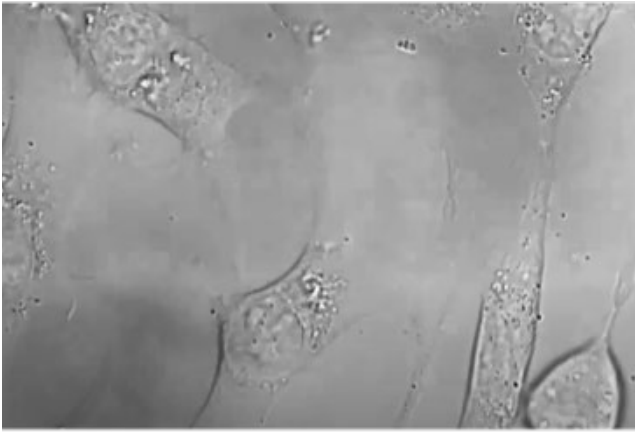
[On the screen] are human cells in a time lapse, growing in a dish – not ones that I've grown. The cell is a factory. It is a factory that makes thousands of different products that all come together and are built at the same time. And the most amazing thing about this factory is it can build more factories. No human technology can do that.

At Autodesk, a design company, we work very closely with companies that make 3D printers. 3D printing is a very interesting technology, but most can only print a single material. These are multi-material 3D printers that can make more 3D printers.

Take the *E. coli* bacteria. The beautiful thing about this little machine, this factory, is that it's been around for almost 4 billion years – older than us. Our bodies are actually designed to be farmers of this little organism. They grow in your guts and help digest your food and absorb it so that we can live. Under ideal conditions, they'll reproduce every 20 minutes. So, one bacterium will grow to over 50 billion bacteria in 12 hours. I love this organism – seriously.

I love comparing mobile phones with cells because, although very different mediums, they actually have very similar architectures. Both are systems of systems. And with the mobile phones, we started at the bottom and built up. We built the components. We started to build, put them together to make circuits. We made more complex circuits; we made networks. With biology, the cell, we started with – the thing, the object, the organism. And we've spent literally all of our time taking it apart, first classifying them, and then starting to dissect them. And today we do that molecular dissection all the way down to the single proteins and other components within the cell. It's been a journey of exploration that you don't need rockets for. You can do it really from just about anywhere. We are the gods of small things.

We just don't understand how they work. Take the genome of an *E. coli*. That's the molecular thread of DNA and it encodes about 4,500,000 bits of information. To give you an idea of how much

information that is, it's one photo on your phone. And yet that's enough information to build an organism that has persisted for billions of years.

Today we have microscopes that can allow us to directly visualize the double helix of DNA. We can even read the sequence of that code in the helix if we choose to – but it's not the most efficient way of doing it.

Biotechnology simply explained is DNA + cell/cell-free systems = biological products (an apple, fuel, a drug, an animal). This is biology really dumbed down – because I speak to a lot of kids. But this is really the whole. This is the meat and potatoes of biotech. If you have a segment of DNA that encodes something you want, something that's useful. And you can put it into a bacterial cell, or even a cell free system where you just break cells open and put the components in a tube. Those components or cells will use the instructions in DNA to make biological products. Whatever you've designed in that code: it could be a protein for food; it could be a high energy molecule like a fuel; it could be a medicine; it could be a structural material; it could be the whole organism edited or engineered.

We don't know the limits of this, it's so universal. Because there's only one programming language for all living things. Unlike our computer systems, which are very fragmented and very diverse systems. And the take-home message that I try and deliver to everyone is that, if you can write DNA, if you can read it and write it – because it's a programming language – you can engineer anything biological. Anything. Any living thing that has ever existed on this planet uses this programming language. And every component thereof. So, it's a really, really powerful language.

We've done that engineering in labs. And the labs haven't really changed much in the last 100 years. They're basically just complicated kitchens. For the most part, the people working in those kitchens were doing manual processes. When I started off, if you could sequence a few hundred base pairs of DNA code and say anything useful about it, you got a PhD. Today, in just a few hours, you can sequence a human genome sitting on a bench like this using equipment.

The manual processes are being changed; they're being digitized. And it's because of the manual processes, you had to manipulate the actual molecule of DNA. We use molecular scissors and molecular glue to stitch things together to write new code. That just doesn't scale. I actually sat down with magazines, scissors and glue and wrote out this quote from a synthetic biologist. It took me an hour and 20 minutes. It looks Frankenstein-ish. It's scary. We used to have ransom notes written like this.

Quote by Stanford synthetic biologist Drew Endy

Today, just like the film industry, just like the music industry, genetic engineering has been digitized. Synthetic biology is just the intersection of our growing knowledge of life science, combined with this foundation of computing that we've built over the last 50-60 years, intersecting now with automation, essentially just robotics.

With computation and life science together, you get bioinformatics or systems biology. That's where I started my biological career. Take life science and automation and put it together, and you get machines sitting on desks that are much more powerful and reliable than its people.

Put computation and automation together, and you get the amazing world of machine learning and artificial intelligence. And when those three intersect, we get this incredible new technology that gives us the ability to manipulate life digitally and physically with very powerful tools.
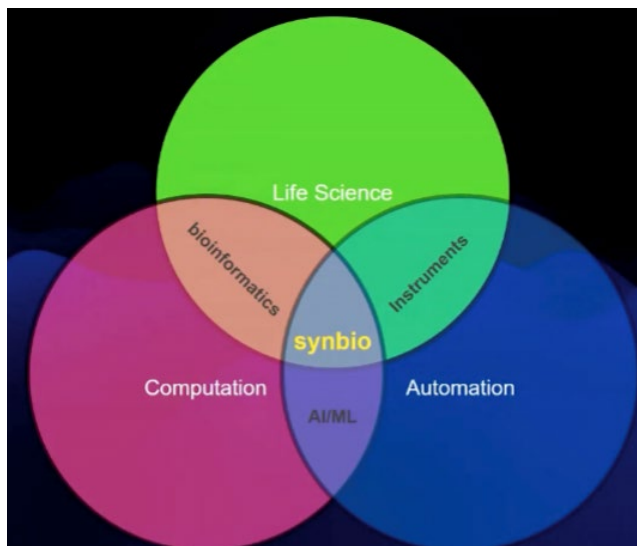
Today, the reading of DNA – something that was seeded in 1990 seriously with the Human Genome Project – is an automated process. A few technicians can run armies of sequencers with all the information flowing into computer systems. The software tools for designing and editing DNA are getting more and more powerful. They run on your laptop. They're not that tough. And the artificial intelligence that's being applied to the software is giving us new capabilities that we're just starting to explore. Because, in the same way that I made that cup of coffee I mentioned, you can now design a protein that has certain features, and the artificial intelligence will try to do that.

Instead of manipulating the DNA molecule physically, we also have printers for it now or services that do it. But many of these services will print out as much DNA as you send them in a file, and it will be shipped to you in a day. This is genetic engineering. It used to be something that required years of training, specialized facilities, free agents that were very hard to come by. Today it's something I can teach a seven-year-old – at least the very basics.

The labs themselves are becoming automated, so you don't need those physical laboratories. I started working with "cloud labs" over a decade ago: these are programmable laboratories. So now you have a whole digital path from design compilation of genetic code to ultimately the manipulations that would normally have to be done manually, all using a programmable facility. It's essentially a closed loop.

And those technologies are coming to chips. The first molecular electronic chip published earlier this year. It took six years to develop. It is the same chip that might be in a computer or mobile phone, but now you can attach biomolecules to it. It has 16,000 bio transistors, so to speak. It's the equivalent of

the first computer processors that were developed in the early 1970s. So, this is an incredible new technology that's just starting to appear. And this is the game changer. Because when you can make a chip, it suddenly costs just a few dollars to make incredibly powerful technology.

Life is becoming more and more programmable. People argue whether it's programming or not. It doesn't matter to me. We can now engineer life using digital tools. And because it rests on a digital foundation, it has everything we know digital technologies do. They get faster, better, cheaper, smaller. Everywhere. My fridge is Wi-Fi connected today. It's allowing small groups of people, even individuals with the right tools, to do genetic engineering, to do biotechnology. We can make nucleic acids to reprogramme cells. We can make virtually any protein. Google's DeepMind division just solved the structure computationally of every protein ever published. This is now going to move into a design phase. We've started to engineer small organisms like viruses. The first virus was made from scratch 20 years ago. This is not new. It's something that's been happening for a while. But now the field is starting to accelerate.

And just so you understand how I think about viruses, because I have a company that makes them, they're just a USB stick. Without a cell to plug into, like a computer to plug into, they're completely inert. Some of these viruses are harmful to us. The vast majority of them are harmless. But as we start engineering them, they could be far deadlier than anything nature has ever produced. Nature cannot make highly infectious, highly pathogenic viruses, and so it kills all the computers that they would run on. That's no blockage for us.

Twelve years ago, Dr Craig Venter and his team synthesized the first bacterial genome. This is ancient history in digital times. But most people aren't aware that this has even been done. I don't think this work is properly recognized: it closed a 4-billion-year cycle of evolution from the first cell naturally appearing in our primordial oceans or wherever to evolving an organism that understands enough of biotechnology to synthesize a new bacterium. That's pretty remarkable. So, if you're on the Nobel committee, please recognize this work. It's absolutely the foundation of synthetic life.

We've been climbing up now that we know we can make synthetic cells. Three years ago, the *E. coli* bacteria was synthesized from scratch. There's now a company that's built around that technology that's going to create a Cambrian explosion of new bacterial designs. By the time my kids are old enough to go to university, they'll be doing this work every day. Because it's only four-and-a-half million bits in an *E. coli*. And when things get faster, better,

cheaper, it'll cost a few dollars to synthesize the bacterial gene.

Scientists today are on the cusp of synthesizing the yeast genome, they're literally debugging this bug. It's a single-cell organism. Yeast is what we use for making bread and beer. But it's about a billion years more evolved than *E. coli*. It's closer to you and me. So, we're learning a ton of genome engineering technologies from this work, and it's nearing the end. It's been a lot longer than they thought.

This summarizes where we go from here. It's taken 20 years to build the foundational synthetic technologies, to start building proteins, circuits and the simplest organisms. We're starting to move into mega-base size synthetic DNA constructs. That's whole chromosomes. The smallest human chromosome is 50 million base pairs. We're going to be synthesizing human chromosomes. And most chromosomes and plant chromosomes very shortly. After that, I don't know where it goes. I just know it changes the world.

It's our intention that's going to drive evolution. We're already using these tools of editing synthesis in conservation, trying to protect some of the organisms that we nearly destroyed. We're even de-extincting some of the more recently lost organisms. Because DNA is a really tough molecule and can last unprotected for millions of years, we can recover these genomes and resynthesize them.

And of course, we're going to use them on ourselves. There's already been reports of the first gene-edited babies in China – unconfirmed scientifically because [the authors of this breakthrough] are not exactly transparent. But believe me, it's not that hard to engineer anything in human chromosomes, either. This writing of a human genome or parts thereof will give us not just the technology to diagnose every disease – that's what sequencing gave us, another technology. It'll give us the ability to cure any genetic disease. It'll give us the ability to enhance. And maybe that's not what you want, but you can bet there are people out there that want to do that. So, I think it's naive to not think these are going to be applied to us as well. And fairly soon.

That's not the end; it's going to keep going. There's no species barrier in general. We can mix and match across every living organism. So, we're going to make organisms that nature couldn't. I don't know what those will be. We'll be shocked and surprised.

There's a giant economic driver for this. A [paper](#) was published a few years ago by a group that was funding synthetic biology companies. They said:

the global economy is about $100 trillion, and it doubles about every 25 years. But a lot of these industries are already maxing out the capacity of natural resources to sustain them. Biology is going to fill that gap. Biology is the most natural of natural resources. Where do you think the oil came from? Today, we don't have to refine them. We can just make the stuff that we want, whether it's a polymer, high energy molecule, etc. So, there is a giant economic driver to push these technologies forward. It's going to happen faster than almost anyone expects because the factories are everywhere. So, it's going to be rate limited by our ability to code. And of course, our ability to code is being accelerated through artificial intelligence and design tools. Today, the rate limiting step is how fast we can synthesize DNA, and that's going to improve very quickly. After that, it'll be our ability to test the organisms and designs that we make.

So, this is a world-changing technology. No exaggeration. This will change the living world, this planet on which all life that we know of exists. It's fundamentally going to change economies in the same way that digital technologies have changed the economy. It's going to need regulation. I have no idea what regulation is going to do because if I look at the digital technologies that we're built on, the regulations came after the technology. It moved so quickly that it surprised everyone, and synthetic biology is going to move even faster.

There are some real risks with this technology, because the smallest organisms, these viruses, are the ones that spread the fastest, and they're also the easiest to synthesize. I thought COVID-19 would be the wake-up call for getting our shit together, folks – pardon my language. But it hasn't happened yet. But this field is still in its very earliest days; it's in its absolute infancy. There have only been three synthetic cells made to date. A few hundred viral species, a few thousand proteins. There's time to organize.

We can look to our experience from computing. Because we built those systems without any foreknowledge. We were pioneering this space, were naive, and silly. We connected computers without putting in firewalls, immunity. Biology figured all this out ages ago. We just need to get more young people working in this field. I'm a little sad that this room isn't filled with graduate students because they're the ones that will be building this technology and driving the very forefront of it.

I remember these computer systems appearing. In the 1970s, they were only available to large organizations, governments, military and industry. When these devices came around the holy trinity of personal computing, they started to open up to millions and millions of more people, including me. It shaped my

life; it still does. We worried about the worst-case scenarios. We made fantastic movies about this. There's War Game. There's been plenty of them.

And we've made tons of mistakes with computer systems and still do. But the reality is, everyone here has … a mobile phone. It's become a foundational part of our society. They work well enough that we trust them. They run our most crucial systems.

I'm an optimist when it comes to these technologies. We'll figure it out. It's really hard to see and anticipate what's going to happen in synthetic biology. It's just so early. But I truly believe that our experience and the lessons we learned in digital systems can and should be applied to synthetic biology, so we avoid the biggest pitfalls. We know that this needs to be an open and transparent network because, again, it's universal for all life, all humans. We can't have the monopolies; we can't have the lack of access that we sometimes see with other digital technologies.

We need to take the lessons and use them as our starting point for this new foundation because our evolution as a species isn't over. In fact, it's just starting to get interesting because we finally got the reins. If we're going to build a new relationship with nature, you can bet that we're going to want dominion over it. It's going to take everybody coming together to figure out what that looks like.

Thank you for listening to me.

Highlights

Scientists have been searching for a "golden spike" – radionuclides, fly ash or core samples taken from ice, mud or rock, for example – that shows we've entered a new Anthropocene epoch of geological time marking when humans became the primary driver of planetary impact. Regardless of what geologists decide, said the session's moderator, Jane Metcalfe, Founder of Neo.Life and Co-Founder of Wired magazine, we've certainly entered a new phase as a species "in which our tools are now so powerful and our impact is potentially so great that we can literally destroy *Homo sapiens* as we know them, along with the planet."

Yet, for 70 years, we've navigated the atomic era without blowing ourselves up, Metcalfe noted, and it's possible the advent of "new god-like, powerful synthetic biology tools" for rewiring or reprogramming organisms can likewise be harnessed for good to fight climate change, create new materials, cure human diseases or bring back lost species.

Andrew Hessel, a microbiologist and distinguished researcher with Autodesk who studied bacterial genomics and ended up in pharma, is leading an effort to write with DNA, synthesising genomes from scratch. Hessel, co-author of [The Genesis Machine: Our Quest to Rewrite Life in the Age of Synthetic Biology](#), noted that we're the only species that doesn't live in nature but re-engineers life's technology to support us. "It is a technology that makes us; we didn't make it," he said. "The only time we really notice it is when we're creating a new life." His favourite machine, the cell, is the Lego brick of all living things, a factory that makes thousands of different products. "And the most amazing thing about this factory is it can build more factories. No human technology can do that," he said.

Like 3D printers, Hessel said, the *E. coli* bacteria is a factory that's been around for almost 4 billion years, but scientists recently made it from human-made DNA, opening a door to designer bacteria. "If you have a segment of DNA that encodes something, you want something that's useful. And you can put it into a bacterial cell or other cell or even a cell-free system, where you just break cells open and put the components in a tube. Those components or cells will use the instructions in DNA to make biological products. Whatever you've designed in that code, it could be a protein for food. It could be a high energy molecule like a fuel. It could be a medicine. It could be a structural material. It could be the whole organism," said Hessel. "We don't know the limits of this. It's so universal because there's only one programming language for all living things, unlike our computer systems."

Pragmatism, rather than optimism or pessimism, is an effective lens for considering humanity's ceaseless "arms race" between new technologies like synthetic biology, according to Sir Peter Gluckman, President of the International Science Council and member of GESDA's Diplomacy Forum, who trained as a paediatrician and has published half a dozen books and more than 700 scientific papers on evolutionary biology, neurobiology and other topics. "One technology leads to another technology to deal with that technology. When we invented the spear, somebody had to invent the shield. And then we had to invent something stronger to pierce the shield, which led to armour and to something else, and so on. We ended up with ballistic missiles, and we now use other missiles to shoot down missiles," he said, emphasizing a common theme of GESDA's work – the rapid pace of technological development – which leads to the big diplomatic issue of our time: "How do we get to a depth of differing technological regulation at speed?"

Peter Gluckman

Jurisdiction across borders is another issue. "Viruses, bacteria don't need passports," Gluckman said. "And, if we just think about the pragmatic reality of the world we're in now, where we have very distinct techno poles emerging between – just in the digital world, between China and America, with Europe trying to be something in the middle – the ideas of getting consistent technological regulation on the digital technology are not there. Now, you put on top of that the geostrategic issues of our times: China versus America, now Russia versus the West. The issue of how we get a compromise on something rapidly moving into this technology is the diplomatic challenge of our time. I don't know how we will do it."

China and the United States aren't yet in a Cold War, but we're headed towards "a two-world, two-system" approach to new technology, or "maybe two-and-a-half, maybe three," because while breaking down frontiers of science and technology, "the real world is erecting barriers" due to geopolitical and economic challenges, said Arancha González Laya, a lawyer and dean of the Paris School of International Affairs

at Sciences Po. She has served as Spain's Minister of Foreign Affairs, European Union and Cooperation; UN Assistant Secretary-General and Executive Director of the International Trade Centre; and Chief of Staff to World Trade Organization Director-General Pascal Lamy. "We're living in a moment of power competition and technology and science-based power. It's geopolitical power. It's military power. Imagine bio-enhanced soldiers. This is not a dream. That's what we're talking about. And, of course, there is a power competition also on the economy." Her advice? Something along the lines of what GESDA is doing.

"We need to create a space for this conversation to take place. This space does not exist," González Laya said. "This space needs to be with scientists at the table, with the business at the table, and the non-state actors," she said. "But we have to start this conversation because there are huge dimensions that will have huge impact." She recommended having conversations about societal boundaries before governments set regulations, opposite to today's usual process of "fragmented regulation" that concentrates wealth. "Maybe we start by moving guidelines that would help in every constituency," she said. "How to manage, how to leverage, how to limit in order to get the benefits." When an audience member asked if people in the Global South should have to respect regulations when they don't participate in the science, González Laya said the question shows a need for "fairness and building spaces where this diversity is put together" that can add to "the legitimacy of the end result."

Synthetic biology is an information-based industry that has developed similarly to how other information-based industries developed over the past half a century, said Timothy Swanson, Professor of International Economics and Academic Co-Director of the Geneva Graduate Institute's Centre for Environmental Studies. He recalled a meeting in Redmond, Washington, where Microsoft Founder Bill Gates' associates wanted to develop an industrial business campus with "nothing in his pocket" but an IBM contract. "The fundamental problem of information-based industries is that – and this is Arrow's fundamental paradox of information – the only way that you can capture the value of information is to attach it to something else, like a patent," Swanson said. "Gates knew he was going to take away the IBM monopoly, the operating system monopoly with MS-DOS, and he knew he was going to take away the business programme monopoly with Windows and then Word and Excel. So essentially walking in there in 1982, he already saw it all."

Later while teaching at Cambridge, Swanson said, British government officials asked him to study

agricultural crop yields worldwide – an example of why new technologies like synthetic biology must be "diffused" for people to share in the benefits. "The top two crops in terms of expansion were maize and sorghum. Maize and sorghum are two crops where, essentially, the information is embedded in the plant because of hybrid varieties. You can actually capture the information in the plant. [With] these two, we had the fastest growth at the frontier, but they didn't diffuse. They were the slowest growing and, in fact, the poorest countries in the world were falling further from the technological frontier with every year of the Green Revolution. So, you had this amazing paradox, once again, of the private sector finding an area in which they can appropriate the information," he said. "But at the same time, it compacted the information, and it wouldn't diffuse."

The rapidly developing global synthetic biology market, worth an estimated $9.3 billion in 2021, is forecast to more than quintuple to $52 billion by 2028 as it offers solutions in agriculture, manufacturing and medicine, among other fields, according to ResearchAndMarkets.com. In recent months, for example, scientists used synthetic biology to create artificial enzymes programmed to target the genetic code of SARS-CoV-2 and destroy the virus, which could be used to develop a new generation of antiviral drugs. But the big issue of our time, said Gluckman, is how diplomats and the governments they represent grapple with this fast development. "How do we get to a depth of differing technological regulation at speed?" he asked. "Ideally, you want to regulate technologies to magnify the benefit of the upside and reduce the risk of the downsides. You will never obviate the risks of the downsides, but you can try to constrain them. I don't think anybody knows how to do it. I really don't. Part of the problem, of course, is that the technologies now emerge out of nowhere."

Arancha Gonzalez Laya

Takeaway Messages

We've entered a new phase as a species, developing tools so powerful we could bring about our own extinction and, potentially, destroy the planet – but we've survived so far in the atomic era.

New and powerful synthetic biology tools are emerging that can rewire organisms, fight climate change, create new materials, cure human diseases or bring back lost species.

Synthetic biology is an information-based industry similar to how other information-based industries developed over the past half-century.

E. coli bacteria has been around for almost 4 billion years, but scientists recently made it from human-made DNA, opening a door to designer bacteria.

We need to create a space for conversations about science and diplomacy to occur, along the lines of what GESDA is doing, to avoid living in a world of conflicting regulations for new technologies largely based on different approaches taken in China, Europe and the United States.

Fairness and diversity are needed to include the Global South and add legitimacy to the result.

Regulation of synthetic biology involves diplomacy and is a common theme of GESDA's work: How do governments deal with the rapid pace of technological development?

Pragmatism, rather than optimism or pessimism, is an effective lens for considering humanity's ceaseless arms race for new technologies, like synthetic biology.

More information

Explore this topic in the 2022 GESDA Science Breakthrough Radar®

Session recording on YouTube

Tweets related to the session

Science Anticipation

Deciphering the Human Immunome with AI for Better Therapeutics

Abstract

The biggest difference between two individuals doesn't lie in their physical traits, but in the set of genes and proteins that constitute their immune systems. This complex ecosystem – the immunome – may hold the key to biggest health breakthroughs in the 21st century. Like the sequencing of the human genome, mapping myriad immunomes across diverse populations will advance immunology, opening avenues of innovation in health diagnostics and therapeutics. With the new help of machine learning (AI), breakthroughs will likely materialize in the next decade and could even lead toward human enhancement technologies.

- How can medical professionals, scientists, and policymakers manage the enormous transformation a mapped immunome will bring?

- Can such a project remain open and coordinated among representative stakeholders?

Join this session to delve into the benefits and risks of groundbreaking science and to discuss the vast opportunity for governments and societies.

Participants

Moderated by:

Samia Hurst, Professor of Ethics, University of Geneva, Switzerland

With:

Jacques Fellay, Co-director Health Genome Center, EPF Lausanne/University of Geneva, Switzerland

Wayne Koff, President & Chief Executive Officer, Human Vaccines Project, USA

Jürgen Schmidhuber, Director & Professor, The Swiss AI Lab IDSIA; Co-founder & Chief Scientist, NNAISENSE, Germany

Soumya Swaminathan, Chief Scientist, World Health Organization, India

Chorh Chuan Tan, Chief Health Scientist, Ministry of Health of Singapore; Board Member, GESDA, Singapore

Highlights

The potential of decoding the human immune system, the genetic underpinnings of people's ability to respond and adapt to a huge range of diseases, is a major frontier in science. This complex system of genes, immune cells, proteins and tissues, and everything that ever happened to it – the immunome – differs among us, keeps changing and is our biggest distinguishing characteristic.

Learning how the immunome works, which requires the help of artificial intelligence (AI), could unlock major health breakthroughs. But it's a vastly bigger undertaking than the Human Genome Project, which was launched in 1990 and completed in 2003. An international group of researchers set out to study all of the DNA, or genome, of a set of organisms and generated the first sequence of the human genome, accelerating the study of biology and practice of medicine. Our immune system is billions of times more complex than our genome, so researchers lacked the tools to study it until this past decade.

"Our challenge is that we have an unprecedented amount of data. We don't understand the data. Luckily, though, in the past decade there have been incredible, incredible advances in AI and machine learning," said Wayne Koff, President and Chief Executive Officer of the Human Immunome Project. "What we want to do in the Human Immunome Project is to bring these two worlds into one." A month before the GESDA Summit, they did exactly that at a Human Immunome AI Summit in La Jolla, California. "It's the initial one of a range of meetings we're going to do all over the world. We'll do one in Africa, we'll do one in Asia, we'll do one here in Europe. The goal of the meeting, which brought together leading immunologists, assistant biologists and AI experts, is to begin to understand how we get from where we are now, which is a lack of understanding of the immune system, to where we want to get to, which is an AI model of the human immune system," he said.

"The impact, if we are successful, is going to be across all diseases, infectious diseases, the ones we haven't been able to tackle, like AIDS, tuberculosis, malaria; the non-communicable diseases like Alzheimer's, cancer and multiple sclerosis. We need a lot of help," said Koff. A series of partnerships from academia, industry, NGOs and governments – with labs worldwide – is needed to work on this problem, he said. "We need to work in Africa, we need to work in Asia, we need to work in individuals who are most vulnerable on a range of diseases – the elderly, the maternal infants and those living in the developing world."

Audience member and GESDA Board Vice-Chairman Patrick Aebischer said that a lot of big science projects on the human brain have been

"struggling, because there are no clear endpoints," and the projects get bogged down in "geographical competition" between China, Europe, the US and UK, leading him to ask: "How would you foresee and avoid those pitfalls in the immunome project?" Koff said it will take a pilot project and "a range of partnerships, academic and industry, NGOs and governments" to avoid those pitfalls.

Modern AI's deep artificial neural networks are somewhat inspired by the human brain, which has about 100 billion little processors called neurons that take in audio and video signals and trigger our muscles. In between each of them are tens of thousands of connections that add up to a quadrillion connections in our brains, which, from birth, are fine-tuned through learning. "The same is true for our neural networks that are big and deep and learn to predict," said Jürgen Schmidhuber, an AI scientist who is Director and Professor at the Swiss AI Lab IDSIA, one of four Swiss research organizations founded by the Dalle Molle Foundation. Schmidhuber is also the Co-Founder and Chief Scientist of Swiss AI company NNAISENSE.

"It depends on how much data you can collect from many different people to fix the quality of the systems that are going to predict the consequences of actions depending on the data that you can collect from people. Here there is one big issue, which is privacy. In certain authoritarian states, privacy is not an issue. But in Switzerland, or in most European or Western nations, it's a big issue," said Schmidhuber. "You really want to have a system which collects lots of data from lots of different persons in a way that keeps that privacy sphere intact. This is leading to all kinds of challenges, but then also solutions." He proposed launching a market-based system for data in which patients would own and sell their data.

Tan Chorh Chuan, a GESDA Board Member and Chief Health Scientist of Singapore's Ministry of Health, said that many of lessons from the

Soumya Swaminathan

Wayne Koff

pandemic are applicable to learning about the immunome. "The preservation of public trust is very critical," he said. "We owe a duty to keep the public informed as through the safeguards we put in place, to make sure that even as we extract insights from their data, we are taking all the steps necessary to protect the confidentiality. So, I think government can play a very important role here."

In Singapore, said Tan, the government took steps in that direction, but a broader governance infrastructure needs to be built. "This is already very, very difficult within the country. When you think about sharing data across jurisdictions, the challenges are compounded and therefore we do need additional approaches – like federated learning approaches – that allow interrogation of data *in situ* without having to move data across jurisdictions," he said. We need to address the fundamental issues of data in order to proceed at the scale that's required, said Tan.

Soumya Swaminathan, Chief Scientist at the World Health Organization (WHO), said the UN health agency has been trying to address issues of data-sharing that arose during the pandemic. "Setting the standards and interoperable data standards is also an important role for us and is part of our strategy on digital health," she said. We're doing that to [encourage] countries to put in place exactly the governance, stewardship elements, the financing elements, the infrastructure. But very critical is the data-sharing policies."

The issue of giving credit to others who share their data is an important ethical consideration for WHO to think about with the Human Immunome Project, said Swaminathan, and "all of these have to be accompanied by ethical frameworks as well." She also suggested more consideration of equity issues as the technology is being developed rather than in a later stage, "because very often we think about it at the end when we are already seeing that there are large numbers of people who are left out." When thinking about new technologies, "we have to start

thinking about equity. In AI, of course, this is very important because of the representativeness of the population and the data that you're feeding into the algorithms," she added.

The situation now is similar to what happened in genomics a quarter-century ago, said Jacques Fellay, a medical doctor and researcher who is the Founding Director of the Precision Medicine Unit of the Lausanne University Hospital (CHUV) and leads a genomics laboratory at the Swiss Federal Institute of Technology in Lausanne (EPFL) School of Life Sciences. "Probably the community at the time did not believe that it would be possible to get worldwide efforts that would lead to the first Human Genome Project and then the 1,000 Genomes Project and others. And still it succeeded. It was possible with retrospectively easy targets, because reading the genome once and for all, it went fine. That wasn't that complicated. And we could call it a day at the end of the 3.2 billion letters of the genome," he recalled.

"We are pretty much at the same place with the immunome project today. It's not that we have a blank page, and nothing has been done. There are excellent research groups working on putting together the knowledge on immunity since a decade and especially over the past few years, thanks to advances, especially in AI," said Fellay. "Some of the main challenges are related to accumulation of enough data and the transnational

Samia Hurst

sharing of those data in a way that respects individuals," he said. "Here, there is something that is slowly happening and that should be accelerated; and the immunome project can be some kind of a catalyser for that. It's the transformation of the healthcare system into research in a crisis. This will be needed for this project, will be needed for all healthcare to become much more reactive and much more of a learning experience for everyone," he said.

"If you want to accelerate the improvement of tools, drugs and strategies, we really need every citizen, every patient that is willing to share data and become research participants to get opted in into being research participants," said Fellay.

Audience member and GESDA Board Member Sir Jeremy Farrar, Director of the Wellcome Trust, urged the panel to be cautious about being overly simplistic about big global projects and going back to the Human Genome Project again and again. "There are many other big, apparently global projects which have been a disaster and have eaten up so much time and energy by just running the thing that they haven't delivered on the goals of the thing. The human genome was special but it's not necessarily the model for everything else," he said.

"Everybody always says to me, this is a role for WHO," said Farrar. "WHO can't do everything, and

Chorh Chuan Tan

we can't keep putting stuff on them, saying 'that's your responsibility' but then not give them any of the ability to do that. The money or the people." He added: "I think we should be really cautious about saying, 'WHO, this is your responsibility.' I can't imagine WHO being given responsibility for running the Human Genome Project many years ago."

Swaminathan agreed: "WHO can't coordinate these massive global projects. I think WHO's role is to set some standards, provide guidelines around the ethics, around regulation. And then countries and others have to implement."

Takeaway Messages

The potential of decoding the human immune system – the genetic underpinnings of people's ability to respond and adapt to a range of diseases – is a major frontier in science.

Researchers have an unprecedented amount of data and need artificial intelligence (AI) and machine learning to understand it and, using AI, create a model of the human immune system.

If successful, the model could be used on infectious diseases, including AIDS, tuberculosis, and malaria, and non-communicable diseases like Alzheimer's, cancer and multiple sclerosis.

Researchers need partnerships with academia, industry, NGOs and governments to be able to work in labs worldwide in ways that benefit the people most vulnerable to a range of diseases.

Data privacy is an important issue in a system that collects data from lots of different people, including data-sharing across jurisdictions.

International standards and guidelines are needed on the ethics of immunome research and data.

More information

Session recording on YouTube

Tweets related to the session

Science Anticipation

What are the Limits in the Digitalization of Conflicts?

Abstract

Machine-learning, data policies, and social media platforms are already adding complexity to the conflict zone, and conventional technologies are being continuously enhanced by digital capabilities and computer systems. In the future, nanotechnologies could upend international policies. Exposed health data could put individuals at risk from precisionengineered pathogens. Governments require a much deeper expertise to respond to unconventional threats. Ultimately, reliance on non-state actors, large global tech companies, and informal citizen groups to engage in direct political actions may be a standard part of conflict and intervention, but we cannot wait until tomorrow to assess the boundaries of this transformation.

- What are the best diplomatic approaches to such destabilizing forces?

- How can governments and societies move forward and address this ideological change in the boundaries of conflict?

Join this session to debate where red lines may emerge in 21st century conflict and which resolutions are needed to sustain security for all.

Participants

Moderated by:

Anja Kaspersen, Senior Fellow, Carnegie Council for Ethics in International Affairs, Norway

With:

Kobi Leins, Visiting Honorary Research Fellow, Centre for Science and Security Studies, Department of War Studies, King's College London, Australia

Charlotte Lindsey, Chief Public Policy Officer, CyberPeace Institute, Switzerland

Elina Noor, Director, Political-Security Affairs; Deputy Director, Washington, D.C. Office, Asia Society Policy Institute, Malaysia

Jean-Marc Rickli, Head of Global and Emerging Risks, Geneva Centre for Security Policy, Switzerland

Balthasar Staehelin, Special Envoy for Foresight and Techplomacy, International Committee of the Red Cross, Switzerland

Highlights

The disruptive, unanticipated effects from a convergence of digital technologies and geopolitics began accelerating rapidly with Russia's invasion of Ukraine in February 2022. The conflict drew in digital platforms, technology companies and international volunteers along with governments and a range of opponents and allies. Supporters began sending money to Ukrainians by booking Airbnb stays they didn't intend to use. Elon Musk's SpaceX donated 20,000 Starlink satellite units, which kept Ukraine's military connected. Volunteers showed up to fight. Russia struck Ukraine with Iranian-made Shahed drones. Ukraine's navy deployed a fleet of explosive-laden drone boats. Ukraine's digital outreach to Russians tried to counter Kremlin disinformation. Ukraine President Volodymyr Zelenskyy's tech and social media savvy response became a model of digital leadership.

With this range of cyber involvement and weaponization of data, the lines between direct and indirect participation in conflicts is becoming blurred, according to Charlotte Lindsey Curtet, Chief Public Policy Officer for the Geneva-based CyberPeace Institute, which has been monitoring cyberattacks in Ukraine since the war broke out with Russia's invasion in February 2022. What it shows the world is that the limits, if there are any, are unknown, she said, and it will be difficult to set up guardrails with such a wide range of involvement or surrogate warfare – but it's critical to identify red lines amid the world's rising polarization.

"We've been monitoring now more than 500 attacks happening against critical infrastructure: things essential for the survival of the civilian population. And that is not just affecting the two belligerent countries, that's affecting 33 other countries, all linked to that conflict," said Curtet. "What we have been able to monitor so far is 58 different threat actors that have actually self-attributed the attack that they have committed. This means that there's probably a lot of other acts that we have not yet either aggregated or publicly made available details of these attacks, because we haven't been able to confirm the details of the attack. What is critical there is we are seeing that coming from actors around the world. And that can be loosely affiliated actors to state, it can be state actors, it can be non-state actors, and it can also be what's called hacktivists or collectivists who have been carrying out attacks."

Things get even more interesting when one considers the ways of using remote technologies to "intervene in the human body," said Kobi Leins, an international lawyer, author of *New War Technologies and International Law: The Legal Limits to Weaponising Nanomaterials* and honorary

Senior Fellow in the Department of War Studies at King's College London. Her research looks at how some nanomaterials have been weaponized through neurological and biological applications. The combination of AI, nanotechnology and biotechnology can be used to create unmanned intelligent robotic systems able to navigate dangerous environments with weapons of mass destruction.

Leins noted that optogenetics is already being used to create or erase memories in people, or to prompt them to have different reactions than they would normally have. Micro-targeting is being used on Facebook to track users throughout the internet. The connection between these emerging technologies should be examined more closely, according to Leins. "There are a lot of invasive technologies now," she said. "I don't think people fully appreciate exactly what's being collected, what's being curated and, particularly, what data brokers are stitching together in the background – ostensibly anonymously, but you can be re-identified very easily."

One of the first militant groups to control the information space in this way was the Islamic State (IS), which emerged from the chaos of Syria's civil war to wrest control of broad regions of Iraq and Syria in 2014. It's an example of how non-government forces can innovate, said Jean-Marc Rickli, Head of Global and Emerging Risks at the Geneva Centre for Security Policy in Geneva and co-author of *Surrogate Warfare: The Transformation of War in the Twenty-first Century*. Eight years ago, IS declared an Islamic caliphate and killed and executed thousands of people before it was defeated by international forces in 2017. Thousands of militants went into hiding but were still able to carry out attacks.

"They were the first to understand how to militarize social media by using hyper violence with the virality of the social media. They were the first organization, non-state organization, to develop active chemical programmes with research labs," said Rickli. "On 72 occasions, the Islamic State used chemical weapons in both Iraq and Syria. And finally, they were the first non-state organization to ever win tactical air supremacy against traditional state actors during the Battle of Mosul. How did they do that? They basically built commercial drones, DJI drones, replaced a camera of a small part that contained a hand grenade and, during the Battle of Mosul, up to 30 Iraqi soldiers lost their lives on a weekly basis."

What it means, said Rickli, is that as far back as a decade ago, digital technologies began proliferating in warfare at a rate that outpaced governments' ability to counter them. "Proliferation is impossible to stop. So even though you develop technology with

good intentions in mind, these could be repurposed by bad actors," he said. "What is new is with the growing autonomy of technology thanks to artificial intelligence, technology increasingly becomes an actor on its own."

Technology and digitalization are most often viewed from an economic standpoint in Southeast Asia but there should be more thought put into how the data is used, said Elina Noor, Asia Society Policy Institute's Director of Political-Security Affairs and Deputy Director of its Washington office. "We need to be thinking also about how this data that's being accumulated – whether it's for surveillance purposes, not necessarily nefarious, but just to promote efficiency and efficacy in many services – how this might be used in the future in conflict situations," she told the panel.

Peter Maurer

"These lines of fragmentation along ethnicity, along religion or along culture, particularly in very diverse regions like Southeast Asia – if those lines are already there, then obviously the propensity for misinformation, disinformation and hate speech becomes even more significant. These are already being exploited in places like Myanmar with social media. If we dig deeper into the numbers, many countries in Southeast Asia rely on social media as their first point of contact for news," said Noor.

In the South China Sea, intelligence gathering initially focused on open-source materials about energy and other natural resources little more than a decade ago. But, in recent years, governments began using these digital tools to target law firms involved in arbitration fights over the resource-rich region, which has vast oil and natural gas reserves and fishing grounds crucial for food supplies. "Digital trade arrangements are no longer just digital trade arrangements. We see this in arrangements like the Indo-Pacific economic framework, which the US government has said is not your typical trade arrangement. It involves standards, it involves rules, it involves regulations. If we think in terms of silos,

where digital trade arrangements just have to do with trade and economics, we're going to be sadly mistaken. Because the data that's collected through these agreements, whether they are localized or whether they flew across borders, is going to have an impact on the people whose data is being collected," said Noor.

"It is in the Global South that we now have a prevalence of conflicts, unfortunately, for different reasons than what's happening in Ukraine. But we need to stop with this dissonance of what happens in a trade and economic sphere does not cross over into the political or peace and security sphere," said Noor.

Audience member Anne-Marie Buzatu, Vice-President and Chief Operations Office of the ICT4Peace Foundation in Geneva, noted her concern over the Geneva Conventions, and asked: "How can we better respond and how can we better organize our regulatory and governance frameworks to respond to these challenges?" Another audience member, Jean-Yves Art, Senior Director for Strategic Partnerships at Microsoft in Geneva, raised similar questions: "What do we do with the Fourth Geneva Convention? Because, in the Ukraine war, you see cyber weaponization being used against civilians and civil infrastructure, directing cyberattacks at civil infrastructure. This information is also a form of weaponry that attacks and targets civilians. So that's one thing: How do we protect those targets against the cyberattacks? The second is the role of tech companies. What is the position of tech companies that are unwilling actors of those conflicts?"

For the International Committee of the Red Cross (ICRC), the Geneva-based guardian of the four conventions, the most important factor in this panel discussion is the impact of digital technology on people and their protection under international law, said Balthasar Staehelin, a Special Envoy for Foresight and Techplomacy at ICRC. The character of the battlefield is changing, he noted, with tech companies' latest inventions proving decisive on the battlefield and civilians increasingly enticed to participate through digital means.

Disinformation and hate speech can also erode the trust on which humanitarian organizations depend. As indicated in the GESDA Science Breakthrough Radar, artificial intelligence can be applied in ways that allow for the microtargeting of populations and that push propaganda or misinformation. "The essential elements of international humanitarian law, the principles of distinction, proportionality, precaution, can and must absolutely be upheld and translated into this evolving warfare," said Staehelin, adding that armed conflict is a magnifying glass for issues that in a place like Switzerland revolve around privacy, but in a war-torn place like Afghanistan can be literally a matter of life and death.

Charlotte Lindsey

"The issue is if you directly participate in hostilities – and we see now more and more actors directly participating in hostilities – you become targetable under international law," said Staehelin. "We haven't totally thought through the implications. People encourage thousands of civilians to directly engage in hostilities. What does that actually mean? And people ask them to attack civilian targets on the enemy side. What does that mean for upholding international humanitarian law?"

Audience member Peter Maurer, who served as the ICRC president for 1o years until the start of October 2022, reminded the panel that, after "a certain point when we have recognized all the bad things that can happen, we somehow have to find pathways to think what to do." Maurer, a veteran Swiss diplomat who is the incoming board president for the Basel Institute on Governance and a leading voice internationally on humanitarian and related

issues, noted that, in 2021, he convened a high-level advisory board to support the ICRC on legal and policy challenges to protect civilians from cyber threats and other digital risks during armed conflict.

"At the end of the day, you can't imagine solving the problems that you have all laid out. It's a huge amount of problems, which create that kind of impression of insolvability of where we are. But what you can do is basically mount, as a counter and social movement, responsible behaviours," said Maurer. "One of the challenges that we have is the fragmented and highly divided world. Because, at the end of the day, when we go back to minimal consensus as the basis on which we have to deal with threats, and not into legal processes which are imposed, but which are brought in because they are right – I think when we look at consensus-building on basic ethics, basic responsibilities, then we are in a different kind of mindset."

More information

Explore this topic in the 2022 GESDA Science Breakthrough Radar®

Session recording on YouTube

Tweets related to the session

Takeaway Messages

With growing cyber involvement in conflicts and the weaponization of data, the line between direct and indirect participation in conflicts is becoming blurred.

The range of involvement includes tech platforms that are used to raise volunteers and money for fighting or a multibillionaire tech mogul whose donations can upend the geopolitical balance.

A growing number of cyber-influence operations are vying to control the information space, which is as much about sovereignty today as it is about influencing populations or the narrative.

The weaponization of nanomaterials through neurological and biological applications is another complication. The combination of artificial intelligence, nanotechnology and biotechnology can be used to create unmanned intelligent robotic systems.

Micro-targeting on popular platforms like Facebook also can track users throughout the internet.

The rise, fall and continuing threat of the Islamic State militant group over the past decade show how digital technologies began proliferating in warfare at a rate that outpaced governments' ability to counter them.

Technology and digitalization are most often viewed from an economic and trade standpoint in Southeast Asia but are also being exploited for intelligence gathering and geopolitical concerns.

Cyber weaponization used against civilians and civilian infrastructure, and the unwilling involvement of tech companies, raises questions about enforcing the Geneva Conventions, the 20th-century treaties that govern the rules of war and military occupation.

Disinformation and hate speech can erode the trust on which humanitarian organizations depend.

Consensus-building and a focus on realistic possibilities are needed to counter the challenges of a fragmented and highly divided world.

Elina Noor

Jean-Marc Rickli

Science Anticipation

The Future of Financing for International Impact

Abstract

Despite considerable volumes of funds flowing into emerging technologies that are poised to deliver scientific breakthroughs with global impact, their financing remains a challenge. The funding of scientific breakthroughs for the common good, is not happening at the scale and with the benefits to society, that humanity should aspire to. As evidenced during the peak of the COVID-19 pandemic, nationalist positions may override the democratization of global public goods, such as novel health-care services and access to innovative scientific advances.

- What are the main challenges, and the hurdles holding back broader international access and investing into global public goods, including scientific breakthroughs? Are the obstacles financial, political, social or governance related?

- Where is the funding for emerging technologies coming from? Where is it allocated? Where is it needed?

- Could disruptive technology related Impact Funds, blended-finance mechanisms, foreign direct investments, generative futures, and impact investments in general, become standard models for global positive impact in the near future?

Join this session to engage in the debate around the challenges, hurdles and opportunities posed by models of financing new technologies, that are required for inclusive transformational change.

Participants

Moderated by:

Louis de Montpellier, Chair, rePLANET; Board Member, de Pury Pictet Turrettini & Cie, Switzerland

With:

Maria Cattaui, Global Board Member, Open Society Foundations, Switzerland

William Egbe, Managing Partner, Vibranium Capital Group; former President, Coca-Cola Africa, Cameroon

Kate Fox, Investment Manager, Positive Change, Baillie Gifford & Co, United Kingdom

Maria-Francesca Spatolisano, Assistant Secretary-General, Policy Co-ordination and Inter-Agency Affairs, United Nations, Italy

Maria Cattaui

Highlights

Global economic volatility and uncertainty clouds the future of impact investments that are intended to generate positive, measurable social and environmental impact in addition to a financial return. However, the growing impact investment market is needed to provide capital for global solutions like renewable energy and conservation, healthcare, education and sustainable agriculture.

The impact investing market has $1.164 trillion in assets under management despite disruptions from the COVID-19 pandemic, according to the Global Impact Investing Network (GIIN), leaving a $4.2 trillion funding gap to achieve the UN's 17 Sustainable Development Goals (SDGs) for 2030. GIIN estimates, however, that just 1.1% of all assets held by banks and institutional asset owners are needed to address this gap.

GESDA has identified scientific breakthroughs that could accelerate the implementation of the SDGs through financing from the private and public sectors and has created an Impact Fund and Forum to help power the world towards some of these solutions; but, financing remains a challenge in a time of global health and climate crises, widespread hunger, war in Europe and elsewhere, inflation and supply chain disruptions. Impact investing has become an emerging field of asset management where environmental and social outcomes rank with financial returns. Analysis of sustainable or sociological targets is mixed with those for financial gain.

Some investors, while seeking financial returns, want to play a more active role in contributing towards a more sustainable and inclusive world. This is done by supporting public companies whose products and services are providing solutions to global challenges, according to Kate Fox, an Investment Manager and Partner at independent fund management firm Baillie Gifford. She says the approach is based on three core beliefs. "The first one is that capital has the potential to be a powerful mechanism for change, that investors can play an important role. I think that GESDA is a great example of showing the different stakeholders that are needed to try and promote scientific breakthroughs and address global challenges," she told the panel.

"The Sustainable Development Goals call into action all members of society, governments, businesses, investors and individuals. Investors who take a thoughtful, responsible and long-term approach can contribute to helping individuals grow their savings, but also towards societal development and to the benefit of the planet," said Fox. "We've got a responsibility as investors."

"The second core belief in what we're doing is that this provides a fantastic opportunity, because companies whose products and services are providing solutions to global challenges – whether it be companies that design and manufacture electric vehicles or companies that are providing renewable energy or companies providing access to digital education tools – they're going to prosper over the long term. They'll be growth businesses," said Fox.

Kate Fox

"Over longer periods of time, the market rewards that. Investors can grow their capital and their savings."

"That leads me to the third core belief, which is related to the first two," said Fox. "To live up to this responsibility as investors and in order for us to capitalize on the opportunity that presents, it takes a long-term approach and a thoughtful approach."

Audience member, impact investor and Club of Rome Member Mariana Bozesan said that, even though turning a profit remains the primary criteria for investors, she's "slowly but surely trying to bring people and the planet into the conversation, particularly within planetary boundaries if we want to survive." She asked how the metrics could be changed, and how the due diligence process, which is a key to aggregating the capital, could be lengthened to facilitate these kinds of investments. Fox suggested engaging with broader organizations like GIIN, seeking third-party audits to ensure the "linkages to the SDGs" are sound, and being "quite open" in financial reporting. "There's no such thing as a perfect company," Fox added. "There are companies that will be negatively contributing towards the SDGs, and I think you've got to be transparent about that."

The easiest way to think about financing for international impact is in two different aspects: one is a pull, the other is a push, said William Egbe, Managing Partner of the strategic private investment company Vibranium Capital Group, and former President of Coca-Cola Africa. On the pull side, the Global South has to create a more attractive investment environment by tackling corruption, creating firm policies and regulations that give business a greater sense of certainty, and persuading risk capital that entrepreneurs have the unique skills to manage risks that are inherent in this environment.

"There's no question that operating in the Global South has huge complexity and high risk," said Egbe. "But I also think that, within these environments, you have the skills and the capability to be able to navigate through all of that risk and reduce the impact of that risk. We have to be able to better assure that we have the skills and capabilities ready. So those are some critical components around creating a conducive environment to attract more investment," he said.

On the push side, said Egbe, the key is to support, promote and showcase innovation locally. "And that investment is required to power some of the entrepreneurship that would attract that risk capital. So that's one thing that our governments and the public, the private sector [and] the public sector have to partner to do a better job at," he said. Training for local entrepreneurs also is important, not just technical skills, but also business management.

But there has to be some capital available to ensure the solutions are discovered, applied and tested, said Egbe, which is why "creating the right platform for that to happen is very important, and something which GESDA is doing here – it's about making sure you have an engagement platform where the different parties can come to discuss and debate the ideas. It's about frameworks for sharing. If, after you share information about progress on the scientific side, how do we share it? How do we protect the things that we need to protect from a business perspective, but yet to share the stuff that's for the common good? And how do we align to make sure that we have the same success metrics to show that we're progressing?"

"Those kinds of platforms are required to bridge the gap between the private sector, the risk capital that looks to identify opportunities, the public sector that creates the radical systems, and then the scientific researchers who help find the solutions," said Egbe. "Those kinds of platforms we're in desperate need of. And, of course, the last aspect is co-investment from major development banks, which are doing a great job" but "we know they can do more."

Maria Cattaui, a Global Board Member of Open Society Foundations, former Secretary-General of the International Chamber of Commerce, and former Managing Director of the World Economic Forum, noted that most major scientific breakthroughs have been publicly financed, and the supporting ecosystem for them is extremely expensive. "It's always been a complex group of different pockets of finance that have led to the largest of the scientific breakthroughs. I'll be realistic. That mostly happens in not so many places," she said. "It's not realistic to think that it's going to happen everywhere equally. So, I've been looking at the next step, and that is actually what happens after scientific breakthroughs and what perhaps some of our concepts should be on funding, on putting together packages that use different players. That's in the commercialization, industrialization and adaptation of scientific breakthroughs."

"I think it's there right now that we have the most possibility to make impact with our investments, our funding and multiple sources of that funding," said Cattaui. One of the difficulties of putting together so many different kinds of financing from the private sector and from regional and international financial institutions it that it takes a long time, it's complicated and there isn't clear governance, she said. When the UN proposes a partnership, she said in describing her experience at other major international organizations, "they don't really want to be a partner. They want us to donate to something. And we do because it's important."

The panel's moderator, Louis de Montpellier, Co-Founder and Chair of the Board of Directors of the ecological restoration joint venture rePLANET, noted that financing for international impact "could prove to be especially challenging in today's circumstances, and for the years to come" due to global economic woes, deglobalization, economic fragmentation and geopolitical conflicts. "As an economist, you will forgive me not to be extraordinarily, wildly optimistic about the financing of fundamental science for the common good," he said, later noting "there was not 100% optimism on this panel."

The key to financing is to create a "mission economy" aligned with the SDGs that were approved by the UN General Assembly in 2015, according to Maria-Francesca Spatolisano, Assistant Secretary-General for Policy, Coordination and Interagency Affairs in the UN Department of Economics and Social Affairs, who works on the global architecture for financing science and technology. "Choices are what is in our power to do. If we make the right choice, we may address the challenges we have. If we don't, we may create even more problems, more divisions, more radicalization, more difficulties for all of us," Spatolisano told the panel.

"In spite of the geopolitical divisions, in spite of the fact that the situation today globally is very different from what generated that consensus in 2015, we still have governments luckily coming to the UN and telling us, yes, this is what we want to do. We don't know exactly how long it will take. Probably it will take longer than what we thought," said Spatolisano. The financial system, business, communities and civil society have a common task, she said. But the global financial architecture is "clearly not" geared to deliver these kinds of goals, so "we have to incentivize the multilateral development banks to do their job a little bit better and take maybe a little bit more risk. We have to make the investors … very much more aligned with the SDGs. And this, of course, you can do it in a number of ways. It can be by incentives, it can be by regulation, it can be by stick instead of carrots. I mean, add all the tools you want. But you have to do that. That's our message."

It's also important to talk with people where they live to find out what their needs are and to "support better policy options for countries to choose from," said Spatolisano. "That's the role of the UN – building consensus around sustainable solutions – and that would be my invitation. GESDA is doing this. We are very happy to hear more from you, to get you involved in what we do, and vice versa."

More information

Explore this topic in the 2022 GESDA Science Breakthrough Radar®

Session recording on YouTube

Tweets related to the session

Takeaway Messages

GESDA has identified scientific breakthroughs that could deliver technology solutions that merit financing from the private and public sectors, and it has created an Impact Fund and Forum to help power the world towards some of these solutions.

Financing remains a challenge at a time of global health and climate crises, widespread hunger, war in Europe, inflation and supply chain disruptions.

Some investors, while seeking financial returns, want to play a role in contributing to a more sustainable and inclusive world.

GESDA is showing stakeholders what's needed to promote scientific breakthroughs and address the UN's Sustainable Development Goals (SDGs).

Developing nations have to tackle issues of corruption and create policies and regulations that give business a greater sense of certainty to persuade risk capital that entrepreneurs can manage risks.

Engaging with impact-investing organizations and using third-party audits to monitor progress towards the SDGs would help ensure the collective goals are accomplished.

GESDA's platform helps bridge the gap between the private sector, risk capital, public sector and scientific researchers who help find the solutions.

The key to financing is to create a mission economy aligned with the SDGs that encourages people to make good choices about the challenges we face.

A complex group of different pockets of finance has led to the largest scientific breakthroughs; it's not realistic to think that it's going to happen everywhere equally.

Investors need a long-term, thoughtful approach to be responsible and capitalize on these opportunities.

The global financial architecture is not geared to deliver these kinds of goals, and the multilateral development banks could do a better job of providing incentives.

More support, promotion and showcasing of local innovation locally would help attract risk capital.

Louis de Montpellier

William Egbe

Maria-Francesca Spatolisano

Patrick Aebischer

**Vice-chairman, Board of Directors;
Chair, Impact Forum and related Impact Funds,
GESDA, Switzerland**

Keynote Address

It is my pleasure to try to give some concluding remarks to what was said [in the session, Future of Financing for International Impact]. I would like to take this from the angle of GESDA. And I am going back to what Maria Cattaui has said, which I think is very important: We are living in incredible times, where we see scientific disruption happening at a pace that we have never seen so far. This trend is exponential. It really affects what we do, who we are; and it is going to be even more important in the coming years. The role of GESDA is to try to anticipate [this trend].

As Maria said, a lot of these scientific efforts come from [institutions with] public funding. In fact, these are the top universities, on average, which are developing those disrupting innovations. They come from quite a few – about 100 top universities produce about 80% of the most important innovations. There are two exceptions today. First, in the AI and quantum [worlds], some of the big companies, the GAFAs and others, have top scientists that are really competing. Second – and it's something that we don't see because there's no transparency there – the defence labs around the world. Those are the places where the disruption is also happening.

So, what we have tried at GESDA is to produce this mapping of anticipation: the GESDA Science Breakthrough Radar. The difficulty is to try to see where it is going to go in five, 10, 25 years. And the further out we are, the more difficult and the less probably precise we will be. However, we absolutely need to anticipate the utilization [of science advances and technologies]. That forms the second part of the Radar. This is what the GESDA task forces are doing in the Anticipatory Situation Room depicted on the walls in this auditorium: to develop solution ideas, starting from the kinds of discussions that we are having here at this summit.

But then, thirdly, we are going to have to finance this. With what kind of financing? We are talking about impact; we are talking about basic financing – what we as scientists call pre-competitive financing. And that is really the whole matter today.

If you take the key innovation of quantum computing, we know it is just coming, without knowing exactly when. But let's say that, in this decade, we will start to have the first utilization of the first machines that will allow us to exploit the power [of this technology]. One could do the same mental exercise about human augmentation: this is at the tip of our fingers. Gene editing is coming. Those technologies are not 20 years or 30 years out. But we do not know how to use them.

To some extent, if one wants the people to benefit, they will have to go through a normal economic system. But, before the private sector can make its profits, it has also to participate in setting, to some extent, the rules. How are we going to use those disruptive discoveries for the good of mankind, but also for all mankind? Because for now, this [power] is concentrated. If one looks at quantum computing, it is within a couple of countries, a couple of companies.

That is why, through last year's GESDA Summit and from the various discussions we had through the years, we came at GESDA with this idea of establishing this Open Quantum Institute here in Geneva. It is the perfect city, also hosting CERN. We do not have to create any new quantum computing technology; the various labs and countries will make it. The idea is to be sure that we are going to use those machines in the proper way. To do this, we are going to have to finance this before it becomes an economic matter. I think that is where this pre-competitive financing is needed, and everybody needs to be around the table.

At GESDA, after we have had the Radar (the anticipatory tool), which fed the Anticipatory Situation Room to come with Solutions Ideas (the accelerator), we are now ready to create an Impact Forum with an Impact Fund to support advances on subjects that are highly disruptive – this to be sure that we are going to use them the proper way. That is where we are going to rely on innovating new financing schemes, which are going to be public-private by definition. In that vision, innovation does not only include the start-ups, the established companies, but also the public and philanthropic institutions. We need to get together.

What we would like to do during this coming year is to take the couple of examples [of disruptive advances] that we have identified – but hopefully each GESDA Summit we will have new ones – and repeat the exercise. With some, we are not ready yet [to move forward]. For example, we are working on the NeuroTech Compass [which scans advances in neurotechnologies]. Being myself a neuroscientist, I know that the brain-machine interfaces are coming; that the human-animal chimeras are coming. While we do not know exactly how to use [those technologies], I think this needs to be thought through.

For me, GESDA's core mission includes the need to evaluate test cases for those technologies – but this, also, needs to be finance – to bring the scientific community to the table of multilateralism, and

to ensure access to the benefits of science to the world's inhabitants. It is also to make of Geneva the place where we can discuss all this.

But to do this, we will need financing. That is why we are going to come back to some of you to see if you are ready to participate in this essential part, to learn how to use those disruptive discoveries before they escape us, in order to use them for the good of mankind and in a very inclusive manner.

If we achieve this with one or two [scientific advances], we will have set up the mission of GESDA. For this third stage of the "rocket" – the implementation part – we will need to have an Impact Forum and an Impact Fund. That really is the ambition of today. And today's panel brilliantly illustrates the need to find this financing across the world, including the Global South, because this is the question at the heart of who we are and how do we want to live together and where, to some extent, on this planet.

Thank you.
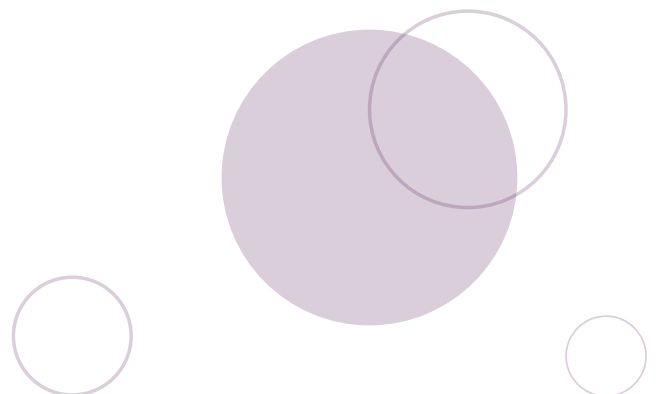
Initiative

Reviving the Human Right to Science

Abstract

As the 2022 GESDA Science Breakthrough Radar® shows, anticipated scientific and technological breakthroughs have the potential to change not only society but even human beings themselves. We believe that decisions concerning the development and use of these powerful technologies should be adopted within a human rights framework. One framework from which States and other institutions derive duties and responsibilities to anticipate both the risks and the benefits of science is the Human Right to enjoy the benefits of scientific progress and to participate in that progress, grounded in Article 27 of the 1948 Universal Declaration of Human Rights.

- How can this Human Right to Science be used to benefit humanity?

- What are the current challenges for this right?

- What are the duties derived from this Human right regarding emerging technologies?

Participants

Moderated by:

Gérard Escher, Senior Advisor to the Board, GESDA, Switzerland

With:

Samantha Besson, Professor, International Law of Institutions, Collège de France and University of Fribourg, Switzerland

Andrea Boggio, Professor of Legal Studies, Bryant University, Italy

Frederick Fenter, Chief Executive Editor, Frontiers, USA

Gabriela Ramos, Assistant Director-General, Social and Human Sciences, UNESCO, Mexico

Alexandra Xanthaki, UN Special Rapporteur in the field of Cultural Rights, United Nations, Greece

Thomas Zeltner, President, Swiss UNESCO Commission, Switzerland

Highlights

The link between science and human rights was firmly established in the United Nations' 1948 Universal Declaration of Human Rights (UDHR), which asserts that everyone has a right to "share in scientific advancement and its benefits."

The right to benefit from scientific progress and its applications is also an important part of Article 15 of the International Covenant on Economic, Social and Cultural Rights, a multilateral treaty adopted by the UN General Assembly in 1966 that obliges nations to take as much action as their available resources allow to progressively achieve full realization of the rights it guarantees. That covers all of the sciences – life, physical, behavioural and social – along with engineering and the health professions, according to the UN Human Rights Office.

In practical terms, it means there should be access and opportunities for all to gain the benefits of and contribute to science, and people are entitled to be well-informed in all relevant matters and to live in an environment that promotes science and technology and provides the freedom needed to conduct scientific research.

In the 21st century, this right is dormant. The rise of disinformation, misinformation and authoritarian populism undermines trust in science, the news media and the notion of common facts in general. As with much of life, inequities pervade the scientific profession; women, for example, often are denied leadership posts or underrepresented in some disciplines like STEM and artificial intelligence.

"Despite the extraordinary progress in all fields of science, we are far from being able to consider it a right, the right to the science, the right to benefit from science. Many of the new and persisting challenges are human rights issues," said Gabriela Ramos, UNESCO's Assistant Director-General for Social and Human Sciences. She cited 332 documented attacks on scholars, students and universities in 65 countries between September 2020 and August 2021, and a huge gap in access to COVID-19 vaccines; 72% of people in rich nations got at least one dose, compared with 15.2% in poorer countries. "Trust in science is being eroded by disinformation and misinformation. It's spreading through the digital world, but also fuelled by rampant populism," she said.

On a more positive note, Ramos said, UNESCO is playing a central role in expanding protections for scientific research, including to more marginalized populations, and pushing for nations to live up to their obligations spelled out among several international treaties. "We need to move more precisely towards anchoring science and human

rights, building on this positive momentum. In particular, we need our members to be accountable. They need to deliver on what they sign."

The Swiss Commission for UNESCO has made the human right to science a priority – and GESDA should continue to make it a priority, too – particularly since "seven out of seven" Swiss people likely don't know it exists, according to the commission's President, Thomas Zeltner, a physician and lawyer who chairs the WHO Foundation. Previously, he was Switzerland's Secretary of Health and the Swiss National Health Authority's Director-General. "The UNESCO Commission said, 'That's a big problem and we need to raise the awareness that there is something like that,'" he said. "The first thing we need to do is actually to have a narrative that the government, the Parliament, the population understands." But after more than two-and-a-half years of pandemic, he said, there are some lessons to be learned, such as Switzerland buying 35 million doses of COVID-19 vaccine for its 8 million inhabitants, which he called "crazy" and predicated on an assumption that the leftovers could be exported to lower-income countries, which he noted has "not really happened."

GESDA's inaugural summit in 2021 began a debate over how to rectify the world's unequal access to scientific advancement and its benefits, nowhere more prominently featured than with the global inequities over access to COVID-19 vaccines. Proposals for reviving the right include a collective commitment to open science and inclusivity, new forums for data-sharing and establishment of a deliberative body to ensure the latest scientific evidence is part of policymaking.

One of the major challenges to the human right to science, however, is the privatization of science and knowledge. International legal instruments are not equipped to deal with that aspect because they're designed to address how governments implement it. The core issues are how to balance competing interests, provide access to scientific information and protect vulnerable people.

This follow-up session at the second GESDA Summit sends an important signal that it is imperative to ensure that existing rules apply to the freedom of expression and the obligation for science to benefit all, particularly in countries that lack the policy frameworks to ensure access.

"This resonates, of course, deeply with our anticipation efforts. We want science to be there for the good of all. The texts are beautiful, but are they being used? Does this human right to science have an impact nationally or internationally? Do we even know its implications?" asked the panel's moderator, GESDA Senior Adviser Gérard Escher, a neuroscientist.

Frederick Fenter

Andrea Boggio, Professor of Legal Studies at Bryant University in Rhode Island, a leading scholar of science policy in international law, said that much work remains to be done to nail down the precise meaning of the words in the relevant treaties, then translate those words into actions and standards that can be put to use in science. "We have this very general and abstract language. How do we translate that into something that can be meaningful to people in the field?" he asked.

The first step would be to identify certain standards of practice and precise, proper standards, for example with data-sharing or access to data. "That's another way to implement the right to science, by having scientists themselves adopting some of these standards and agreeing to open science in their practice of science. Now, will the public benefit? Are we still implementing the right to science in this broader sense? The answer is yes because, if you share data, you will have more powerful ways to investigate the scientific questions. So, ultimately, you also serve the public," said Boggio.

In total agreement was Frederick Fenter, Chief Executive Editor of Frontiers, a research publisher and open science platform based in Lausanne that has published 285,000 articles since its founding in 2007. "Open access publishing is an integral part of the human right to participate in science. I think that it's an integral part in terms of sharing in scientific advances and scientific benefits. There are two levels: The first level is that, very simply, if somebody wants to participate in the scientific endeavour, access to the scientific literature is a prerequisite. You have

to have access to the scientific literature even to get started," said Fenter, a chemist who conducted research in atmospheric science before moving into scientific publishing.

"There's a second level and that's providing access to the public, to everybody else who could benefit from this access. Again, very much in this spirit of participation," said Fenter. He said the COVID-19 pandemic showed the importance of organizing scientific knowledge around solutions, innovation and education, including the decision by the US government and a coalition of leading research groups to establish the COVID-19 Open Research Dataset (CORD-19), a resource of more than 1 million scholarly articles.

"We will bring true equity and intellectual partnership to the Global South because that access to the corpus of the scientific literature is the starting point," said Fenter. "This was powerfully demonstrated with the CORD-19 database. This is an example of how policy is actually able to have an important driving effect." He also cautioned that complying with the "spirit" of the UDHR's Article 27 means "we have to protect against misinformation. We have to have a knowledge base of validated knowledge, and that must be fully open. And there should not be any technical, financial or logistical reason for this to be any other way."

For a thorough review of the human right to science, Escher turned the floor over to GESDA Board Member Samantha Besson, a prominent research scholar who holds the Chair "Droit international des institutions" as a Professor at the Collège de France in Paris and is a Professor of Public International Law

and European Law at the University of Fribourg in Switzerland. In her view, the human right to science is more precisely expressed as the human right to *participate* in science, because that is more faithful to the origins of the right as expressed in Article 27, Paragraph 1, of the UDHR.

"It originates, indeed, in the post-war belief that science should be guaranteed as an independent, participatory good with a strong institutional and normative structure. Of course, as we all know, amidst the Cold War and with the individualization of science, the human right to participate in science lost its participatory dimension in the Covenant on Economic and Social Rights to become a purely passive right to enjoy scientific benefits," said Besson. "Hence, the sadly inadequate term that we use today: the human right to science," she said. "Having been stripped of its participatory and social teeth, it was put to sleep."

For Alexandra Xanthaki, the UN Special Rapporteur for Cultural Rights and a leading expert on Indigenous rights in international law, the word *participation* is too passive. Xanthaki, who is a Professor at Brunel University London and Senior Fellow at the Institute of Advanced Legal Studies, called for a more active interpretation. "The right to science has not been developed enough and certainly has not been implemented enough," she said. "I would differ a little bit from Professor Besson in the sense that participation for me seems to be a little bit passive. The Indigenous debate has shown us that we should be talking with local populations."

Xanthaki noted that access to peer-reviewed scientific publications restricts debate to "specific areas of the scientific community" and should be expanded to include more beneficiaries of science, not just a "*sui generis* category" of Indigenous peoples. "When we talk about participation, the right to participate in science cannot be only focused on scientists. Unfortunately, the COVID debate has shown us once again how reluctant the general population is to accept the opinions of what they see as experts who they see are separated from them. Something has to happen with that."

Xanthaki advised fighting discrimination in science to "create structures and implement the human rights standards so that science helps equality rather

than having the opposite effect. We need to reflect a lot more on every aspect of science and how it contributes to structural discrimination."

With UNESCO and GESDA trying to reinvigorate this human right, Besson advised doing so in the name of "public and participatory good of science," pushing back against "individualization, instrumentalization and privatization of science." That entails anticipation, a prominent theme in GESDA's work and much of international law, which involves an effort to foresee potential harms, identify risks, and control them as much as possible.

There are "three panels of the anticipation triptych," Besson explained. The first is *precaution*: taking measure to avoid or mitigate risks of serious and irreversible harm. The second is *prevention*, which evolves as scientific knowledge grows: doing one's best to avoid the harm or mitigate the risk in concrete circumstances. The third is *due diligence*, which qualifies the duties of precaution and prevention: it requires reasonable care or diligence in precaution or prevention. As in, the duty bearer knew or should have known about the risk of harm and had the capacity to do something about it. "To the extent that GESDA's focus is on anticipation – anticipation of the science in the making and of the science to come – it's interesting for us to explore anticipation under the human right to participate in science in the context of plans to reinvigorate the right."

Besson concluded that reinvigorating the human right to participate in science can elevate GESDA's mission of anticipation, but there are risks. "Anticipation duties under the human right to participate in science are both duties to anticipate and promote the beneficial aspects of science and duties to prevent and protect against the adverse effects of science," she said. "It is both positive and negative at the same time. What matters is reaching a balance between the potential beneficial and adverse effects when specifying the content of the human right to participate in science. A second very interesting feature of the human right to participate in science is its participatory dimension. The right protects the participatory good, and individual and collective interest in that participation. To that extent, this implies organizing equal public participation in science over the beneficial and adversarial effects of science."

More information

Session recording on YouTube

Tweets related to the session

Takeaway Messages

The link between scientific research and human rights was firmly established in the United Nations' 1948 Universal Declaration of Human Rights and the International Covenant on Economic, Social and Cultural Rights.

Everyone is entitled to benefit from and contribute to science, be well-informed about new developments and enjoy an environment that promotes research about it.

Trust in science is being eroded by disinformation and misinformation spreading through the digital world and fuelled by populism.

UNESCO pushes to expand protections for scientific research and for nations to live up to their legal obligations. The Swiss Commission of UNESCO has made the human right to science a priority.

The second GESDA Summit sent an important signal that it is imperative to ensure the existing rules apply to freedom of expression and the obligation for science to benefit all.

GESDA's inaugural summit in 2021 began a debate over how to rectify the world's unequal access to scientific advancement and its benefits.

The human right to science could be more precisely expressed as the human right to participate in science; UNESCO and GESDA could try to reinvigorate this human right in the name of participatory science for the public good that entails anticipation.

The core issues are how to balance competing interests, provide access to scientific information and protect vulnerable people.

Lack of consideration for Indigenous people's points of view has shown that more consideration should be shown to local populations' reflection that science contributes to structural discrimination.

Open-access publishing is an integral part of the human right to participate in science.

Thomas Zeltner

Gérard Escher

Samantha Besson

Alexandra Xanthaki

Andrea Boggio

Science Anticipation

How can we prepare for collaborative human-machine intelligence?

Abstract

In many fields, such as healthcare applications, economic modelling, and social robotics, the mix of human experience and computational capabilities combine to generate breakthroughs in understanding population dynamics, climate cycles, and even management processes. Collaborative human-machine intelligence ranges from combining data analytics with decision-making humans to interactive knowledge developed through interconnected biological and technological systems. As these collaborative technologies advance, the future of knowledge economies hangs in the balance.

- What will be required to responsibly integrate sprawling varieties of data, computing systems, and AI methods with human agency and experience?

- How will we live, work and socialize in a world where machines do more than analyze data, they make knowledge?

Join this session to debate how individuals, societies, industries, and governments should prepare for a future that demands a symbiotic way of observing, analyzing, and creating knowledge.

Participants

Moderated by:

Geoff Mulgan, Professor of Collective Intelligence, Public Policy and Social Innovation, University College London, United Kingdom

With:

David Harel, President, Israel Academy of Sciences and Humanities, Israel

Wendy Mackay, Research Director, Classe Exceptionnelle, Inria, Canada

Illah Nourbakhsh, Executive Director, Center for Shared Prosperity, The Robotics Institute, Carnegie Mellon University, USA

Eric Salobir, Chairman, Executive Committee, Human Technology Foundation; President, OPTIC, France

Highlights

Soon after the Russian invasion of Ukraine in late February 2022, ordinary Ukrainian citizens began using the government's app for administrative services, Diia, as a military intelligence-gathering platform. People could spot Russian tanks and upload their positions to the Diia platform, where artificial intelligence (AI) recognized the exact details, and Ukraine's military made more assessments. With that information in hand, the military could quickly send out drones to destroy the Russian tanks. Ukrainians also began using Diia to submit evidence of war crimes.

It was an extraordinary example of a new and spontaneous human-computer collaboration with a big impact, and it's an example of the enormous disruptive potential of collaborative human-machine intelligence, which ranges from combining data analytics with decision-making humans to interactive knowledge developed through interconnected biological and technological systems. "Where are the comparable hybrids, assemblies and combinations which could be used on anything from healthcare to climate change to misinformation and democracy?" asked the panel's moderator, Geoff Mulgan, Professor of Collective Intelligence, Social Innovation and Public Policy at University College London.

Our first ideas about computers were based on how we imagined the human brain, then we started imagining the human brain from a computer's perspective – a device to which we could add

memory and connect other things – which raises questions about how we define ourselves, according to Eric Salobir, President of the Human Technology Foundation, Founder and President of OPTIC Technology and Member of the French Digital Council. "It blurs a little bit the line. And for me, it's first a philosophical question, but that's also a psychological one," he said. "I'm not so sure that the machine adds knowledge, perhaps it is just information. And we just need to be sure between, I would say, data, information, knowledge and perhaps wisdom, what's the part of the human being? What's the part of the machine? How do we have to put all of that together?"

Salobir said he recently spoke with a team developing self-driving cars that had experimented by putting a camera in the back seat to see how people adapted to them. "After two weeks, people were sitting in the back with a newspaper and they said, 'Hey, drive me to the office,'" he recalled. "There's a lot of work to do just to be sure that the human being will flourish in such a context. Otherwise, we will have a kind of digital proletariat working for a machine, and some other people having a machine working for them. I think this is not the kind of society we want to develop."

Illah Nourbakhsh, Professor of Ethics and Computation, and Director of the Centre for Shared Prosperity at Carnegie Mellon University, said the fundamental problem is that we use the word *autonomy* as if it's good for technology to have such independent decision-making. "In fact, what we're

Wendy Mackay

doing is stripping human beings of agency," he said. "What I would want everybody to understand is, first of all, complexity. As the complexity of these machine systems increases, their errors increase, and our misunderstanding of how they can make errors increases. The systems we create are not autonomous. When people teach you that they're autonomous or when they use semantically inflated terms like *thinking* and *wisdom* and *decision-making*, they're mixing simple logistics that these machines are capable of with human conceptions that you fill with your desires and understandings and intentionalities, which just aren't there."

Nourbakhsh said the best designs increase personal human agency, rather than concentrating power in the hands of already powerful corporations through information and autonomy. He pointed to data from the UN refugee agency showing waves of migration that get far less attention than hot spots like Syria and Ukraine. "When we show images like that, massive data analytics and AI combined with human understanding, then we provide agency to human decision-makers to make better decisions," said Nourbakhsh. "That, to me, is the thesis of what I want to say: Stop giving autonomy to machines and start designing machines that work shoulder-to-shoulder with us to give us greater agency and better relationships in society." But, there's a silver lining to the technology, he added: "You can use AI to invert hegemonic power structures in society. I've seen it happen."

As a consultant to governments on issues related to science, David Harel, a computer scientist and President of the Israel Academy of Sciences and Humanities, said he often hears people talk about AI and they forget about the human angle. "It's not only the interaction with the machine, but it's also the way we communicate," he said. "Beware of AI when done alone; do not rely on systems which are just simply

pure AI. The issue is not only human-computer interaction, which of course is very important; but the issue is: there are so many systems in which human classical-model-based software and systems engineering using human beings' expert knowledge is crucial."

Harel said we have to find technical ways of building systems that can use both artificial intelligence (AI), which can for example recognize traffic signs or lighting conditions, and classic software, which doesn't have the ability to learn.

Verification in human-computer systems is another issue. Since AI enables computers and machines to perform human-like decisions and automate tasks, it can be used to automate cybersecurity portals to prevent identity theft at a scale used by financial institutions. "Verification is a very rich, very deep and very productive topic in computer science," said Harel, "but there is no way as of yet to verify even a simple, deep neural network, even probabilistically."

Given these issues, audience member Anne-Marie Buzatu, Vice-President and Chief Operations Officer of the ICT4Peace Foundation, asked how we might craft the governance frameworks that will be needed to cope with AI-assisted machines that make errors in different ways than people.

"There is a huge debate underway on assurance audit regulation of algorithms, and every European country will have to create a new regulator," answered

Eric Salobir

David Harel

Illah Nourbakhsh

Mulgan. "We've got one in the UK already from a few years ago, but that's about stopping the problems, the biases." Harel said he's working on a project called Wise Computing that's intended to shift the power balance towards humans.

Many AI system designs are based on an algorithm's quality and not how well they interact with humans because they're designed by computer scientists, who are trained in math and engineering but not in how people think, said Wendy Mackay, a Senior Research Director for the Ex-Situ project in human-computer interaction at France's National Institute for Research in Digital Science and Technology (Inria) and Université Paris-Saclay. "What we as human beings want are partnerships of some sort, where we do what we as human beings do well, which is interpret data like that. And machines do a lot of interesting calculations. But we also want much richer ways of interacting with the world," she said.

"When we interact with the physical world, we have what we call technical reasoning. We can look at the properties of an object and interpret its properties and figure out what we can do with it," said Mackay. "This is a pen; it's designed for me to write but it could also be used as an almost straight edge. I could use it to tie back my hair. I can take

advantages of its properties and we, as human beings, are very good at doing that with the physical world," she said.

"But, when we design technology, we forget about all of that. We create a lot of very arbitrary, very difficult to understand ways of interacting. My argument when I talk to my colleagues in AI is that we need to actively engage in both creating these interactive systems from a human perspective and also measure the impact on human beings in the microsecond, short term, midterm and long term, so we think about upskilling people rather than de-skilling or replacing them," said Mackay. That reflects a movement towards "human-centred" AI, which joins psychology, sociology, anthropology, design, engineering and math to design effective systems that can continuously improve from human input and collaboration.

"It is important that we create an environment in which they understand that it's just a different value system, a different set of skills and knowledge that they can use to apply to any question and be able to develop the communication among the people who are designing these systems," said Mackay. "It's quite a shift culturally to get the universities to shift that perspective. But it is happening."

More information

Explore this topic in the 2022 GESDA Science Breakthrough Radar®

Session recording on YouTube

Tweets related to the session

Takeaway Messages

The Russian invasion of Ukraine has shown the enormous disruptive potential of collaborative human-machine intelligence, from drones to satellites to fundraising platforms.

New combinations of human-machine interactions are blurring the way we define ourselves.

A fundamental problem is that we use the word autonomy as if it's good for technology to gain independent decision-making.

The systems we create are not autonomous; that word semantically inflates terms like *thinking* and *wisdom* and *decision-making* that connote intentionality that just isn't there.

The best human-machine designs increase personal human agency, rather than concentrating power in the hands of an already powerful corporation.

We have to find technical ways of building systems that can use both artificial intelligence (AI), which can for example recognize traffic signs or lighting conditions, and classic software, which doesn't have the ability to learn.

Verification in human-computer systems is an important issue because, as AI enables computers and machines to perform human-like decisions and automate tasks, it can be used to automate cybersecurity portals to prevent identity theft at a scale used by financial institutions.

The design of many AI systems is based on an algorithm's quality and not on how well they interact with humans; this is perhaps because they're designed by computer scientists trained in math and engineering but not in how people think.

The answer may be found in a movement towards "human-centred" AI, which combines psychology, sociology, anthropology, design, engineering and math to design effective systems that can continuously improve from human input and collaboration.

Science Anticipation

Enabling Digital Empowerment with Trust and Transparency

Abstract

In a complex, changing and interconnected world, digital twins and avatars are set to become a norm for decision-making in policy, ecology and the economy. Currently, several initiatives plan digital avatars and digital twins on the scale of individuals (in precision medicine), local municipalities (digital urban twins for city management) and the planet (climate forecasting, epidemic control). Sensor webs enable real-time synchronization of such twins and avatars with the physical world. Building trust between the science and diplomacy communities in this area is urgently needed.

- What challenges will these pose to data privacy, transparency of algorithms, accountability, and ownership?

- Who decides what a digital models should and should not do, and to whom are developers accountable?

- How can we empower citizens and other stakeholders in their design and use?

Join this session to hear developer and user perspectives and to understand what widespread use of digital tools for decision-making in all sectors of society will mean. Participants in this session are invited to discuss new approaches for advancing and governing digital models, manage risks, develop ethics-based standards, and avoid dual use.

Participants

Moderated by:

Sean Cleary, Executive Vice-Chair, FutureWorld Foundation, South Africa

With:

Jérôme Chenal, Senior Scientist, Urban and Regional Planning Community, EPF Lausanne; Academic Director, Excellence in Africa, Switzerland

Neil Davies, Executive Director, Richard B. Gump South Pacific Research Station; Research Affiliate, Berkeley Institute for Data Science, USA

Soledad Garcia Ferrari, Professor, Global Urbanism and Resilience; Dean, International College of Arts Humanities and Social Sciences, University of Edinburgh, Uruguay

Dirk Helbing, Professor for Computational Social Science, ETH Zurich, Germany

Sami Kanaan, Administrative Councillor, City of Geneva; President of the Board, Geneva Cities Hub; Former Mayor of Geneva, Switzerland

Christian Kirchsteiger, Former Responsible, Strategy Development of EU Policies for Smart Infrastructures, EC Directorate-General for Communications Networks, Content and Technology (DG CNECT), Germany

Mami Mizutori, Special Representative of the UN Secretary General for Disaster Risk Reduction, UNDRR, Japan

Huang Zhongwen, Director, Smart City Projects Office, Smart Nation and Digital Government Office, Prime Minister's Office, Singapore Government, Singapore

Highlights

The use of "digital twins" and avatars to model complex systems like cities, ecosystems and climate promises to become a norm for decision-making in policy, ecology and the economy. With the use of sensor webs, these models can provide real-time synchronization with the physical world. However, the systems raise questions about data privacy, algorithms, accountability and ownership, which is where GESDA's science and diplomacy communities might be able to help.

Before these digital tools for decision-making gain widespread use in all sectors of society, experts say new approaches will be needed for advancing and governing digital models, managing risks, developing ethics-based standards and avoiding dual use.

The panel's moderator, Sean Cleary, Executive Vice-Chair of the FutureWorld Foundation and GESDA Diplomacy Forum Member, said digital twins and avatars are increasingly being used to understand and monitor systems and interactions in real time. "There is a problem, however, because it involves the collection of enormous amounts of data using satellites, data sensors, the internet of things and everything that you're familiar with in the greater scheme of the artificial intelligence and related technological revolutions taking place today," he noted.

"The key question around all of those issues – masses of data privacy, transparency, accountability and ownership – is: Who should be responsible? Where should ownership rest? How should we ensure that there is adequate societal participation? To enable effective trust between citizens and the instruments that are being used – ostensibly to improve their lives and the workings of a complex system – for that, because of the scale on which much of this is undertaken, we need not only good practices but international standards," said Cleary.

Soledad Garcia Ferrari

Mami Mizutori, Special Representative of the United Nations Secretary-General for Disaster Risk Reduction, and head of the United Nations Office for Disaster Risk Reduction (UNDDR), told the panel that digital models can improve the prediction and management of risk and thereby help vulnerable countries and communities build their resilience. "Extreme weather events are an area of particular concern to many countries, given their growing socio-economic impact. Now more than ever, we need data, tools and models to better anticipate such events and mitigate their impact. To that end, my team has been working with the GESDA Task Force for the past year, helping to shape a possible science diplomacy solution idea around this topic," she said.

In a related session at the GESDA Summit in 2021, she and Cleary participated in a discussion about how these models could be of use to decision-makers and whether they can be made flexible enough to include local contexts and people in designing policy or relief solutions. "It is essential that these tools look not only at hazards, such as earthquakes and floods, but also at their cascading impact on factors such as displacement, economic systems and food security," said Mizutori.

"There must also be trust and transparency in the models to enable full utilization," said Mizutori. "How we achieve this will be at the core of this session's reflections. That is why I am encouraged that this session will bring together key inputs from both developers and users. Your reflections can guide the building of trust between the science and diplomacy communities."

The purpose of these digital models is to "make observations across all scientific domains, including in the social and economic domain," said Neil Davies, an evolutionary geneticist and Executive Director of UC Berkeley's Gump South Pacific Research Station. However, "the big challenge scientifically is working from the scale of the planet down to – as I'll point out – the scale of molecules." Davies also took part in the related 2021 GESDA panel.

Almost a decade ago, while at the Swiss Federal Institute of Technology at Zurich (ETHZ), Davies created an island digital ecosystem avatar, or digital twin, of Mo'orea, an island off the coast of Tahiti in French Polynesia, so local governments could better prepare, respond to and build climate-resilient communities. The project uses a collective intelligence infrastructure to possibly spur democratic ecological action. Davies said they need not only to understand things at the scale of molecules, cells and organisms to see how they form communities and ecosystems, but also to get a sense of the global forces driving them, and their interactions.

"We need to study the planet from the genome up and the planet down. That's vastly challenging, to put it mildly," said Davies. The idea is to build a model ecosystem on Mo'orea, which is also home to a French National Centre for Scientific Research lab that is particularly focused on coral reefs, some of most intensively studied anywhere in the world because of coral bleaching caused or exacerbated by climate change.

Davies' team has developed a roadmap and is using new sensors to collect data to view interactions. "The idea of a digital twin or an avatar is integrating these data and then understanding what's coming, at least from the scientific side, to connect it to society," he said, comparing the data sources that could be used for decision-making to a self-driving car. "We're getting all these data coming in and the car's driving, but we're driving an island, we're not driving a car. We're using all these data sources to alter our decisions, whether it's on the design of, say, marine protected areas, or fishing policy or invasive species or infectious disease. We're getting some data coming in. We're finding this new virus. Maybe we should drive the island in a little bit different way to respond?"

Davies compared their process of decision-making to Hōkūleʻa, the voyaging canoe model in which everyone in the canoe must democratically decide on where they're going: "We're taking the island to a new future; we need to agree on where we want to

go and use these tools to help us navigate safely to the future."

Christian Kirchsteiger, a physicist responsible for the strategy development of EU policies for smart infrastructures, including energy and transport, said the European Commission's €150 million Destination Earth project, launched in March 2022, aims to build a high-precision digital model on a vastly different scale. The goal is to develop a model that can help monitor, model and predict natural and human activity, and to develop and test scenarios for more sustainable development. "It's on a much larger scale and at the same time on a much less developed one, he said.

The project stems from a convergence of new computing power and data available to generate new modelling capabilities for the European Green Deal, a three-decade blueprint to sustainably overhaul Europe's trade, industry and politics announced by the EU in 2019. The policy intention is to significantly improve Europe's capabilities on disaster risk management and anticipation of environmental extremes for climate change adaptation. Kirchsteiger said it's about creating a continuous long-term process, a set of digital twins of the Earth's socio-economic and physical systems, one for climate change adaptation and the other for disaster risk management, but they need to be "right-sized" for real users.

"We're not trying to develop a new supermodel encompassing the entire Earth plus humankind, in this case. What we are trying to create is a set of very good models, based on the best available science and data," said Kirchsteiger. Since modelling can lead to different outcomes, policymakers also need a mapping process that reflects a deeper level of uncertainties, or the model's limitations. "These two points: the right-sizing for the real user and the visualization of limitations, in our view, are the key ingredients to make such models, independent of the scale, in principle informative for a policy end-user," he said.

Singapore's experience over the last decade in building digital governance tools has shown they are extremely useful but have certain limitations in their accuracy and timeliness, and raise questions about ethics, trust and responsibility, according to Huang Zhongwen, Director of Singapore's Smart City Projects Office in its Smart Nation and Digital Government Office. He compares these digital tools to airliners with pilots who steer them while the passengers aren't quite sure where they're going or landing. "They allow us to create better living environments for our citizens. It allows us to make sure that the city runs efficiently, runs well. People feel that they can trust what they can expect every day to get to their daily work, send their kids to school. It also allows us to improve the services that we provide to meet the needs of the community," he said.

Huang leads an interdisciplinary team that uses data to understand urban systems and deal with the risks from automation in cyberspace. "Singapore, like many cities around the world, has a lot of urban challenges. Ageing population is one of the challenges that we face. Through the use of the insights, we are now much better able to be quite targeted in knowing which neighbourhoods, which communities, require more of what type of services, especially services that are quite niche in the community segments. For example, healthcare and eldercare services, which as a nation that is ageing rapidly, much less need of this in the earlier years, much more pressing needs today. But these are needs that are not especially even. Certain neighbourhoods need it more than others, certain neighbourhoods need it sooner than others. How do we be more targeted spatially and temporally, so we make the right investments in the right location to create the greater impact?"

Singapore has been using the same approach for managing public transport, taking care of more than 5 million trees, and dealing with crowding in public spaces during the COVID-19 pandemic. It views data as an ingredient that must be cleansed, managed, stored and protected and that, while usually collected through regulatory and transactional

Huang Zhongwen

processes, is also needed for policy and planning purposes, according to Huang. "As we think about how we make use of this data, it's something we need to be quite careful with," he said. "I think many in the room would agree with the notion that all models are wrong, but some are more useful than others. How we think about the use of these data and these models becomes very important."

Huang said the ability to turn data into actionable insights depends on what they were collected for initially, because "as we use them for other purposes, which is where a lot of the returns are, we then need to be quite careful with whether there are certain limitations that we see in the use of such data models. Are they telling us the right thing? For example, whether it is in the use of transaction data on public transport or is about using information about demographic patterns, do they tell us enough, and accurately, in a timely manner? Are there certain biases that arise because of the nature of the data, because of how it is collected, because of who collects them? Ultimately, I think it's very important for us to ask ourselves: is it ethical to be using data of such nature for such purposes?"

Speaking by videoconference from Daejeon, South Korea, where he was attending the World Congress of United Cities and Local Governments (UCLG), Sami Kanaan, former Mayor of Geneva and President of the Board of Geneva Cities Hub, said there was discussion at the Congress about the digital roles of local governments. Geneva also needs to establish a formalized, digital policy for the city, according to Kanaan, and to bridge the "digital divide" among

Proceedings of the 2022 Geneva Science and Diplomacy Anticipation Summit

Dirk Helbing

Neil Davies

city workers, which includes some people doing manual jobs who feel lost when a digital component is added.

"There is a lack of trust and framework for advancing the digitalization in an acceptable and inclusive framework for everybody. The technical evolution is extremely quick," said Kanaan. "The commercial one goes mostly with a technical one and it's obviously attractive for citizens, consumers to test new options. Now we are talking about metaverse and all these quite fascinating, funny things. But the risk is obviously that we forget the crucial issues that we all have to tackle, the classical issues: migration, climate change, social inequalities, urban planning, urban management. And that the digitalization should be used as an opportunity but not have the risks of it and the bad sides of it."

It's important to understand the differences in perceptions of risk among communities to arrive at potential solutions, including infrastructure, said Soledad Garcia Ferrari, Professor of Global Urbanism and Resilience, and Dean and Director of several programmes at the University of Edinburgh, Scotland. She uses digital tools to improve governance in Latin American rural and urban spaces, primarily through data collection and citizen empowerment, especially in vulnerable neighbourhoods affected by climate change. Her interdisciplinary team of researchers in the UK and Latin America has studied landslide risks in Colombia, flooding risks in Mexico and the nexus of energy, food and water needs in the Galapagos Islands.

"What we know in all of these projects and strategies is that top-down solutions and decisions, including smart solutions to reduce climate-change-related risks, have failed to produce tangible results, particularly in these vulnerable areas of the Global South," said Garcia Ferrari. "What we are looking at is approaches that are based on the co-production of monitoring, mitigation and adaptation solutions

that result from agreement between diverse stakeholders, which are showing promising results."

That principle of building trust is important because the question in building the best solutions is: "The best for whom?" said Dirk Helbing, a physicist and Professor in Computational Social Science at ETHZ, who also took part in the related 2021 GESDA panel. "Digital twins will be a big business and it's already there. The question is, what would be the social and societal implications? The approach works very well for infrastructures, for production plans, reasonably well for logistics, but less well for complex dynamical systems. This includes weather, people and society. That's us. And our body and health. Some of the questions we need to be concerned about are about privacy and self-determination. We're talking about potentially quite intimate data," said Helbing.

Helbing said that, someday, these digital twins will extend beyond use for cities, ecosystems or the planet to our bodies, minds and personal health, raising questions about governance. "Should the military govern it? Should the government govern it? Should it be a big IT company? Should it be the Secret Service? Your health insurance?" he asked. "Here, you see, we're somehow in trouble. We're now living in social technical systems because we use those tools to change our society. We have made great progress in terms of technological innovation, but social innovation has not kept up with that quick change."

"I think we need new social innovation and frameworks in order to be able to govern those technologies well and make sure that they will be at our service, that we will have the opportunities used and risks minimized. This concerns ownership and control of data," said Helbing. "I think the problem is unsolved. There are ethical issues, all sorts of them, a lot of them. We also don't know the systemic effects of the interventions that would be made." His advice? It's something that GESDA, the United Nations and other institutions need to work on.

Takeaway Messages

The use of "digital twins" and avatars raises questions about data privacy, algorithms, accountability and ownership, which is where GESDA might be able to help.

The principle of building trust is important because the question in building the best solutions is: "Best for whom?" Since we don't know the systemic effects of these interventions, it's something that GESDA, the United Nations and other institutions need to work on.

Digital models collect huge quantities of data that call for government and corporate responsibility and greater transparency through good practices and international standards.

Digital models can improve the prediction and management of risk and thereby help vulnerable countries and communities build resilience. However, top-down solutions and decisions have failed to produce tangible results in vulnerable areas of the Global South.

Before these digital tools for decision-making gain widespread use, experts say, new approaches will be needed for advancing and governing digital models, managing risks, developing ethics-based standards and avoiding dual use.

More information

Explore this topic in the 2022 GESDA Science Breakthrough Radar®

Session recording on YouTube

Tweets related to the session

Thursday 13 October, 11.45-13.00 CET

Pipeline of Solution Ideas

Navigating the NeuroTech Compass

Abstract

Recent technological advances in electronic miniaturization, brain signal detection, and the use of artificial intelligence (AI) for data analysis pave the way to a better understanding of neurological and mental health disorders. Anticipated developments offer potential for health, communication, mood regulation, and memory enhancements. This outlook has generated huge financial investments from the public and private sectors, bringing the technologies to patients and consumers more quickly. Other applications, outside the medical field, are developing rapidly for neuromarketing, gaming and entertainment, and military purposes. With the scientific and technological landscapes rapidly accelerating, a global and inclusive approach enabling their development remains a challenge.

- Why is this a topic policy makers should be interested in?

- What are the challenges they face preventing them to take action?

Join this session to learn more about the proposal currently developed within GESDA's Pipeline of Solution Ideas to engineer a convening space that will give governments and other stakeholders information, analysis, and tools to help them best support research in neuroscience and neurotechnology and their applications in society.

Participants

Moderated by:

Daria Robinson, Executive Director, Diplomacy Forum, GESDA, Switzerland

With:

Olaf Blanke, Professor of Neurosciences, EPF Lausanne, Germany

Lidia Brito, Regional Director, Southern Africa, UNESCO, Mozambique

Ricardo Chavarriaga, Head, Switzerland Office, CLAIRE Initiative for Excellence in AI, Colombia

Stephanie Herrmann, Staff Attorney, Perseus Strategies; Lawyer, NeuroRights Foundation, USA

Jürg Lauber, Ambassador, Permanent Representative of Switzerland to the United Nations and other international organizations, Switzerland

Estelle Nakul, Postdoctoral Researcher, LNCO, EPF Lausanne, France

Olivier Oullier, Co-founder, Inclusive Brains; Professor Aix Marseille University, France

Ayaka Suzuki, Director, Strategic Planning and Monitoring Unit, Executive Office of the Secretary-General, United Nations, USA
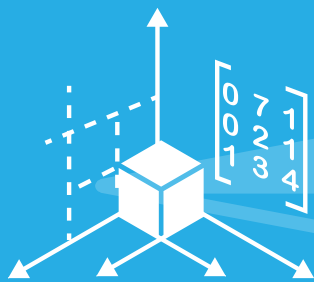
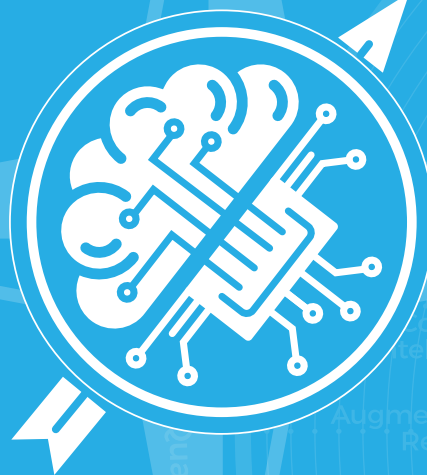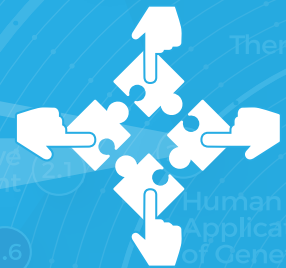# Pipeline of Solution Ideas

Human Augmentation

NeuroTech Compass

Fostering responsible innovation

A matrix for assessing governance and impact

A convening space for policy development

Building a neurotechnology tracker

Highlights

Mind probes, improved diagnoses and better treatment; less free will or autonomy, invasive neurostimulation, and discrimination. Those were among the opportunities and concerns that prompted GESDA to begin exploring the promise of neurotechnology as a result of the 2021 Science Breakthrough Radar and Summit. "Every day I am having discussions with my peers, students and young postdocs about the great potential of our work," said Estelle Nakul, a postdoctoral neuroscience researcher at Campus Biotech, GESDA's headquarters in Geneva. "This is truly exciting, but it also raises many questions about the impact of neurotechnologies. Things we are working on ourselves and things we're seeing coming out of other labs all around the world," she told participants at the summit.

GESDA formed a task force to explore the topic further and get to the next stage in 2023, which would be to develop and test the prototype for a new centre or "NeuroTech Compass" where scientists, policymakers and industry can gather, said GESDA's Solutions Accelerator Executive Director Daria Robinson. "This summit will help us get to that stage," she said, "and bring the right voices in and continue shaping the final design of this proposal."

Scientists have long made use of neurotechnology but with recent advances there has been an explosion of new methods and devices, said Olaf Blanke, Founding Director of the Center for Neuroprosthetics and Bertarelli Foundation Chair in Cognitive Neuroprosthetics at the Swiss Federal Institute of Technology at Lausanne (EPFL), where he directs the Laboratory of Cognitive Neuroscience. He also is a Professor of Neurology at the University Hospital of Geneva. With Parkinson's disease, for example, 5 million patients worldwide are affected by slowness of movement, shaking, cognitive decline and other motor disorders. But a neurosurgeon can now implant electrodes designed by engineers to stimulate a particular region of the brain, and that can alleviate the shaking or allow patients to move again and speak.

"What will happen in 10 to 25 years? Think about not just a handful of electrodes implanted and decoding, but thousands of electrodes. This is not science fiction," said Blanke, a co-chair of the GESDA Task Force, adding that engineering, computer science and artificial intelligence will all be used to process the massive amounts of data obtained from people's brains and to decode it "on the spot in real time." But that raises questions about whether these techniques can augment memory and target other forms of dementia. If they can, they could allow healthy people to use them for neurotech enhancements. "What are the rules?" Blanke asked.

"What is in place to help us take decisions and be forward-looking, anticipating? I think these are things that are currently completely missing."

These are governance issues that must be addressed, said Lidia Brito, UNESCO Regional Director for Southern Africa. UNESCO's role as a standard-setter led to its 2005 adoption of a Universal Declaration on Bioethics and Human Rights, which prioritizes the interests and welfare of people over the sole interest of science or society. It promotes social responsibility, informed consent, privacy and confidentiality, non-discrimination and non-stigmatization. In 2017, UNESCO's Recommendation on Science and Scientific Researchers codified goals and value systems for science to flourish.

"What we have seen is that emerging technologies – if you don't have a good conversation between science, diplomacy, and policymakers – what happens is the governance mechanisms set almost naturally and then it's very hard to change," said Brito, a forest engineer and GESDA Task Force co-chair. "That's the first issue that we have been discussing in the task force. We know where the science is going, but where are we developing enough knowledge about the governance systems that allow us to make sure that, indeed, the technologies will benefit the ones who need it most and not the other way around?" She said it's not only about data-sharing; a "critical mass" of research and infrastructure is needed.

Permanent Representative of Switzerland to the United Nations and other organizations in Geneva, Jürg Lauber, a veteran Swiss diplomat and lawyer who also represented his nation at UN headquarters in New York, said he first tried to understand the complexities of the issue by talking to other people rather than engaging in ideology. "Only a few governments have the capacity, the time, the resources to really look into this. This is, I think, where GESDA comes in. We need to bring this information to the table of the diplomats. Something's happening: UNESCO's looking at it; Council of Europe is looking into it; OECD is looking into it."

An audience member, Israel's UN Ambassador in Geneva, Meirav Eilon Shahar, said during the Q&A session that her nation tends to frame new technologies as presenting "opportunities and challenges" when considering regulations and the human rights implications. "GESDA is doing a very good job in bringing the scientists' community, the diplomats, as well as the policymakers, of course, the academia, the civil society," she said. "It's important for us also to see how we push forward the governmental part of it, not only the private companies, the start-ups."

Gérard Escher, a neuroscientist and Senior Adviser to GESDA, said the goal is to "have the best benefits in the future" by navigating the challenge of understanding neurotechnology's impacts on individuals and society and mapping out regulations and laws nationally and internationally. "The impacts we should look at are dignity, freedom, equality, solidarity, citizens' rights, justice, there might be others. Then we look at legal frameworks, of course, the universal frameworks, the creation of human rights and regional charters, international charters, and then national constitutions."

Neurotechnology is a hotbed of legal concerns, according to Stephanie Herrmann, International Human Rights Lawyer for Perseus Strategies, the US firm founded by Jared Genser, a renowned attorney who has helped free 350 political prisoners in the past decade. Herrmann also assists Genser in his role as outside general counsel to the Neurorights Foundation, which he co-founded in 2019 to protect citizens from potentially harmful neurotechnologies. "When we talk about neurotechnology or methods to read and record brain activity, we are always thinking at the Neurorights Foundation about how this technology advances human rights or whether its misuse and abuse by states and private actors needs to be regulated to prevent human rights violations," Herrmann told the panel.

"We've written a report applying international human rights law to neurotechnology to analyse where there might be human rights protection gaps that the United Nations can act to fill. And in that, we've proposed a number of ways that existing international human rights law can be further interpreted to account for neurotechnology and the unique ways it affects human dignity or can," said Herrmann. "At the national level, we are engaged with a consumer advocacy publication to review what is now widely available consumer neurotechnology to assess for the first time its civil and human rights implications. Within the medical context, when neurotechnology is used in the doctor's office or in other sensitive settings, countries tend to have national laws regulating the data that's collected by this technology. So, for instance, your brain scan for a medical purpose is likely protected under the laws of a country. But, when you buy a consumer device, that may not be the case. And when you buy that device, the data that is stored from it can be sold to third parties. It may not be fully de-identified by the companies that collect it. A host of civil liberties and human rights concerns arise from the use and pervasiveness of consumer tech," she said.

Proceedings of the 2022 Geneva Science and Diplomacy Anticipation Summit

The question of who can enhance their body with technology – even with something as common as a pair of glasses, which many people in wealthy countries take for granted – can be a matter of life or death in other, less privileged places, noted Olivier Oullier, a co-founder of Inclusive Brains and Professor of Behavioural and Brain Sciences at Aix-Marseille University. Oullier has worked in neuroscience as an academic and policymaker at governmental organizations and had a leading role in revising France's bioethics laws. To him, access to technology is paramount. "For me, not being able to see clearly is not a matter of life and death. But there are a couple of kids in countries where they could step on a snake or a scorpion, where seeing what is happening is a matter of life and death. Unfortunately, they don't have access to the technology the way I have," he said.

"Should we stop developing this technology because there is an unequal distribution? That's the first question. And it's a very important moral dilemma. The second point I would like to raise is there wouldn't be this technology without the industry," said Oullier. The industry wants stringent regulation, too, so consumers know what companies to trust. "For better or worse, industry is far ahead when it comes to what can be done with technology," he said. "The industry wants to be part of this, not just to block regulation or to support it. Again, as the co-founder of a company that is creating brain-computer interfaces for disabled people to have access to work to stop being excluded – yes, it's so unfair. Our technology will first benefit people from my country and from the Western countries. Because this is where we're located. But hopefully, thanks to regulation, but also thanks to the private sector and its power to spread and to deploy, the technology will be available to people."

Regarding GESDA's idea, Ouillier noted, "The strength of a compass as a unique tool is that it's not just about informing people – information is necessary, but not sufficient. If information were sufficient, no physician would be smoking because they have information that it's bad. Physicians

smoke. Two words that show you that information is not enough. Second, you also need people from different angles, perspectives, different stakeholders to make a decision or a set of decisions, thanks to a tool. If you just ask society, you might end up with things some of us wouldn't want."

In March 2021, UN Secretary-General António Guterres spoke with a scientist about neurotechnology. That was the moment he "immediately realized its potential impact on society and asked us to convene, informally, stakeholders to look at those human rights impacts of this technology, but also the broader governance implications," said Ayaka Suzuki, who directs the UN's Strategic Planning and Monitoring Unit in the Executive Office of the Secretary-General. Her office later organized two roundtables with UNESCO, the UN Office of the High Commissioner for Human Rights and UN Global Pulse, along with experts outside the UN system. "We have also extensively reviewed a mapping of existing human rights treaties and conducted a survey of private actors to analyse the implications of future neurotechnology scenarios. And here I can't overemphasize the urgency for action," said Suzuki. "The interesting outcome from the survey was that most experts predicted that these technologies will be gaining widespread significance as early as three years from now."

Suzuki said the United Nations fully agrees with GESDA on the need for more dialogue and bringing all the stakeholders together to collaborate on solution pathways. "This is a topic that is gaining momentum among governments and policymakers. In fact, at the end of September, the UN Human Rights Council in Geneva called for a formal report on the rights-based implications for neurotechnology to be delivered within two years," she said. "It is essential that we all contribute to this process and processes like that and like the NeuroTech Compass of GESDA, so that we can maximize our voice, join forces and try to stay ahead of the curve of this rapidly developing and vastly consequential technology to maximize the benefits and also mitigate the risks."

More information

Explore this topic in the 2022 GESDA Science Breakthrough Radar®

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Tweets related to the session

Takeaway Messages

GESDA began exploring the promise of neurotechnology as a result of the 2021 Science Breakthrough Radar and Summit and formed a task force to explore the topic further.

Scientists have long made use of neurotechnology but, with recent advances, there has been an explosion of new methods and devices.

Engineering, computer science and artificial intelligence will be used to process the massive amounts of data obtained from people's brains and to decode it, raising questions of governance.

Only a few governments have the capacity, time and resources to deal with the governance questions, which is why GESDA can help by bringing diverse communities together.

Countries tend to have national laws regulating the data that's collected by this technology, but consumer devices that use brain data may not be regulated.

Access to technology is an important moral consideration and industry wants to be included in the debate over how to spread and deploy it.

The UN is mapping existing human rights treaties and surveying other information for the implications of future neurotechnology scenarios, some of which could occur soon.

The next stage in 2023 would be to develop and test the prototype for a new centre or "NeuroTech Compass" where scientists, policymakers and industry can gather.

Neurotechnology is a hotbed of legal concerns in the field of international human rights law.

Lidia Brito

Stephanie Herrmann

Ayaka Suzuki

Pipeline of Solution Ideas

Catalysing a Decarbonisation Accelerator

Abstract

After COP26, there is global agreement for governments, businesses, and citizens to embark in a decarbonisation global effort at every level. Global decarbonisation efforts are being stalled by objective gaps in science, technology, processes, and diplomacy. The nature of the gaps is often complex and systemic, and therefore impossible to solve with linear or singleparty solutions. Solutions currently in the pipeline need to be accelerated to reach the right stage of maturity for their implementation. The global ambition is to achieve net-zero CO_2 for 2050, which requires accelerating the energy transition to switch to renewable energy and deploying technologies that directly remove CO_2 from the atmosphere

- How can cooperation help boost R&D on decarbonisation processes, scale them up and accelerate the transition?

- How will collaboration create sector-specific sustainable business cases for decarbonisation technologies?

- How can we create a policy framework connecting science and diplomacy to enable the net-zero CO_2 ambition?

Join this session to learn more about the proposal currently developed within GESDA's Pipeline of Solution Ideas to set up an eco-systems orchestrator that helps current decarbonisation solutions and projects to overcome obstacles and flourish.

Participants

Moderated by:

Carlo Giardinetti, Sustainability Lead for Consulting, Deloitte, Italy

With:

Belinda Cleeland, Head, Research & Innovation, International Organization for Standardization, Switzerland

Jim Hagemann Snabe, Chairman, Supervisory Board, Siemens AG, Denmark

André Hoffmann, Businessman, Environmentalist and Philanthropist; Vice-Chairman, Roche Holding, Switzerland

Wendy Lee Queen, Associate Professor of Chemical Engineering, EPF Lausanne, USA

Nikhil Seth, UN Assistant Secretary-General; Executive Director, United Nations Institute for Training and Research (UNITAR), India

Massamba Thioye, Project Executive, Global Innovation Hub, United Nations Framework Convention on Climate Change, Senegal

Pipeline of Solution Ideas

Eco-regeneration & Geoengineering

Decarbonisation Accelerator

Catalyzing Decarbonisation

Transparency

Trust

Science

Business

Diplomacy

Effectiveness

Assessing overall environmental impact

Power to X - Identifying emerging innovation

Highlights

Governments and businesses vowing to achieve net-zero carbon emissions in coming decades face a series of hurdles – political, scientific and technical gaps – in trying to make the jump from burning fossil fuels towards greater reliance on renewable energy and carbon removal technologies. It's typically taken at least two decades to scale up solar and wind technologies, however, so as part of GESDA's new Pipeline of Solution Ideas, experts worked to identify ways of bringing promising technologies to scale much faster by connecting science and diplomacy.

A leading example is Jim Hagemann Snabe's effort to decarbonize the world's largest container shipping company by converting green electricity into green liquid fuel to power vessels in a process called "Power-to-X". In 2018, when Snabe chaired Danish shipping and logistics behemoth A.P. Møller-Maersk, it committed to net-zero emissions by 2050 with no idea of how to achieve that goal. Long-distance vessels can't simply adopt an electric-car approach due to battery weight, making hydrogen-based fuels the most promising solution for maritime shipping, which produces 2.5% of global emissions. "We knew the solution was Power-to-X, which is really creating green fuels out of green electricity," he told the panel. "You take green electricity from wind and solar, you make green hydrogen out of that, and then you create a green fuel. There are various types; that's why it's called Power-to-X."

Hydrogen, sometimes described as the "Swiss Army knife of decarbonization" because of its potential role in every sector, powered the first internal combustion engine 200 years ago and the rocket fuel for the Apollo moon-shot in the 1960s, then vanished in the era of cheap oil. The electricity needed to produce "green" hydrogen comes from renewable sources, such as hydroelectric, wind and solar power, but almost all the rest is "grey" – powered by burning hydrocarbons. Greening it all would require eliminating 830 million tonnes of CO_2 a year that the International Energy Agency says comes from hydrogen production, equivalent to the combined emissions of Indonesia and the UK. And, like any technology, hydrogen is not and never will be completely risk-free. It can ignite at anywhere between 4% and 74% concentrations, giving it the widest flammability range of any fuel.

Snabe, who left the Maersk board but remains Chairman of German manufacturing giant Siemens, said he wonders if GESDA could help facilitate and scale up a solar-to-hydrogen project in Morocco, which has become a world climate leader in solar arrays. In a video message to the summit held during the High-level Ministerial panel, Morocco's Foreign Minister Nasser Bourita said his nation supports GESDA's proposed solution for an Open Quantum

Institute in Geneva and hopes for GESDA's success since "the challenges of today's world need scientific contributions to enable humanity to overcome the major threats they are facing."

Just before Snabe – one of Europe's top industrialists – stepped down from Maersk, its board accelerated the net-zero emissions goal to 2040. The company has ordered 19 container vessels that will require 600,000 tonnes of green fuel – but no one makes it yet. The company is taking a gamble, sending what he calls a market signal by creating the demand for green fuel. "This is a moon-shot approach. It's a leadership moment where you have to have the courage. Now, I'm arguing that, if you can do it in shipping, you can do it in any industry," said Snabe, who also co-chairs GESDA's decarbonization solutions effort with Wendy Lee Queen, an Associate Professor of Chemical Engineering at the Swiss Federal Institute of Technology in Lausanne (EPFL).

Jim Hagemann Snabe

"I always define innovation as the multiple between the greatness of an idea multiplied by its scale, so, if one of these is zero, there is no innovation," said Snabe. "You can have the best idea in the world, but if it's not scaled, the innovation is zero. Or vice versa. You scale something stupid; it may even have a negative impact. Now, I think the role of science is to combine brilliance and money and convert it into great ideas. And the role of business is obviously to convert these great ideas into money. And then this cycle can continue. And businesses are good at that; that's what they do."

Scientists and engineers can also have a huge role in decarbonization, Queen said, but need to be able to implement technologies like renewable energies and batteries that are extremely well advanced. "The most important role we can play is

André Hoffmann

in helping to eliminate fossil fuel use immediately and converting to renewables like wind, solar and hydropower. Science and engineers are behind the materials design and devices design that are absolutely necessary for the implementation of these various processes," she said. "Once we have the renewables, we need energy storage, because we know that solar and wind are not operable at all points during the day. We need batteries for energy storage. We also need scientists developing a variety of different methods and catalysts that can be used to create chemical storage, for instance, the production of fuels from things – waste like CO_2 and even hydrogen that's produced from water. I believe that what we need are incentives to promote their widespread adoption."

The panel's moderator, Carlo Giardinetti, a Sustainability lead and Leadership Senior Adviser at Deloitte Consulting Switzerland, noted that, until the COVID-19 pandemic, it normally took five to 10 years to launch a new vaccine. "What is the problem that we don't recognize the sense of urgency when it comes to decarbonization?" he asked. "Or that we haven't learned yet how to orchestrate at the systemic level the right player and how we can allow the right player to actually get through the system and accelerate at speed?"

UN Secretary-General António Guterres has emphasized that the world's addiction to fossil fuels is suicidal. "The truly dangerous radicals are the countries that are increasing the production of fossil fuels," said Nikhil Seth, Executive Director of the UN Institute for Training and Research, who noted that the bulk of CO_2 emissions come from three sources: 41% from electricity and heat; 24% from transport; and 19% from manufacturing and construction. "Governments and corporations and the finance industry have to provide the incentives

for the decarbonization of the global economy. We need to reduce emissions by 8% a year, but we are growing emissions by an annual average of over 2%," he said. "We need to go sector by sector clearly and apply technology revolutions in each of the major sectors: in electricity generation, in cars, in buildings, in shipping, in agriculture, in aviation and in steel."

However, the public debate "also has to capture the popular imagination," said Seth, because in India he would "laughed off the stage" talking about decarbonization rather than issues like urban pollution, sanitation and congestion, which are paramount in people's minds. Creating a circular economy worldwide also is needed, he said: "Reuse, refurbish, remanufacture and recycle, extend the life of products, and better manage waste that retains quality and value by recycling. Moving from a linear system takes an effort but it is possible, easily for some processes but more difficult for other processes."

Every business must manage for climate risks and losses in nature because they are happening now, said André Hoffmann, Vice-Chair of Roche Holdings, the drug company founded by his great-grandfather. "For business leaders to not take this into account is a sign of not-very-good business leaders," he said. "It's a sign of not being particularly switched on. Now, what can we do at business level? Well, first of all, we have to recognize the evidence of decarbonization. And then we need to change our practices to do things together. Again, the example of the pandemic can be useful. When we work together, we work much better than if we work separately. So, we're all in this together." Hoffmann emphasized the need for better accounting and measuring systems, such as an initiative begun by then-Prince Charles with seven British companies to decarbonize their supply chains.

An audience member, André Loesekrug-Pietri, President of the European funding agency Joint European Disruptive Initiative, similar to the US DARPA, offered what he called a "variable" to Hoffmann's equation: interdependence. Since the EU Commission depends on China for 55% of its batteries and 97% of its permanent magnets, he asked: How in the practical world can the EU align its goals with its politics?

"You cannot just focus on one dimension. I would contend that there will be no opportunity to decarbonize our planet if you don't have a happy humanity. The two things are linked," answered Hoffmann. "The free capital and the interdependencies are what's going to help us to create a sustainable economy. I understand that it is a heavy lift. We have a lot of work in front of us. And we should not shy away from the fact that we really do need what you were mentioning before, a complete system change. That's why we need GESDA."

From the standpoint of global governance, the International Organization for Standardization (ISO) is creating voluntary standards to help businesses and governments turn their net-zero commitments into actions on climate, said ISO's Head of Research and Innovation Belinda Cleeland. "Everyone is making commitments – what they're going to achieve by 2030, by 2050 – but how are they going to do that?" she asked. "They're all also looking for guidance and looking for potential solutions to help them. International standards can provide them with tools to help them do that. We have a wide range of standards that promote action on climate and help decarbonization, and the demand for these comes from the market."

For example, businesses need a baseline measurement – the ISO 1406x series – for measuring and reporting carbon emissions. ISO has also been working on standards for green transportation, electric vehicles, fuel cells, batteries, solar power, hydrogen technologies and other renewable energy solutions. It has a committee that works on carbon capture standards to help with the design, construction and safety of capturing carbon and geologically storing it. "What we are hoping to do at ISO is to promote awareness," said Cleeland. "These international standards are out there, and they can be excellent tools for governments and for businesses to help them achieve their commitments."

However, the UN Climate Change's Global Innovation Hub found that governments fall short on decarbonization by thinking about what's possible and not taking a "moon-shot" approach, said Massamba Thioye, an expert on energy management systems who leads the UN hub. Since they only consider existing technologies, policies and financial instruments, he said, these incremental changes will not be enough – more transformative approaches are needed. "If you ask them why, their response is because 'we want to be credible'," said Thioye. "The problem is it does not provide room for innovation. More importantly, if you interrogate those who are developing climate and sustainability solutions, and you ask them why they are not able to find the right solution, they will say,

Belinda Cleeland

'because there is no demand'. Because those who are at the demand side are not ambitious enough. So, we are stuck in a vicious circle."

The UN hub instead works to promote goal setting based on capability, what's needed and contribution to global demand. "This global demand for climate and sustainability solutions will be built by aggregating the specific demand, and this demand will be a transformation of the gap between what is needed and what is perceived as possible," said Thioye. But, there's another problem: "The reality is that innovation is mainly used to maintain the system of wealth production. It's not about serving people," he said. "What we are proposing is something completely different: This is to go back to the core human need that products and processes are satisfying and explore how innovation can serve the development of the forward-looking value chain that will be able to provide well-being to 10 billion people by 2050." This approach, said Thioye, "is fully aligned with actually the vision of GESDA: Use the future to build the present. What we are doing is starting from the future that we would like to build."

More information

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Takeaway Messages

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The aim is to widen the global circle of beneficiaries of advances in science and technology and close the gap between scientists and diplomats so they can effectively work together on policies and actions.

The prototype of this global curriculum began in May 2022 as Science and Diplomacy Week, an immersion programme and open forum in Geneva for emerging science and diplomacy leaders.

GESDA continues to build a global curriculum around the premise that no single individual or organization has a monopoly on how best to merge science anticipation with multilateralism.

To make better laws and policies, policymakers need to understand what is happening to people.

Diplomats are often crisis-oriented and don't take time to think about the future, but scientists also need time to understand how policy is made.

The complexities behind merging education and training in science and diplomacy present a new kind of challenge to universities.

Leadership skills and mindsets for driving change must be cultivated so people are prepared to listen, ask the right questions, empathize and understand others.

Geneva is a great place for boundary-spanning professionals and mechanisms to thrive.

Carlo Giardinetti

Nikhil Seth

Solution Idea

Creating a Global Curriculum on Science and Diplomacy

Abstract

A new mindset and professional pathway are needed to establish Anticipatory Science & Diplomacy methodologies among experts and decision-makers. We must start with the way we train our current and future leaders across all sectors: in STEM fields, in national governments, in multilateral institutions, and in the private sector – to empower the current and next generation with a «multilingual» mindset in science and diplomacy and foster boundary-spanning professionals and institutions. This session will explore existing and emerging educational frameworks, training approaches and pedagogical methods to foster competences, capacities and networks to bring Anticipatory Science & Diplomacy to the center of decision-making in multilateral and national contexts to successfully tackle global future challenges.

- What are the necessary ingredients (knowledge, skills/competences, and network) for an effective curriculum in Anticipatory Science & Diplomacy?

- What coalition of institutions must come together to design and deliver this curriculum?

- Where and how should it be deployed for future leaders to understand and jointly promote anticipatory Science & Diplomacy as a tool for a renewed multilateralism?

- How can we create effective opportunities and spaces for intensified interaction and understanding between scientific and foreign policy actors?

Join this session to learn about the potential for a global curriculum on science and diplomacy from topical experts who contributed to the Science Breakthrough Radar, members of the Geneva Anticipatory Science & Diplomacy Coalition, and alumni representatives from the inaugural Geneva Science Diplomacy Week.

Participants

Moderated by:

Achim Wennmann, Director, Strategic Partnerships, Geneva Graduate Institute, Germany

With:

Francesca Bosco, Chief of Staff & Head of Foresight, CyberPeace Institute, Italy

Ismael Buchanan, Senior Lecturer, University of Rwanda, Rwanda

Martin Chungong, Secretary-General, Inter-Parliamentary Union, Cameroon

Tamara Gomez Marin, Consul General, Embassy of Costa Rica in Rome, Italy; Minister Counsellor, Ministry of Foreign Affairs and Worship of Costa Rica, Costa Rica

Marga Gual Soler, Founder, SciDipGLOBAL; Academic Moderator and Solution Co-chair, GESDA, Spain

Nicolas Levrat, Director, Global Studies Institute, University of Geneva, Switzerland

Sandeep Mishra, Expert, Digital Technologies and Innovation, India

Alysson Muotri, Professor, Department of Pediatrics and Cellular & Molecular Medicine, University of California, Brazil

Christina Orisich, Deputy Director; Head of Executive Education, Geneva Centre for Security Policy, Austria

Rémi Quirion, President, International Network for Governmental Science Advice, Canada

Nicolas Seidler, Executive Director, Geneva Science-Policy Interface, Switzerland

Solution Idea

Science & Diplomacy

Global Science & Diplomacy Curriculum

Leadership for change

Multidisciplinary Literacy

Capacity-building through science anticipation

Highlights

GESDA has been working to establish anticipatory Science and Diplomacy as an academic topic, a mindset and a new professional pathway since it emerged as a leading idea from the inaugural GESDA Science Breakthrough Radar and Summit in 2021. As with all of GESDA's work, the aim is to widen the global circle of beneficiaries from advances in science and technology. The two co-chairs for this effort, Inter-Parliamentary Union (IPU) Secretary-General Martin Chungong and GESDA's Head of Science and Diplomacy Capacity Building Marga Gual Soler, focused on closing the gap between scientists and diplomats so they can effectively work together on policies and actions.

"Today, we face a paradox. Many global challenges of scientific and technological dimensions transcend national boundaries and require all sectors to work together. But scientists and diplomats lack a shared language, common mindset and place to exchange," Chungong told the panel. "The curriculum wants to bridge this gap. To establish an anticipatory science and diplomacy mindset, we must begin with how we train current and future leaders in all sectors in STEM, national governments, multilateral organizations or the private sector: empowering the current and next generation with a multilingual mindset in science and diplomacy; and fostering boundary-spanning professionals and institutions." As the global organization of national parliaments, IPU has a unique vantage point on science diplomacy, said Chungong: "We're here to ensure parliamentarians are fully integrated as one of science diplomacy's key stakeholders, because multilateral agreements are implemented at the national level through parliaments."

Initiated by GESDA, the Geneva Coalition on Anticipatory Science and Diplomacy was created with 14 Swiss and global institutions. It successfully designed and delivered a prototype of this global curriculum as a first joint pilot programme, the Science & Diplomacy Week, an immersion programme and open forum in Geneva for emerging science and diplomacy leaders. GESDA and 20 other Swiss and global institutions welcomed 30 participants from 20 countries to the first one, held in May, which encouraged interaction and understanding among scientists and diplomats, helping to fill thematic gaps and leverage opportunities in conflict prevention and resolution. GESDA continues to examine educational frameworks, training approaches and teaching methods to build a global curriculum around the premise that no single individual or organization has a monopoly on how best to merge science anticipation with multilateralism.

Gual Soler said it was a great pleasure for GESDA to unveil "one of the two most advanced solutions that we want to put forward to the world to get your feedback"; the other is the proposed Open Quantum Institute in Geneva. The panel's moderator, Achim Wennmann, Director for Strategic Partnerships at Geneva's Graduate Institute of International and Development Studies, asked for a show of hands from audience members who felt they knew enough "to do science diplomacy tomorrow." He observed that about 10% raised a hand. About one-third indicated they don't know; and another one-third responded they aren't ready. As part of the GESDA-initiated coalition, the Graduate Institute believes "science without social science" or "science only in the laboratory that is not connected to the world" is too great a risk, he said, advising that the curriculum should "embrace conflict" with "a real culture of debate, disagreement."

Tamara Gomez Marin

Ismael Buchanan

Christina Orisich

Nicolas Levrat

Learning to speak others' languages is key in science and diplomacy, said Rémi Quirion, President of the 130-nation International Network for Government Science Advice (INGSA), one of GESDA's partners. Nations of all sizes show interest in having science advisers, he said, "but you need to bring that to the level of cities, to the level of the citizen, working with mayors, working with the citizens. And there, the science advice needs to be framed a bit differently, in very practical terms. We need to build capacity and that's what we want to do."

Diplomats often are crisis-oriented and don't take time to think about the future, but scientists also need time to understand how policy is made, according to Tamara Gòmez Marin, Consul General of Costa Rica in Rome, who took part in Science and Diplomacy Week. "That's why I think the GESDA Science Breakthrough Radar is so important. For me, it was really a transformative experience," she said. "I saw a really big need from the scientific partners … to try to understand how diplomats take decisions." She said the process of finding common ground among scientists and decision-makers can also be extended to generate discussion among her local communities to help define "national realities".

Frank Tressler, Chile's Ambassador to the UN in Geneva, suggested getting more career diplomats involved. Two other Science and Diplomacy Week participants, Ismael Buchanan, Senior Lecturer at the University of Rwanda, and Sandeep Mishra, an expert in digital technologies and innovation, said GESDA helped improve their interdisciplinary communication skills. "It's very different from all my past experience," said Mishra. "It's a very diverse flow coming from different backgrounds."

Technological risks – but different ones – were on the minds of Francesca Bosco, Chief of Staff and Head of Foresight at the CyberPeace Institute, and Alysson Muotri, Professor of Paediatrics and

Cellular and Molecular Medicine at the University of California, San Diego, who each highlighted the multidisciplinary background needed for science and diplomacy.

Bosco said it takes both technical skills and economic expertise to understand how cyberattacks impacted vulnerable communities by denying them vaccines during the COVID-19 pandemic, for example. When collecting data, analysts need a common "lens" through which it's understandable. "The policymakers, to make better laws and policies, need to understand what is happening to people," Bosco said. "We did the same when it comes to attacks against civilian infrastructure in the conflict in Ukraine. What we are doing is providing support to policymakers but also to civil society organizations in the field that they will need to enhance their cybersecurity posture."

Muotri explained that his lab works with brain organoids, tiny 3D structures made of stem cells that can replicate the complexity of human organs. In 2019, his lab showed that those tissues can generate neurological "sympathies and oscillations" similar to an EEG, opening a Pandora's box that news outlets headlined as "mini-brains in a dish". He lacked the media training needed to deal with it, he recalled, but couldn't find any help. "Talking to my colleagues at the basic science lab, this is not unusual. This happens to everyone," he said. "It's better to work with policymakers, with the public, to establish a dialogue between how the science is advancing before this turning point."

Three members of the GESDA-initiated coalition explained how the complexities behind merging education and training in science and diplomacy present a new kind of challenge to universities. European institutions have a close link between research and teaching "but the way our universities are organized is not producing sufficient results to meet the needs of the global challenges," said Nicolas Levrat,

Sandeep Mishra

Director of the University of Geneva's Global Studies Institute. "It's a question of culture," he added. "We will try with this curriculum to build a new generation of decision-makers who have both structures."

Since science and diplomacy is a multidisciplinary, multistakeholder field, said Christina Orisich, Deputy Director and Head of Executive Education at the Geneva Centre for Security Policy, it would be advisable to "include now, early on, the private sector, civil society and the organizations, all youth, all the different groups as part of the science diplomacy training" so that scientists and diplomats can better understand the complexities. Leadership skills and mindsets for driving change also must be cultivated, she said, so that people are "prepared to listen, to ask the right questions, to have the empathy, to really understand the other parties."

Nicolas Seidler, Executive Director of the Geneva Science-Policy Interface, said: "We need to have a higher baseline of appreciation and understanding from both communities on what each other's profession is doing. At the same time, I think it's not realistic to expect that all scientists will have a deep understanding of policy processes and, on the other hand, that all policy actors would have a deep understanding of how science works." Seidler said that's where people who are "boundary-spanners" enter the picture: "People that you know can help build relationships, build trust, gather policy and science actors around the table around common projects. Now, Geneva is actually a great place for boundary-spanning professionals and mechanisms to thrive."

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Solution Idea

Building an Open Quantum Institute & the GESDA-XPRIZE Contest

Abstract

Quantum technology is an issue of geopolitical importance, becoming a critical infrastructure important to national security and innovation capability. The last decade has seen major breakthroughs in research, leading to an increase and investment from the private sector from $1.5b to $22b in the last five years. Quantum capabilities could impact key sectors of the economy including pharmaceuticals, materials, chemistry, energy, finance, security, and logistics. If applied to the right set of issues, quantum computing has the potential to become a world-improving technology, directly applicable to implement the Sustainable Development Goals (SDGs) outlined by the United Nations. Quantum computers are tremendously expensive and hard to build so ensuring broad access to them will be difficult. To make sure the technology can be used with purpose in 5-10-25 years, new R&D collaboration and governance models that consider both technology security and equity of access need to be put in place now.

- How can we make sure this new technology benefits all of humanity, focusing on impact on the planet and society, and not just be used for the greatest profits?

- With so much on the line, how can scientists and policymakers make sure to maintain a spirit of open collaboration?

Join this session to learn how the Open Quantum Institute is proposing to make quantum technologies, and quantum computing, accessible and available globally in an open and inclusive manner. This GESDA Solution supports the development of quantum solutions for the benefit of humanity, directly working towards the Sustainable Development Goals of the United Nations (SDGs).

Participants

Moderated by:

Anousheh Ansari, Chief Executive Officer, XPRIZE Foundation, USA/Iran

With:

Graham Alabaster, Head, Geneva Office, UN Habitat, United Kingdom

Alberto Anfossi, Secretary-General, Compagnia di San Paolo, Italy

Tommaso Calarco, Director, Institute for Quantum Control, Peter Grünberg Institute, Forschungszentrum Jülich, Italy

Fabiola Gianotti, Director-General, CERN; Board Member, GESDA, Italy

Sana Odeh, Clinical Professor of Computer Science; Faculty Liaison, Global Programs of Computer Science, New York University, Palestine

Urbasi Sihna, Professor, Quantum Information and Computing Lab, Raman Research Institute, India

Matthias Troyer, Technical Fellow and Corporate Vice President, Microsoft, Austria
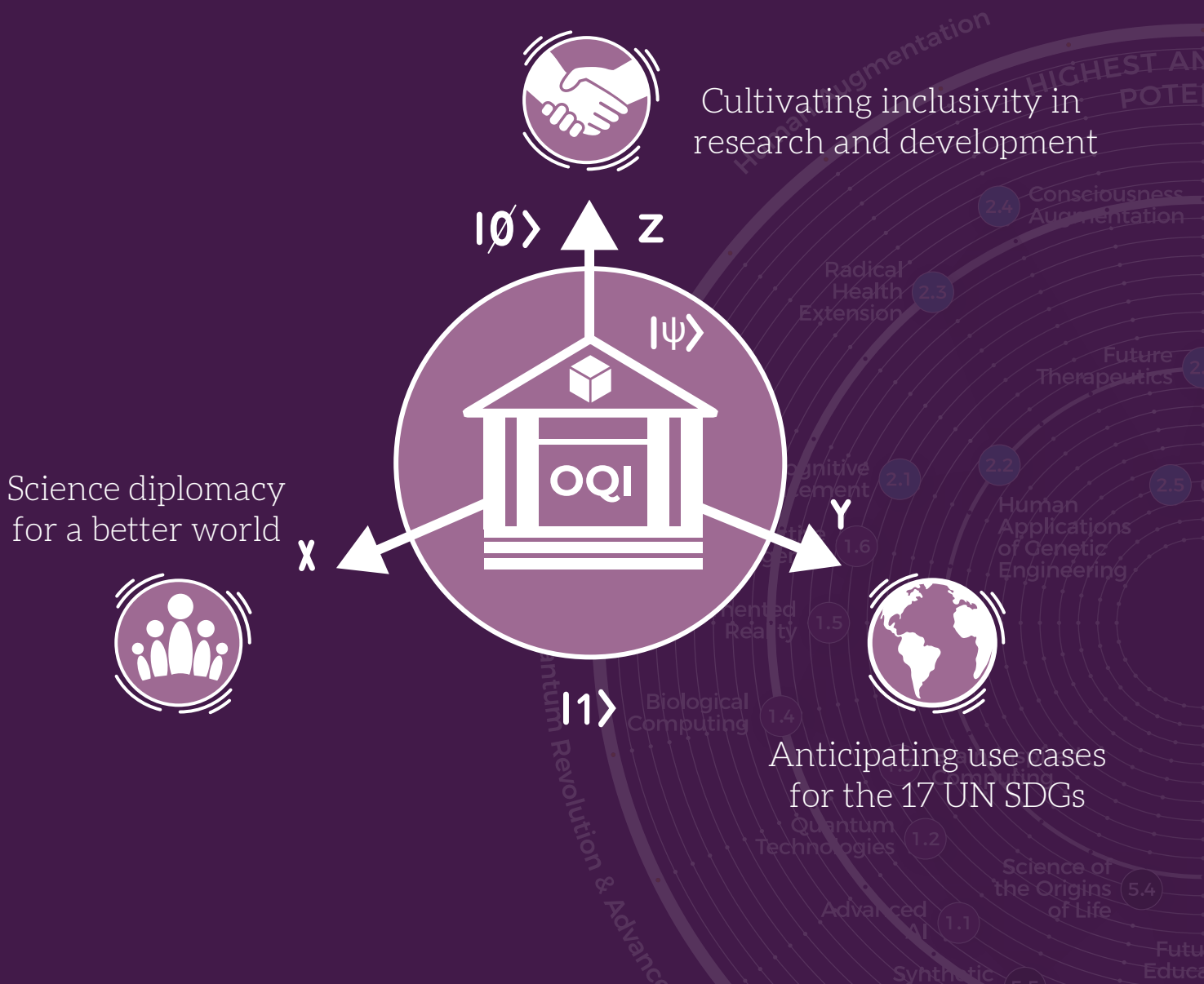

Fabiola Gianotti

Solution Idea

Quantum Revolution & Advanced AI

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Open Quantum Institute

Cultivating inclusivity in research and development

Science diplomacy for a better world

Anticipating use cases for the 17 UN SDGs

Highlights

As the most advanced proposal in GESDA's pipeline, the Open Quantum Institute (OQI) is being created to identify important quantum breakthroughs, figure out what to do about them and bring ideas to fruition. The proposal for a new institution in Geneva promises access to quantum computers to those who lack it and a forum for diplomatic discussions. It is envisioned as a centre of expertise for all quantum applications that could get the world closer to fulfilling the United Nations' 17 Sustainable Development Goals for 2030.

The OQI proposal already has strong support from academic proponents, including CERN, Swiss Federal Institutes of Technology ETHZ and EPFL, University of Geneva, University of Calgary, University of Copenhagen, Quantum Delta NL, Forschungszentrum Jülich, Raman Research Institute (RRI), South Africa's National Institute for Theoretical and Computational Sciences (NITheCS) and the University of KwaZulu-Natal. Compagnia di San Paolo Foundation, one of Europe's largest philanthropic foundations, also endorses the project. Initial supporting industry partners include Microsoft, AQT, AWS, IBM, IQM Quantum Computers, PASQAL, Oxford Quantum Circuits and Strangeworks.

In addition, permanent missions from a number of countries – Australia, Austria, Brazil, France, Japan, Malta, Mexico, Morocco, Netherlands, Norway, Pakistan and Singapore, along with Switzerland – have been actively involved in defining the multilateral relevance of a future OQI. Several diplomats, such as Morocco's UN Ambassador in Geneva, Omar Zniber, and the Netherlands' UN Ambassador in Geneva, Paul Bekkers, expressed their nations' strong interest in OQI. "The ambassador from Morocco and many others, including myself, are such big fans of GESDA," Bekkers told the panel. "Cooperation is key. That goes for nations, but it also goes for academia and the industry. We all need to work together. And that's why I think this initiative is just wonderful," he said.

For the past 18 months, the GESDA Quantum Task Force has been developing the OQI concept under co-chairs Anousheh Ansari, Chief Executive Officer of XPRIZE Foundation, and Matthias Troyer, Technical Fellow of the American Physical Society and Corporate Vice-President at Microsoft Quantum. OQI will not perform its own R&D but will work to identify areas of interest for partner research institutions to investigate. "We hope that these partner institutions will actually take on the task of performing that research and sharing the results with the world to benefit the world. In the same manner, we want to then bring the talent in the world, educate them, get them interested and involved in creating these solutions," said Ansari.

"By providing a pool of quantum computing resources to everyone around the globe, we hope to create an equal and level playing field for everyone to participate in creating these solutions," said Ansari. The International Space Station and CERN are models of how collaborative research can be done successfully, she said, adding: "We hope to apply this type of experience to the way OQI will operate in the future. We're in the very exploratory stage of this programme right now."

Sana Odeh

Urbasi Sihna

Ansari's XPRIZE Foundation is working closely with GESDA and the task force on a quantum competition that will award incentive-based cash prizes for innovation that expands quantum technologies. Quantum computing presents both huge opportunities and risks of creating or enhancing inequalities around the world, said Alberto Anfossi, a quantum physicist and Secretary-General of Compagnia di San Paolo. "We need to do it in an equitable way," he said. "We have a philanthropic role to make sure this is done for all. That's why, at Compagnia di San Paolo, we decided to be a first mover and to join the proposal of GESDA and XPRIZE and put in some seed money."

Philippe Caroff, Executive Director of the EPFL Centre for Quantum Science and Engineering, said the centre in Lausanne is "perfectly aligned" with OQI's mission. "We're interested in opportunities to contribute to an educational programme that would be open globally, and also to provide some help in the evaluation of use cases that align with sustainable development," he said.

Graham Alabaster, a long-time UN diplomat and chemical engineer who heads the UN-Habitat Geneva Office, participated in GESDA's workshops to help identify sustainable development problems that quantum could help solve and turn into use cases. Among the potential candidates he suggested as examples are antimicrobial resistance in wastewater treatment and biological hydrogen production for powering electric cars and batteries. "Whilst we're developing this technology and using quantum, we also have to understand how we're going to deliver that mechanism on the ground," he said. "How we reach out to those communities, how we use local expertise, local governance structures to make sure these systems can be equitably applied."

A decision was made early on to have OQI focus on facilitating collaborative research, said Urbasi Sihna, a member of the GESDA Task Force who is a professor at India's RRI and heads its Quantum Information and Computing (QuIC) lab. "The whole idea was to discourage forming some kind of a niche quantum club where only the developed nations would contribute," she said. "It's been a fantastic and very stimulating experience being a member of the task force."

Sana Odeh, Clinical Professor of Computer Science at New York University, noted that, even in wealthy nations, there's been a dearth of opportunities for students to learn about quantum computing. That was one of the reasons she founded and chairs the Annual NYU Abu Dhabi International Hackathon for Social Good in the Arab World. "What I'm trying to do with this hackathon is to bring all these young people, the smart people from all over the world, to work together, not separate them," she said. "It really opens their eyes to what computer science can do, what is the potential of quantum computing." Inclusion and collaboration like what GESDA promotes is important, according to Odeh, since everybody has "different approaches and priorities and problems."

The full potential of quantum is unknown today, although the possibilities for quantum technologies to transform society – to bring about breakthroughs in everything from fertilizer to vaccines – have been talked about since the era of late theoretical physicist and 1965 Nobel Prize in Physics recipient Richard Feynman, who understood that its potential reached way beyond classical computing, said CERN's Director-General and GESDA Board Member Fabiola Gianotti. "The time was not right. But the time is right now. With the past years, we've seen a huge increase in the interest and the work, the research work made on

Alberto Anfossi

Matthias Troyer

quantum. Huge investment – billions and billions by both the private and the public sector," she said. "Fifty years from now, we will have quantum computing which will allow us to solve problems that are intractable with classical computers."

At CERN, said Gianotti, scientists delve into quantum mechanics, a field developed a century ago, in their daily work with elementary particles. Initially, the field was thought to be useless knowledge. But that was long before it gave rise to advanced techniques and technologies routinely used in hospitals for diagnosing and treating disease – including hadron therapy for cancer, magnetic resonance imaging (MRI) and positron emission tomography (PET) imaging – and all our electronics gadgets, including computers and smartphones.

OQI would ensure open access to quantum technologies among the world's population that does not have access to the technology, science or education, said Gianotti. Enabling much wider access would boost the science itself, which thrives on an exchange of new ideas and technologies. The institute also would work to apply quantum to health crises, climate change and the other biggest challenges facing humanity.

Yet quantum, like all technologies, poses risks: "The danger is that the technology itself will continue to increase the gap between developed and developing countries, and those with and those without access to that technology. And we know that nowadays this development of technology is not sustainable because it's contributing to a two-speed world," said Gianotti. "It's important that we think about this new technology early enough and we try to frame it in a way that goes to the benefit of all humanity; hence the idea of GESDA using quantum as one of our first solutions." She said the OQI is a good fit for GESDA because it has an anticipatory role and "is extremely well-placed to make sure that quantum will be used in the best possible way."

The quantum technologies industry in Europe "endorses and supports very much" GESDA's OQI proposal, said Tommaso Calarco, Director of the Peter Grünberg Institute for Quantum Control (PGI-8) at Forschungszentrum Jülich, which specializes in novel optimization strategies for emerging quantum technologies. Calarco spoke on behalf of the European Quantum Industry Consortium (QuIC), which he co-founded in 2021. It is now the reference consortium officially recognized by the European Commission as representing the interests of the quantum technologies industry in Europe.

Calarco said there are enormous challenges to be overcome in developing quantum technologies, and leading experts still aren't sure whether it's feasible. "The question is: Can quantum technology revolutionize the world? And a scientific answer to that is, yes, we know. And there's another question, which is: Will quantum technology revolutionize the world? And the scientific standard answer is, we don't know," said Calarco, who is one of the founders of the European Quantum Manifesto, which led to the billion-euro EU Quantum Flagship programme. Within that programme, he leads the Quantum Community Network, which brings together theorists, experimental groups and industry. "And this is extremely important to draw a line between hype and reality," he said. "Nobody knows how to solve the whole challenges. And this 'nobody' means specifically that there is not any single country, not any single organization, industry, no matter how many billions they pour in there – because it is much more than billions."

Troyer, who's worked in quantum for more than 22 years, said he believes we are at an inflexion point, although the technology remains tremendously expensive and hard to build. "This a moment where the hype gives way to clarity. Because we have clarity now on where quantum will go. We have the impact, and we have clarity on what it will take to get there," he told the panel. "The good news is quantum is real, quantum is coming and the impact's real. And it will help us

solve some of the most important challenges of the planet. But what are those? And it's basically simple. You don't need to be a quantum scientist for that. Because what we know is that nature's quantum and that, to really understand nature, we need a quantum computer."

Since we tend to name ages in the history of civilization after materials, Troyer said, we're hovering on the verge of the Quantum Age – the successor to the Silicon Age, Steel Age, Iron Age and Stone Age. Over the last decade, there have been major breakthroughs in quantum research, leading to an increase in investment from the private sector of $22 billion, up from $1.5 billion, just in the last five years. For example, finding a way to remove the build-up of carbon pollution from the air through a new chemical process would have required "an almost blind search" on a classic computer. "With a quantum computer that can change," he said. It's the same with finding a new process for making fertilizer that could ramp up food production. "There are many areas where quantum can have a huge impact just by inventing new chemicals, new materials," said Troyer. "What is needed to get there is we really need to build those quantum machines and we have to develop those applications."

On the flip side, said Troyer, quantum poses a threat to public key cryptography – and those who fear that threat may try to restrict technology, rather than share it. "We should work on the good use of quantum. We should work together to make it happen. Then we have to jointly mitigate the threats. What we need there is the government leaders and the diplomats: we need your help to embrace the global access to quantum technologies, because we need that to make it happen."

More information

Explore this topic in the 2022 GESDA Science Breakthrough Radar®

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Session recording on YouTube

Tweets related to the session

Takeaway Messages

As the most advanced proposal in GESDA's pipeline, the creation of an Open Quantum Institute (OQI) is being proposed to identify important quantum breakthroughs, figure out what to do about them and bring ideas to fruition.

The proposal for a new institution in Geneva promises access to quantum computers to those who lack it and a forum for diplomatic discussions. The proposal already has strong support.

OQI is envisioned as a centre of expertise for all quantum applications that could get the world closer to fulfilling the United Nations' 17 Sustainable Development Goals for 2030.

A decision was taken early on to have OQI focus on facilitating collaborative research to ensure open access to quantum technologies among the world's population that lacks access to the technology, science or education.

OQI will not perform its own R&D but will work to identify areas of interest for partner research institutions to investigate. In recent years, there has been a huge increase in investment in quantum research.

Quantum is real, quantum is coming, and the impact is real. It will help us solve some of the planet's most important challenges.

XPRIZE Foundation is working closely with GESDA and its Quantum Task Force on a quantum competition, which will award incentive-based cash prizes for innovation that expands quantum technologies.

OQI is a good fit for GESDA because it has an anticipatory role and is well-placed to ensure that quantum will be used in the best possible way.

Closing Plenary Session

A Youth Outlook on GESDA and the Horizon of Science and Diplomacy

Abstract

After COP26, there is global agreement for Science Anticipation functions in the service of future generations. While current stakeholders, leaders, and policymakers must address the emergence of new technologies and science, it is imperative to foster inclusive participation in the Solutions process. This session brings youth and aspiring leaders at the beginning of their educational and career paths on stage to discuss what they have noticed, learned, and considered as they participated in the GESDA Summit.

Participants

Moderated by:

Valentine von Toggenburg, Lawyer, Swiss Federal Office of Justice , World Economic Forum Global Shaper, Switzerland

With:

Sophie van Berchem, Student, Columbia University, Switzerland

Aijing Cao, Junior Policy Officer, ITU Office for Europe, People's Republic of China

Adrien Donin de Rosière, Student, Kings College Wimbledon, Switzerland

Bekithemba Ntoni, Master's Candidate, University of Cape Town, South Africa

Rejoyce Kgabo Legodi, Volunteer Marketing personnel, Science Technology Engineering Aviation-Arts and Mathematics (STEAM) Ambassadors Club, South Africa

Silvia Maier, Member and Project Lead, Swiss Young Academy, Switzerland

Sofiia Martianova, Villars Fellow; Student, Electrical Engingeering, ETH Zurich, Ukraine

Jordan Naddaf, Foreign Policy Youth Collaborative Association, United Kingdom

Mamokgethi Phakeng, Vice-chancellor, Universityof Cape Town; Board Member, GESDA, South Africa

Niel Swanepoel, South African Delegate, Y20 Indonesia, Namibia

Stephanie Tauber Gomez, Director Sustainability, digitalswitzerland, Brazil

Eloise Westfeldt, Collège du Léman, United States

Highlights

The results of hard work and hope – and the need to sustain both – were on display in a panel discussion devoted to how science anticipation can function in the service of future generations.

Ahead of the 2022 Summit, GESDA set in motion new initiatives to gather fresh perspectives from the vantage point of youth – those up-and-coming generations that will be the most affected by advances in science and technology. Twelve young people, forming the GESDA Youth Cohort, participated in the summit based on the nominations and support of GESDA partner institutions, including South Africa's University of Cape Town (UCT), the Swissnex network, the Swiss Young Academy of Scientists, the Villars Institute and the XPRIZE Foundation.

GESDA Board Member Mamokgethi Phakeng, Vice-Chancellor of UCT, oversaw GESDA-UCT's new Youth Anticipation Initiative, which drew interest across Africa. Three students were selected to participate in the summit. Her university paper's headline – "Three UCT students will shine the light on science anticipation at Geneva summit" – and story captured the excitement: "Three University of Cape Town (UCT) students are to wow scientists and thought leaders from across the world as they share their ideas at the Geneva Science and Diplomacy Anticipator (GESDA) Science and Diplomacy Anticipation Summit in Switzerland this October."

On the summit's final day, Valentine von Toggenburg-Bulliard, a young Swiss lawyer who has gained extensive experience in private and public law in the corporate and public sector, moderated a panel discussion featuring 12 young and aspiring leaders who are just setting out on their chosen educational and career paths. They included three representatives from the youth initiative assembled by Phakeng. Collectively, they offered observations about the summit and highlighted the need for more inclusive participation in arriving at solutions that benefit everyone.

Joining her onstage, out of the 12 Youth Cohort members, were Aijing Cao of China, a Junior Policy Officer at the International Telecommunication Union's European office; Bekithemba Ntoni of South Africa, a master's candidate and lecturer at UCT; Silvia Maier of Germany, a member and Co-Principal Investigator at the Swiss Young Academy of Scientists; Eloise Westfeldt of the United States, a student at Collège du Léman; and Jordan Naddaf from the United States, a student at SOAS University of London.

"Our wish is that we will continue to engage with each other, not only in conversations but really in working together. We ask you to challenge us – not only to give us the floor – but really to challenge us. You have a lot more life experience than we have. Help us to be exposed to brilliant minds and hearts," Von Toggenburg-Bulliard told the summit's veteran scientists and diplomats on behalf of younger generations. "It's a good idea, because together we are much, much better."

A recurring theme of the panel was how to remain hopeful in a world with so many concurrent global crises, including climate change, geopolitical conflicts, disease, poverty and hunger.

"We have new diseases evolving, we have old diseases re-emerging, because they're now antibiotic resistant. We have icecaps melting, natural disasters crashing down on us from left and right. We have colossal decreases in biodiversity," said Westfeldt, who advised saving "ourselves from ourselves" instead of saving the planet, because it could perhaps go on even without us. "With all this happening at the same time,

Adrien Donin de Rosiére

Aijing Cao

it's hard to find hope. It's difficult to stay hopeful in a time where we don't really see our solutions yet. But I consider myself a rather optimistic person," she said. GESDA's inclusion of youth participants, she added, "helped me realize that we aren't alone."

As a social sciences student, Ntoni called for less focus on where technology can take us and more emphasis on how we appropriate technology to organize our social surroundings. The era of global governance since the Second World War hasn't adequately considered how technology influences our global economy, he said, "so then the question becomes: how do we make sure that we don't repeat the injustices of the past? How do you make sure that we appropriate these technologies in order to make sure that we foster inclusive growth?" The COVID-19 pandemic is a chance to "re-create" the economy, Ntoni said. "We have to think about how neoliberalism, although it had good consequences, only concentrated economic power in the North. And the Global South was still poor, even though we have technological developments that can redress those inequalities." He also called for older generations to do more mentoring. "Who are you sending to the future?" he asked.

Cao offered three takeaways from the summit. One is the need to reshape our future digital governance, she said, so that it preserves human dignity, and tech companies' norms don't become "dehumanizing" by degrading our ability to connect in real life. A second point on the digitalization of conflicts, she said, begs the question of whether we should blame technology or ourselves. Her third takeaway is the enormous potential of quantum technologies, which panellists during a GESDA session the day before said is "nearly impossible to deal with … in one country safe mode. So, for this, that's really

the moment for science diplomacy to kick in," Cao said. "If science and technology need to be inclusive, diplomacy is a means to ensure that they serve the public good."

Maier advised an "upgrade" to the usual talk about bridge-building among science, diplomacy and society: talk about platforms. "We actually need spaces where we can meet. We've been talking in the past about trusted messengers. And we also extend that notion, perhaps, in this space here, as maybe we need trusted spaces, too, where we can exchange as scientists, as diplomats, as members of the civil society, of industry," she said, "to solve all the problems that my young colleagues here have brought to you and that we've discussed in these three days. And so, the hope that I'm taking from this summit is that GESDA could provide one such space where we can have these conversations about these really wicked questions that we are dealing with."

Participating in the GESDA Summit is "the first time that I truly feel that we have a voice, and that we are being listened to and taken seriously," said Naddaf, who urged all participants to support more youths in gaining "pathways and tools" in their professional communities. "I think that it's extremely significant, and I would like to see more of this and other spaces. My hope is that, as GESDA continues, we continue to give you a platform and a voice throughout all of this and some processes to begin making an impact in the world. I think that as we've spoken in the youth cohort, we are all very interested in the action points." Naddaf also acknowledged that, amid so much uncertainty, "it's hard sometimes to be hopeful, as the others have said. We are constantly reminded that there is a lot that we are struggling to cope with as a society, as a world and as a

Eloise Westfeldt

Jordan Naddaf

species. There are a lot of challenges that we have to overcome. And I think that GESDA has left me very hopeful."

After they spoke, several more young people of the GESDA Youth Cohort joined them on stage: Olivia Avalos Villar of Spain, a student and Villars fellow at the International School Basel; Rejoyce Kgabo Legodi of South Africa, a student at UCT; Sofiia Martianova of Ukraine, a student and Villars fellow at ETH Zurich; Niel Swanepoel of Namibia, a G20 youth summit delegate; Sophie van Berchem of Switzerland, a student at Columbia University; and Stephanie Tauber Gomez of Switzerland and Colombia, Director of Sustainability at Digital Switzerland in Brazil. Adrien Donin de Rosière of Switzerland, a student at King's College Wimbledon, was finally unable to participate.

In a keynote message, Phakeng congratulated all of the youths for "making it to GESDA," because it meant they are all working hard and doing things that are important for everyone to hear about. "We, as GESDA, want to engage with you, work with you. We know that if we do anything for you, without you, it will not work. So, we want to work with you. We will then hear your voices," she told them. "And so, in 2023, we will be extending the Youth Anticipation Initiative to the whole world … That's the only way we can support young people, work with young people, to make sure theirs is not just a voice, but it goes to action."

Silvia Maier

The idea is not just to talk, said Phakeng, but to attend to the challenging problems of our world. "Because if we don't, there will be no future for our world. But we, as adults, cannot do this on our own. It is important that we stand by you as young people with us supporting you and enabling to make sure that you can put your ideas into practise or into action," she said. "Because we recognize your power. You will inherit the world. And so, it is important that you become part of the conversation and you, as young people, become part of leading the action into a better future."

Takeaway Messages

GESDA launched the Youth Anticipation Initiative to gather fresh perspectives from young people, who will be the most impacted by advances in science and technology.

A GESDA Youth Cohort of 12 young people participated in the summit with support from the University of Cape Town, Swissnex, Swiss Young Academy of Scientists, Villars Institute and XPRIZE Foundation.

Young people at the summit said it's difficult to remain hopeful in a world with so many concurrent global crises, including climate change, geopolitical conflicts, disease, poverty and hunger.

GESDA's inclusion of youth participants in the summit reminded some that they aren't alone – and made some feel they have a voice and are being taken seriously.

Older generations could provide more mentoring to help spread technologies and inclusive growth to the Global South.

Future digital governance should be shaped to set tech company norms that preserve human dignity and our ability to connect in real life.

Young people who are able to take part in GESDA have demonstrated that the work they're doing is important and others should hear about it.

GESDA understands that young people will inherit the world and adults need to make them part of the conversation.

More information

Session recording on YouTube

Tweets related to the session

Closing Plenary Session

Peter Maurer

Former President, International Committee of the Red Cross, Switzerland

Keynote speech

Mr President and colleagues, it is good to be with you this morning. It's always difficult to come at the end of the meeting, when so many things have happened since the beginning of the meeting, and we don't know exactly where the audience is and what you want to hear. But, I thought today I'd offer some reflections on where GESDA is and where I see that GESDA could further develop in the future. Before doing that, let me come back to a personal experience. I have been, as you've heard from my CV, a Swiss diplomat. As a Swiss diplomat, we have been educated in the fact that, with a country with no significant natural resources, investment in science and technology is what we need to do. Diplomacy for us has always been diplomacy for science to create space so that science could develop; and was always also tapping diplomacy into knowledge and experience coming from science and to bring it to fruition, also in the diplomatic space. Given this presupposition, GESDA was an important adventure to embark on.

As a president of ICRC, I learned how important it is, if you want to be a credible, neutral, impartial and independent operator in areas of conflict and close to the frontlines, you needed to tap into the best possible evidence-based activities that you can. Therefore, advice on law, policy and operational activity would be absolutely critical to heighten your credibility as a neutral and impartial operator. I also saw, over the last couple of years in particular, how leveraging science and technology for good for those who are disadvantaged and disenfranchised in conflict regions is absolutely essential to our mandate.

As a diplomat, today I will focus a little bit more on the "D" aspect of GESDA. Now because of my job, I asked myself how diplomacy could be a better tool to shape a cooperative international environment. I was encouraged over the last couple of days to see these discussions advancing on capacity-building for science policy; it's not only about science diplomacy, so capacity-building in many other areas.

We have advanced considerably over the last years to develop GESDA. Advancing has also heightened and sharpened our consciousness that there are dilemmas that we have to keep on our radar screen if we move forward. I just mentioned three. We want to engage on scientific freedom and, at the same time, we want the functionality of science. We want results from science. That's a tension that is not self-evident, that scientific freedom would lead to functionality, and it's not so evident how we would manage this as we move forward.

We have to balance the right to science with the logic of intellectual property, and we know the arguments back and forth. But GESDA will have to be conscious that there are tensions here, which we will have to address and manage. We see science in institutions, structures, processes, credit lines, the very institutional part of science, which to a large extent is represented here. We know that, in society as well as in science, there is a word about science that is not yet part of the GESDA lexicon. It's not only about opening up to civil society.

I'm very encouraged as we have this meeting on youth, which shows that there is development and, in so doing, enlarging the scope and the audience of GESDA. But, we also have to be conscious and aware that science is not only in scientific institutions. It's also the common sense of communities. It's also scientists outside the traditional institutions, which we will have, too.

Let me mention six brief points where I consider GESDA will have to be conscious and will have to discuss.

First is diplomacy. Whenever I've discussed GESDA over the last two years, I have sometimes been concerned – not so much in the audience I see here, but in some other audiences – of still a relatively conservative interpretation of what diplomacy is today. Diplomacy outside of this enterprise is always understood as diplomacy of states, which somehow at certain moments need to find multilateral consensus among the states. This is very far away from where I think diplomacy should be. I'm very conscious too that it is far away from where GESDA thinks that diplomacy should be. It's important that diplomacy, 2, 3 or 4.0, whatever you count, has to be something different. It has to build on transnational, multiple societal actors ... and can be influenced in recognition of the digital transformation that we are encountering.

Diplomacy increasingly is characterized by fragmented interests encompassing much more than political and security issues, but rather a need to be in service of economic, financial, environmental and other social aspirations. It is critically important that we defend in the development of GESDA a concept of diplomacy that is not only state-based but is also a whole-of-society aspect of diplomacy on which we want to build.

Secondly, it strikes me, when I think about science, that this whole room and everybody present here, in particular the speakers, are presented to the outside world as affiliated with an organization.

I'm here as former President of ICRC, as Peter Maurer. Everybody here has an affiliation, an institutional affiliation. I think there is a danger that, when we only think about the institutional affiliations, we forget about what makes science and diplomacy both – it's beyond institution structure, processes and representation. It's about professional networks transcending institutions; it's about communities of practice; it's about local communities; it's about youth and other constituencies of societies. It is important that we take into consideration this aspect as we move forward.

One book that has influenced me a lot over the last couple of years is the work of Etienne and Beverly Wenger-Trayner, who have worked on communities of practice. It is important that communities of practice, as they work on finding responses to challenges of societies, are not necessarily institutionalized, neither in science nor in diplomacy. It is important to have this concept of horizontal organization again, of a network of communities and how they function. GESDA will have to find a way to include those communities of practice, because from communities of practice comes as much innovation as comes from a top-notch scientific organization.

Thirdly, we all know that we are once again in a divided world. De-globalization and power bloc-building is affecting all our lives, and the international cooperation first and foremost. Political divides entering different professions and communities. Scientists themselves have become vectors of divides because under the responsibility that scientists see for themselves in society, they have also become part of the debates in societies and, therefore, part of the divisions in societies. It's important to take as an objective that GESDA has to go back to this essential truth, which has always kept science beyond political divides.

The proof of the pudding will be whether GESDA manages to become and to create and recreate that space for discussion, including those who are not participating in the discussion today. Because, in terms of global political divides, they are not interested, not coming, they are sanctioned, they are excluded. At the level of science, this can only be a fruitful exercise if we stick to this ambition of science – over hundreds of years as it has developed – as a connector of people, who can be an incubator of societal consensus and not a divider of societal consensus. Scientists can spearhead this movement.

Realistically speaking, in today's geopolitical landscape, GESDA will not be able to limit itself to leveraging science for good. GESDA now enters what I call "defamation professional" – the humanitarian dilemma. Having to mitigate the impact of short-term bad because everybody has complained about the short-term bad and the crises and the divisions in which we are and see how we can gather energy for the long-term good. This is essential as we look at global political divides.

The future of warfare is a case in point, and it is unfolding in front of us much earlier than we would have expected the future of warfare coming to us two years ago. When I look of what the battlefield reality is in today's modernized conflict, in particular in Ukraine, then it is really what we described as science fiction two years ago. It's about space and cyberspace and into the cognitive space; it's weapons which are digitally enhanced and loaded with artificial intelligence; it's civilians neglected. They are militarized, military strategies supported by cyberspace, space-based intelligence and command actors heavily fragmented and operating in the dark.

This is a new environment in conflict areas, and it is important that we take into consideration what we can do as a diplomatic and science community to create and recreate the space again to see what kind of norms and principles can be applied in this new environment of modern warfare. What are the ethical guidelines helping to navigate those deep dilemmas in which we are? What is the behaviour of science to mobilize self-defeating capture? What is going on?

My impression is that we have been overtaken by speed, and what was science fiction two years ago is a reality today and therefore it's much more urgent than the social-science dimension of GESDA; Marie-Laure Salles highlighted in her address that this issue is of critical importance to the development of GESDA.

Fourth, we are confronted today with the conundrum of complexity. We have seen over the last couple of years the complexity of climate change, pandemic governance issues, long-time poverty, violence in societies, all producing what I would call a conundrum of complexity, fragmentation of access, uncertainty, instability, speed and unforeseeability. If this is the environment in which we are, we will have to get our head around how we can find some elements of stability in a world which is deeply unstable. What strikes me most is that the foreseeability that is underlying the basic notion of GESDA is becoming precarious because the dynamics of multiple crises lead us with unforeseeability. I do recognize, and I am the first one to appreciate the effort of GESDA in terms of foresight. But I want to inject a notion of caution that, when I look at what I have experienced over the last couple of years, it has defied foresight. It's to be prepared to the unprepared, which is still important when we look forward.

My fifth point is very personal and subjective. I have made a tour over the last few days here and listened

to many of the conversations. I have been deeply encouraged to encounter some concepts that I find highly promising in view of what I have described at this complex work. I find it really interesting. I have mentioned considering science as a connector of people and society transcending political divides. I have found it important to look at fragility and resilience, building a sustainable ecosystem and complex value chains, which are all notions I picked up in the discussion. I find it important to recognize professionalism as a complement to the political divides and issues that we are looking at.

I find Amandeep Singh's remark at the beginning of this conference very remarkable: when he said that scientists and those who are associated at GESDA must have upstream political engagement. We can't just remain in our 'casiers' and in our closed shops. We need to engage politically and to go to the public space. I found interesting the use of scientific method to make us think about the future of life, which is sometimes not linear but also is unforeseeable, as I mentioned. I was intrigued by all the discussions on trust – not only trust between humans, but trust on data over data, trust in privacy, trusted relationships and how we build it. I think it's a promising concept to further develop. I was very intrigued by what Peter Brabeck said at the beginning, that this should not become and be only a coalition of the willing, but a coalition of the world.

Finally, let me make a remark from governance. When everybody talks about today's insecurities, it's still critically important to start looking at key governance challenges for the future. I would agree, though, that changing realities by the day are not the best basis to find solid thinking on norms, institutions, platforms and processes which will govern the future. Still, we need to ask ourselves what resilient governance would look like. How to make decision-making processes over inclusivity more inclusive. How to overcome divides and while doing so, how to leverage technology.

Diplomacy has a key role in designing governance for science and technology, which are more adequate to the challenges that we all see today. You have heard more explicitly and between the lines that I have taken some freedom of speech as a retired president to share with you some doubts that I have on a too much or a too big focus on institutions instead of governance as system-building. I see a point of focusing some of the discussions on networks, platforms, ecosystems and issue governance rather than on institutions. Also, it may be useful even to nuance the concept of solution, which has a static meaning for most people and, in a hyper-dynamic world, may not be the adequate word that we are really envisaging at GESDA.

This is the moment to give more credit to good old scientific practices and value experiment, experimentation, testing hypotheses, running lessons learned and peer review processes, and find gradual pathways for improvement of society, which might be more realistic than just envisaging a solution in an institution. This might be a little bit too much of putting the patient in charge of the hospital. It's important that we learn from Confucius or Buddhists – Buddhism – that the path is the goal. And I think it's with those few words I wanted to conclude. Thanks a lot.

Muriel Siki

One of the themes in all of the issues that you mentioned is transparency: to be able to have evidence-based policymaking. In your view and with all your experience and your freedom, now that you're retired, what how can we make all of that possible?

Peter Maurer

I feel that, in a hyper-polarized world, evidence is now contested. When evidence is contested as a basis of science, and when evidence is contested as a basis of political and societal creation, then we have to find a mechanism to, again, move to consensus. I think that's a little bit what I wanted to offer as a thought.

Two years or three years ago when we started to think about GESDA, we were in a world in which we still had a basic consensus. I'm not so sure we have that consensus anymore. If we don't have the consensus to build on and to grow, then eventually we have to take a step back and see how we can again establish that space for debate that will try to find agreement on what evidence is. It's something which is mind-boggling and that dominated my experience as President of ICRC. In war, you see the emblematic place where there is no consensus and where you have first to offer a space so that the discussion can come and that the debate and the dynamic unfolds, which leads to consensus, what evidence is.

Evidence may sometimes on certain occasions come from top-notch scientific research and everybody will buy into it. But very often, in the big societal problems that GESDA also wants to help solve, we will have to find that space in which we have debates on what evidence is. That's the tricky change that preoccupies me in the future development of GESDA. It's not something with which we can't cope. But I think, conceptually, we have to be clear that the world today is no longer the world under which we created GESDA. Taking into consideration these complications, it's important to open that space for debate.

Friday 14 October, 09:45–10.15 CET

Closing Plenary Session

Maryna Viazovska

Professor of Mathematics, Fields Medalist 2022, EPF Lausanne, Ukraine

Keynote speech

Highlights

Anticipating the future of science is extremely difficult but the future of mathematics lies in the restless pursuit of abstract ideas, conjectures and pure mysteries, according to Maryna Viazovska, a Professor at the Swiss Federal Institute of Technology Lausanne (EPFL) who, in July, became only the second woman to win the prestigious Fields Medal in its 86-year history. The medal is often described as the Nobel Prize of mathematics.

"Curiosity-driven research is extremely important because science is the art of doing something we don't know how to do. We have industry doing something which we know how to do, but science is doing things we have never done before," Viazovska told participants at the GESDA Summit. "If we don't know what is good for us, then maybe we should come back to those very basic questions and some answers can be found there as well."

Describing her work with colleagues on a variation of a conjecture introduced more than 400 years ago by Johannes Kepler, Viazovska said anticipating the future of science is "extremely difficult" but her experience solving proofs for higher-dimensional equivalents of stacking equal-sized spheres taught her to pursue questions in an abstract world that "lives by its own rules" but can lead to real-world solutions.

"Abstract ideas lead to new inventions, and the new inventions actually change our world, the world around us, and bring us new ideas," she said, noting that conjectures from the logic of mathematics "are extremely important even if they don't have an immediate application. Very often they are just the backbone of mathematics, and this is what helps science grow and develop itself."

Viazovska displayed a slide called "Mathematics of the future: Favourites and dark horses" with a pack of wild horses. Four were labelled "Longstanding conjectures," "Artificial intelligence," "Application-driven questions," and "Quantum computing." The fifth simply bore a question mark.

"My first favourite horse on this slide is the one with the question mark," said Viazovska, calling it the one "which we can say nothing about" but will emerge with more clarity from future applications, theory, artificial intelligence or quantum computing. "This is the horse we should really pay the most attention to," she said. "Because this horse is a question mark, I think it is probably the one that will make the most difference, not only to mathematics, but also to the world."

Kepler, whose best-known work is the knowledge that planets elliptically orbit around the sun, delved into the stacking of cannonballs in the densest way possible on a ship. He asserted but could not prove that the best way filled up almost 75% of the space. It wasn't until 1998 that University of Michigan mathematician Thomas Callister Hales solved the three-dimensional optimization problem, controversially aided by a computer programme.

"Without a computer, it's impossible to obtain the solution, but also impossible to verify that it is correct, and this raised a huge dispute among mathematicians," Viazovska said. "The iconic image of a mathematician is a person who sits in front of a notebook and drives arguments."

Viazovska found the answer in eight dimensions in 2016, then showed the best possible packing method used a Leech lattice of 24-dimensional spheres that occupied about 0.2% of the volume. Theoretically, there is no limit to the number of dimensions that can be studied by adding more coordinates. The sphere-packing proof has real-world applications, for example, with coding so data transmission can avoid being corrupted.

"This is one example of how a problem of packing cannonballs into a ship could lead us to the concept of computer-verified proof. I'm sure that, in the 17th century, people had absolutely no chance of anticipating such a turn of events," Viazovska observed.

That turn of events came about when Claude Shannon, an American mathematician, electrical engineer and pioneer of information theory, applied sphere-packing to error correcting in signals while working at Bell Labs, laying the foundation for modern electronic communications networks worldwide.

Mathematics of the future
Favourites and dark horses
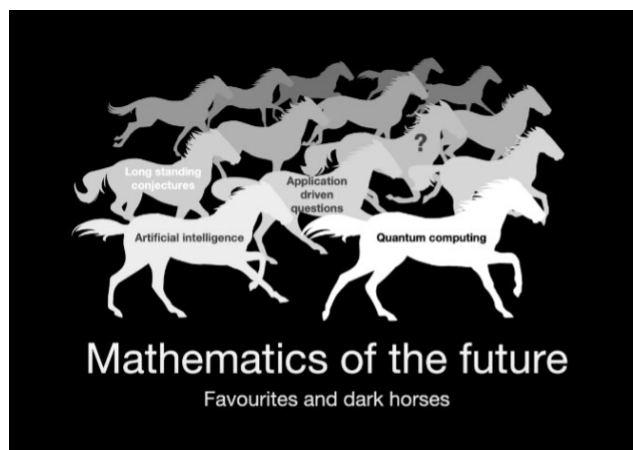
Swiss mathematician, physician and information theorist Marcel Golay also used it to create the Golay error correcting codes used in radio navigation. They're still used in the Voyager programme that began in the 1970s to collect data from two spacecraft for transmission back to Earth from other planets and in interstellar space.

"One would not be possible without the other," said Viazovska. "This brings us to an idea. What is the origin and what is also the value of an abstract idea, in particular the mathematical idea? The way I would like to think of it is that we have actually two worlds. One of them is the real world where we all live, and where we have all these pressing issues, conflicts, terrible problems to resolve. But, we also have the world of abstract ideas, where everything is quiet and stable, and where we are in perfect control of everything. These two worlds are connected to each other … like a magic mirror that the elephant is able to go through."

Viazovska, who was six when Ukraine became independent of the former Soviet Union, became enthralled with mathematics at an early age and, after attending Taras Shevchenko National University of Kyiv, moved to Germany to obtain her PhD on modular forms from the University of Bonn and a postdoc at the Berlin Mathematical School and Humboldt University of Berlin. She joined EPFL in 2017.

Everything we see in the real world has a counterpart in the abstract world, she said, but the abstract world lives by its own rules. "We can take an idea from the real world, bring it to this abstract reality of the curved mirror and actually change it there and play with it. And then it becomes a purely abstract object, which can be manipulated by logic and reasoning," said Viazovska. "Often, we can bring them back into reality; and not only to bring them back as inventions, but actually we can look at something in our real world with different eyes just by having those abstract concepts."

Asked about the Russian invasion of Ukraine in late February, which has taken a toll on all Ukrainians including her family and friends, Viazovska spoke of how Ukrainian scientists are part of Ukrainian society, too, "so any help to Ukraine right now is also a help to Ukrainian scientists."

She appealed for moral support for all Ukrainians, so they know they have a future. "The huge question that the war poses is the threat of whether we have future," she said, adding it's also important for the future of science in Ukraine. Her parents live near Kyiv, but her sisters, nephew and niece left to join her in Switzerland. She lost a close friend, a young mathematician killed in Kharkiv at the beginning of the war.

"I visited Ukraine this summer and of course this is extremely difficult. It's just we are all very concerned about the war and people are shocked by the events that happened in Ukraine," she said. "For 40 million people, their lives are just ruined. For everyone it's in a different way. Of course, there are people who died, who got injured, who lost their loved ones, but even those who are spared for the moment, for all of them, their lives are not the same."

More information

Session recording on YouTube

Tweets related to the session

High-Level Closing Plenary

Peter Brabeck-Letmathe

**Chairman,
GESDA Board of Directors,
Austria**

Closing address

Excellencies, ladies and gentlemen, I feel deeply honoured to start this closing plenary by welcoming the representatives of the political authorities of Switzerland, represented by the President; Estonia; Morocco; Mexico; Singapore; and the United Arab Emirates.

As we know and we have heard, GESDA is a very young foundation. It was created by the Swiss government, both on the federal level as well as on the cantonal level. It was created to put the scientific community at the heart of multilateralism. Why are we doing this? Why was it created in this sense? It was in order to better address the global challenges that people, society and our planet keep facing every day. But, we also want to assure that everybody in this room has access to the benefits of technological breakthroughs like it is foreseen in the human rights declaration.

Let me just mention very shortly what GESDA really does. I think if we look at the last two days, this is the third one, you see that the first day was dedicated to presenting our main product, which is the Breakthrough Radar, which is summarizing the work and the participation of thousands of scientists from all over the world to tell us what is cooking in these laboratories and what could be seen, from their viewpoint, of the impact in the next five, 10, and 25 years. That was the first day.

The second day we presented two of the several solutions which are currently being worked out by the joint task forces between the scientific forum and the diplomatic forum. Those two initiatives are the Open Quantum Institute and the first global curriculum on science diplomacy.

Regarding the Open Quantum Institute, which yesterday was presented in detail to you, it is important to mention that today already we have signed 12 universities, eight private companies, two philanthropy and 20 development institutions, which are giving their support to the creation of the Open Quantum Institute. And, 12 permanent representatives in the UN at Geneva have already publicly announced that they are in favour of the creation of such an institute.

The third thing today was to give the voice to the young, to give the voice to the citizen, and it was very encouraging what we heard from them, but it was also very challenging. I think that's exactly what we expected from the summit. We don't only want to inform you; we want to get your feedback. And let me say, I was impressed by the depth of the discussions we had. But there is something which is new today. Because we are starting a new chapter in the preparation by involving for the very first time the political level in our discussion.

It is extremely important for GESDA, in the first two parts of its work, to be as independent, neutral, transparent and honest as we can. Because that's the only way we create respect from the science community and the diplomatic community. But, GESDA cannot be a substitute for political decision-making. So when it comes to the third phase, which is a phase of implementation, that's the moment when we need the political sphere to come into this phase. And that's exactly what we have here today for the very first time.

So, I will give the floor now to the Swiss Special Representative for Science Diplomacy, our Ambassador Alexandre Fasel, who will moderate the political discussion.

Thank you very much.
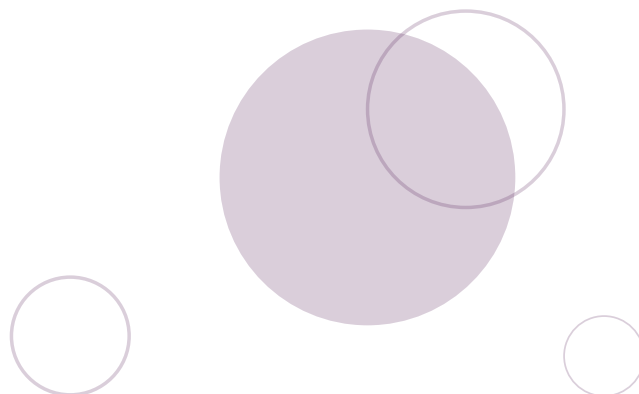
High-Level Panel with Foreign Ministers and Decision-Makers

Highlights

Swiss President Ignazio Cassis and ministers from Estonia, Mexico, Morocco, Singapore, Switzerland and the United Arab Emirates introduced a new element to GESDA's annual summits, bringing political decision-makers to the table with scientists and diplomats. "GESDA cannot be a substitute for political decision-making," Board Chairman Peter Brabeck-Letmathe noted. Therefore, when it comes to implementing potential solutions "that's the moment when we need the political sphere to come into this phase. And that's exactly what we have here today for the very first time."

Moderated by Alexandre Fasel, Special Representative for Science Diplomacy of the Swiss Federal Department of Foreign Affairs (FDFA), the summit's inaugural high-level panel examined GESDA's progress and offered guidance by assessing the opportunities and challenges found through scientific anticipation. Two of those involved, Cassis and Singapore's Foreign Minister Vivian Balakrishnan, already span the professions of science and diplomacy; each is a medical doctor and their nation's top diplomat.

Western nations have become accustomed to thinking that the world is "automatically increasing towards democracy," Cassis said, but wars in Asia, the Middle East and now Europe tell a different story. "Suddenly we realize it is not the case in Afghanistan, Syria, Ukraine – the security bomb now in Europe. Nevertheless, we have tools and we have to be able to use these tools to work together towards a better world," he said, stressing a need to accept greater diversity.

"Every human being and every democratic society must have the freedom to organize themselves. This is called democracy, Cassis said. "I do not choose democracy just in the moment as the majority of the population is thinking like me. I have to accept and choose my democracy even if the majority of the population is not thinking like me. I feel this was one of the mistakes we made in the West in the last 20 years. We were speaking about inclusion, and we were excluding those not thinking like us. This is a topic where science, science diplomacy can help us to do the right thing."

Science diplomacy has its 19th century roots in the creation of the International Committee of the Red Cross, making Geneva a global capital of international humanitarian law. After two world wars, the Swiss city became home in the 20th century

Alexandre Fasel

to the United Nations' European headquarters, including the world body's top forum for human rights. Cassis said he hopes Geneva's role as "the world capital of discussion about governance" will turn its 21st-century focus to the promising role of "participatory science diplomacy" worldwide. "My dream is that GESDA will be a powerful tool in enabling a diverse world, through science, to make some steps together in a peaceful way," he said, and that "we are preparing ourselves to avoid monopolies or concentration of power through technology in oligarchic groups, because history tells us this is the danger we always experience."

Already this century, scientific breakthroughs in digital computation and communication, data science and artificial intelligence, biomedical sciences, nanoscience and new materials, autonomous robots and renewable energy have brought a "profound moment of acceleration," said Balakrishnan, but it is occurring unevenly around the world. "In some cases, it is accelerating. There are also other places which may be left behind," he said. "It is critical for us to understand the underlying factors for these differences in outcomes."

GESDA can help level the playing field through diplomacy, combined with the "tremendous potential offered by the inexorable march of science and technological progress," said Balakrishnan. "Therefore, I stand in support of the GESDA agenda. I stand here in support of the agenda outlined by President Cassis." But, as evidenced by the world's failure to equitably share COVID-19 vaccines for ending the pandemic, intellectual property protections must first be made "fit for purpose,"

he added, so the world can find the "right balance between temporary monopolies for innovators and the dissemination of knowledge for wider exploration and exploitation.

"Equally important for governments is innovation in the policy ecosystem – both national and globally– that will bring together talent, money and the necessary commercial and industrial players to enable innovation to flourish," said Balakrishnan. He said his worry as a foreign minister is whether the world is "sleepwalking into a period very analogous to before the First World War", a time of "empires waxing and waning" with abrupt changes in science and technology that contributed to social and political disruption. Nevertheless, even small nations like Singapore and Switzerland can make a difference through efforts like GESDA, he said, adding: "My point is that regardless of the decisions made by superpowers, if we can get together on open, collaborative platforms, we have a chance."

Representing one of the world's most digitally advanced governments, which through e-Estonia allows nearly all bureaucratic tasks to be done online, Estonia's Foreign Minister Urmas Reinsalu recalled how Estonia and Singapore organized a global conference on the use of digital technology to fight the pandemic by sharing technological improvements. In a similar vein, "what GESDA is doing is truly unique and important for the whole of humanity, and this is indeed a moral perspective of the future of mankind," said Reinsalu, who joined the panel by videoconference.

"I would like to bring the knowledge of GESDA's activities for Estonian scientists to our region, and hope that this will lead to exciting and useful collaboration," said Reinsalu. "We need to punch way above our current weight when it comes to doing science. The sustainability and success of our digital society is very much dependent on the research and development we conduct." In addition to more international cooperation, science and digital diplomacy "have to both align our foreign policy approach and unravel the common global problems that we face," he said.

"The focus on solving global problems has led top scientists to work on the link between plants and climate change, develop smart cities, probiotic bacteria or renewable energy solutions, create data processing solutions that protect privacy and much more. Estonia's main focus of research cooperation has been our immediate neighbours and European countries," said Reinsalu. "But let me stress that, in a globalizing world, these cooperative relationships extend everywhere; there is no difference." With Russia's invasion of Ukraine bringing war to Estonia's "doorstep" with far-reaching global impacts, he said, "the world has changed and new solutions are expected from science diplomacy."

Whether science diplomacy can deliver on those expectations remains to be seen. But, in only three years, GESDA has "been able to join two conversations that have never been joined before – the pulse of science together with the pulse of society – and address the key question, which is what's the role of diplomacy in fostering scientific findings, and what is the role of science in enabling diplomatic efforts," said Sarah Bint Yousif Al Amiri, the United Arab Emirates' Minister of State for Public Education and Advanced Technology.

Population growth, healthcare, the pandemic, sustainable energy and food sources, and climate change "are all fundamental challenges that we all face as societies around the world, all face from a different lens, and all face in a mechanism that we're only able to circumvent it and move forward from it by using scientific and technological advancements," Al Amiri noted. "We need to look at this overarching mechanism of using scientific and technological outcomes to ensure that we don't politicize scientific outcomes." In the absence of diplomatic ties, science brings nations together and enables us to have conversations, enables us to find modes and mechanisms to develop peacekeeping, and to foster that moving forward, she said, "to allow the necessary framework for global collaborations to exist so we don't leave any nation behind. And to ensure that this technological advancement enables growth across countries and between countries."

GESDA could play an important role in helping to determine what sort of global governance "mechanism" might best be established for data-sharing, according to Al Amiri, along with "the interoperability of the systems that underlies them and the outcomes that come from it," especially to inform discussions on climate change, agricultural development and access to energy, she said.

Martina Hirayama, Switzerland's State Secretary for Education, Research and Innovation, said GESDA's role and importance is in anticipation, resilience and sustainable development. "To anticipate challenges and opportunities as early as possible. That's important for the future. Scientists do this; researchers do this; but quite often it's concentrated on their area of expertise. It's important to have an overall picture, including different disciplines," she said. "This means also that political, societal and legal aspects have to be anticipated. All the implications for society are really important. And this is the role of GESDA, to bring the worlds of politics, diplomacy and science together to reflect on our future, on the challenges and opportunities."

The past two-and-a-half years of the pandemic – in which COVID-19 vaccines were developed and brought to market with unprecedented speed but inequitably around the world – have shown that knowledge transfer in the marketplace is crucial for "a resilient society," according to Hirayama. "Science, diplomacy, politics have to set not only ambitious but also clear goals. What do you want

to achieve in the future? GESDA could play and should play an important role in this context as well," she told the panel.

"An important role of GESDA is to help to build bridges. So, actually, scientists and researchers, innovators, they want to answer questions, to find new questions, to develop new products. So, they are open. And we should use this to build bridges, and not only in the easy situations. These bridges should help to communicate between different cultures, different societies. And there, I see, the opportunities also for international and multilateral cooperation and for organizations like mine, like GESDA. That's my hope and my wish that you support us in building these bridges to have a more prosperous future," said Hirayama.

In a video message, Morocco's Minister of Foreign Affairs Nasser Bourita said the pandemic highlighted the increasing relevance of human-machine interactions that have emerged in the fields of quantum physics, quantum computing and artificial intelligence. While the interlinkages between these groundbreaking technologies have yet to be assessed, said Bourita, the international community has a collective responsibility to make the best use of these new tools.

"Designing appropriate policy frameworks and responses are necessary today. On a global level, new technologies bring both challenges and opportunities," said Bourita. "Challenges, on the one hand, as the introduction of these technologies has the potential to question and even undermine the global security landscape," he said. "It accelerates the arms race amongst states, strengthens the capabilities of dangerous non-state actors, and fosters increasing cyberspy risks."

But it is also an opportunity, said Bourita, because new technologies could benefit efforts in conflict resolution and diplomacy through "faster, more secure and increasingly efficient decision-making and early warning processes. New technologies amount, therefore, to a true international issue par excellence. As such, it implies endangering the safety and security of nations, and the entire international system, in case it fails to face the risks of these new technologies." For all of these reasons, he said, Morocco hopes for GESDA's success because "the challenges of today's world need scientific contribution to enable humanity to overcome the major threats they are facing." Morocco also

supports GESDA's proposed creation of an Open Quantum Institute, he added, "which we hope will help us anticipate and promote the benefits that quantum science will offer."

Martha Delgado Peralta, Mexico's Undersecretary for Multilateral Affairs and Human Rights, said in a video message that, while humanity's ability to create tools and knowledge is one of the reasons we've been able to emerge and accelerate our development, "this ability has also endangered our own existence and that of our planet, since scientific advancement and new technologies produce social, economic, cultural, political and environmental transformations."

As a result, technology can be "a barrier of progress and hope, but also of damage and destruction when its use is inappropriate," Delgado Peralta said. "That is why diplomacy, and particularly multilateralism, must not only go hand in hand with these changes, but also be able to anticipate them in order to germinate even better decision-making, regulate both, if possible, negative effects, and channel them towards the common good of humanity."

The pandemic and climate change, among other global crises, are examples of why international cooperation and diplomacy are essential to find solutions, Delgado Peralta said, and "these highlight the importance of integrating scientific research and data management and evaluation from the various disciplines of knowledge at the centre of decision-making at the international level, guiding mitigation, evidence-based response and recovery strategies."

All nations' creativity, knowledge, technology and financial resources are needed to accomplish the UN's 17 Sustainable Development Goals for 2030, Delgado Peralta said; therefore "it is necessary that access to scientific information is not the privilege of a minority and that its use is not contrary to the very principles of the multilateral system. Reconciling both principles without restricting the freedom of research is a great challenge, but it makes it more evident that it requires effort and especially multilateral diplomacy. In this sense, I welcome the timely initiative of the Geneva Science and Diplomacy Anticipator. I reiterate that Mexico is committed to the advancement of science and technology cooperation for the benefit of humankind."

More information

Session recording on YouTube

Tweets related to the session

Takeaway Messages

GESDA's new high-level "political assessment" portion of the summit offers guidance for assessing opportunities and challenges but is not a substitute for political decision-making.

People and democratic societies must be allowed to organize themselves for everyone's benefit. We have to accept that democracy is for everybody, not just for like-minded allies.

In the 19th century, Geneva became a global capital of international humanitarian law. In the 20th century, it served as an epicentre of human rights. The 21st century focus could turn to the promising role of participatory science diplomacy.

Scientific breakthroughs are accelerating at an uneven pace around the world, as shown in the inequitable sharing of COVID-19 vaccines. GESDA's science diplomacy mission can help level the playing field.

Even small nations can make a big difference through efforts like GESDA to join together on open, collaborative platforms.

Our increasingly digital, interconnected societies depend on R&D from cooperative relationships that can extend everywhere.

Equally important is for governments to innovate their national and international policies so the business sector can flourish.

In just three years, GESDA joined two conversations about the pulse of science and society in a way that hasn't happened before. GESDA's role is to bring the worlds of politics, diplomacy and science together to reflect on future challenges and opportunities.

Humanity's ability to create tools and knowledge has helped accelerate its development but also endangered us and the planet. International cooperation and diplomacy are essential to find solutions.

Friday 14 October, 10.45-12.30 CET

High-Level Closing Plenary

Ignazio Cassis

**President of the Swiss Confederation and
Head of the Federal Department of Foreign Affairs**

Keynote Address

Mr Chairman of the GESDA Board of Directors, Herr Peter. First of all, I'd like to thank you, very personally, very deeply, for your tremendous efforts to start this new adventure of GESDA. We decided four years ago to start this new way and to make out of it a success story. I think we are on the right way. This is mainly due to you and your team. Thank you so much.

Dear ministers, dear colleagues from abroad, your excellencies, ladies and gentlemen,

Can I start by welcoming you all, and especially you, my ministerial colleagues, to the high-level closing plenary of this year's GESDA Science and Diplomacy Anticipation Summit. I very much look forward to our conversation. Indeed, I believe it is our role as political decision-makers to accompany GESDA's work, to assess its progress and, where appropriate, to provide guidance to it. This is because, as we have said from the very beginning, GESDA is not a substitute to the legitimate actors of governance, but rather a tool at their disposal, a tool that aims to help them to reinvigorate multilateralism, to focus global governance on the central challenges of our time, to develop ways and means to build convergence, and construct a shared sense of purpose. This is very much needed today. Because the urgency of the challenges, the seriousness of the upheavals, and the rapidity of the change we are experiencing forces the international community to focus on the real and most pressing issues at stake.

As the Chairman of GESDA declared in his opening statement on Wednesday, the international community has no time to waste. We must accelerate diplomatic response to the opportunities and the challenges that are brought about by the convergence of science, of the many different sciences, and the acceleration of technology. But we can only do that if we see them coming, if we understand their potential impact for good and ill, if we anticipate them, which is not easy.

There is no acceleration of diplomacy in the face of existing problems that already impact us. Once the challenge is here, the opportunity is gone, and we can only run after the problems without any real perspective of mastering them. It is exactly what we see nowadays worldwide.

The difficulty is that we cannot, as an international community, go straight from anticipating scientific breakthroughs, sensing technological acceleration to negotiating sustained, sustainable solutions. Whenever we find ourselves in formal negotiation processes, we tend to retreat to our normal ways of functioning. That is to say, we are seeking to maximize our own interests and not really trying to build the common ground. We are negotiating for ourselves as individual countries or groups of countries; we are not negotiating for humanity as the global compact.

In such a context, the common denominator will remain inadequately low. This is why we need an honest broker. An environment where we learn about the medium- to long-term anticipation of opportunities and challenges, where we can come together in a real inclusive manner. We have to be courageous to listen to different people, not just to always repeat the same opinion. It won't be successful if it will be a gathering among just like-minded. We have to expose ourselves to others. We have to fight to bring our conversation to a higher level of sophistication, of nuance, of discernment.

In such an environment, solutions can mature and ferment precisely because they are not taken hostage by a formal negotiating process. And so the legitimate actors of global governance, by which I understand us – nation states – can then repatriate the draft solutions into existing or new format processes at the United Nations, for instance, or other international organizations.

We will then be able to proceed from a far higher degree of commonality than would otherwise be possible. And we maybe will be in time and not too late to do that. Therein lies the acceleration of the diplomatic process. This is the nature of what I call anticipatory science diplomacy.

Dear ministers, dear colleagues, we as political decision-makers are the beneficiaries of these methods. Therefore, it was my will to convene today in Geneva trusted partners and friends, as I said, to discuss this approach developed and implemented by GESDA to assess its progress and, where needed or called for, to provide guidance in the best shared interest that unites us.

I thank you for your presence and for your contribution. I commend the entire GESDA team and all the members of the GESDA fora and task forces for the opportunity they provide us to focus our multilateral action and accelerate our diplomatic efforts. With this, I invite the Swiss Special Representative for Science Diplomacy, Ambassador Fasel, to take over and moderate our panel.

Thank you.

High-Level Closing Plenary

Vivian Balakrishnan

Minister of Foreign Affairs, Republic of Singapore

Keynote Address

Thank you, Your Excellency, Mr Cassis, President of the Swiss Confederation, Peter Brabeck-Letmathe, Chairman of the GESDA Board of Directors, which has brought us all together. Thank you, excellencies, distinguished panellists, ladies and gentlemen. It's an honour to join you here today.

I come from Singapore, a tiny city state in the heart of Southeast Asia. Singapore is uniquely positioned, but we're also exquisitely exposed to both the opportunities and the challenges presented by the scientific, diplomatic and the geopolitical developments which are occurring simultaneously all around us. Let me make a few points.

First, we are on the cusp of another profound revolution, and this is based on a very remarkable cocktail of simultaneous and mutually synergistic scientific breakthroughs in several areas. It includes digital computation and communication, data science and artificial intelligence, biomedical science – which includes genomics, gene editing, immunotherapy and synthetic biology – nanoscience and new materials, autonomous robots and renewable energy. What is unusual is that, in each of these areas of platform technologies we are witnessing breakthroughs, but they're not occurring in isolation. Because a breakthrough in one area feeds into and sets up a virtuous cycle of acceleration in all the other scenarios. So this is a profound moment of acceleration.

The second point – I have to put some context – is that the focal points, the parts of the globe where this acceleration of science is occurring, are not occurring uniformly. In some cases, it is accelerating. And yet, there are also other places which may be left behind. It is critical for us to understand the underlying factors for these differences in outcome. For example, what is the optimal role for government in supporting basic research, in realizing value from its applications? How should universities and research institutions be reorganized in this new age of discovery and innovation? How can the translation of discoveries into new products and services be accelerated?

This involves government playing a role not simply as a regulator and a producer of rules, but also as a proactive enabler, providing the necessary frameworks and infrastructure for progress and excellence. And to translate this research into useful and, if I may add, ethical applications for commercialization.

The third point is to ask whether our current regimes for intellectual property protection are still fit for purpose. Have we found the right balance between temporary monopolies for innovators and the dissemination of knowledge for wider exploration and exploitation?

Equally important for governments is innovation in the policy ecosystem, both national and globally, that will bring together talent, money and the necessary commercial and industrial players to enable innovation to flourish.

My fourth point is that we have all benefited, I would say, the last century or two, from sharing a common open stack of scientific discoveries based on that shared platform of research, methods, applications and technologies. One brutal reality is that we are now in danger of perhaps a technological verification due to geopolitical contestation. This will have a profound impact on all of us because it will lead to a more divided world characterized by slower progress, higher costs, greater contestation and increased risk of conflict. In fact, we are already witnessing these effects with supply chain disruptions, rising cost of living, inflation. Countries today, in managing their supply chains, are thinking in terms of just-in-case rather than just-in-time. And you see this happening in order to ensure continuity and resilience of supply chains.

The ripple effects of all this bifurcation goes beyond just science and technology. It risks the decoupling of the global systems that have been the enablers of peace and prosperity for the last 75 years since the end of the Second World War. It brings us, therefore, the prospect of a more fractured, more divided, less prosperous and certainly less peaceful world.

If I could just draw your attention to some of the early lessons from COVID-19. Treat this as a real-life work example of the interplay between science, public policy and the extent of social cohesion and trust within societies. COVID-19 was not the first pandemic and not even the most virulent pandemic that humanity has faced. Yet, it is obvious that our global system for detection, prevention, preparedness and response had major gaps. The global pandemic response highlighted the importance of governments and the private sector working together to address global problems.

At the outset of the pandemic, actually, the scientific community was able to get together; it was able to publish the genome within weeks, was able to work single-handedly towards devising diagnoses and even the development of a vaccine in record time, in months rather than years, which it would normally have taken. That's the good news. But the other half

of the equation is that we also discovered that it was social capital within societies, in particular, trust between citizens, and trust between citizens and the government and scientific authorities, which made a critical difference for outcomes.

Many people died even in wealthy societies, not for lack of access or treatment facilities, but because of misinformation and political polarization, which adversely influenced behaviour at both the individual and community level. Singapore and Switzerland played a role in co-chairing the Friends of the COVID-19 Vaccine Global Access COVAX Facility, and together with other like-minded partners, we pioneered the term vaccine multilateralism, which encouraged others to join this collective global effort to ensure the unimpeded, fair and equitable distribution of vaccines.

But yet, on this point, it's noteworthy that, in fact, by the middle of this year, vaccine supply at a global level was no longer a limiting factor. Today, if Switzerland or Singapore were to offer free vaccines from our excess stock, no country is willing to accept. Think about that. I have offered a rather sobering assessment of our world today, but my intention is not to cause alarm or to assign blame, but rather for us to acknowledge the challenge before us, and to underscore that, in fact, there is a need to double down – double down on multilateralism and to effect a concerted global response equal to the scale of this challenge.

At the same time, these challenges have also brought unprecedented opportunities, and dramatic advances in science and technology offer new ways of solving major challenges of our generation. If we can harness these advances, if we can mitigate the unwanted downside and distribute the effects and the benefits more equally across the globe, then we hold the keys to a better future.

Our belief is that the only way forward is to uphold an inclusive and rules-based multilateral system that has underwritten global peace and prosperity for the last 75-80 years. Small states like Singapore and even Switzerland have agency, and we have a critical role to play. That's why we worked together with a cross-regional group of countries to establish the forum of small states – 1992 – groupings such as, of course, the Forum of Small States (FOS). Today we account for 108 members in the UN. That is a majority of the UN General Assembly membership. As we celebrate the 30th anniversary of FOS, my hope is that the world can come together. Combining both their diplomacy and the tremendous potential offered by the inexorable march of science and technological progress to chart a better, brighter, more prosperous future for all of us.

So, therefore, I stand in support of the GESDA agenda. I stand here in support of the agenda outlined by President Cassis. And to make the point that we need to establish a network of people who have both mastery of science and diplomacy and to make a difference by making common cause, and especially at this time of historic opportunity and risk.

Thank you all very much.
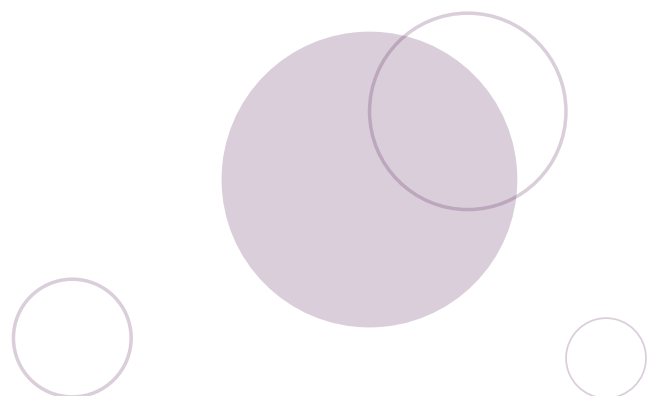
High-Level Closing Plenary

Urmas Reinsalu

Minister of Foreign Afairs, Republic of Estonia

Keynote Address

Mr President, distinguished hosts and guests of the dear colleagues,

I want to stress the wise words of my Singapore colleague. I remember from the harsh times of the coronavirus political crisis when we, Estonia and Singapore, jointly organized a world conference on the digital technology means to fight coronavirus and how to share technological improvements all over the world. We also formed a global declaration on that matter; around 60 countries joined.

This moral perspective of scientific knowledge to help globally will ease human suffering –this perspective is very much what my colleague stressed today. What GESDA is doing is truly unique and important for the whole of humanity, and this is indeed a moral perspective on the future of mankind, what you are arising. I appreciate the Swiss colleagues for such a great initiative and for driving it forward. It is truly inspiring; we need an anticipatory and proactive look at science and analyses of what points in laboratories work for the benefit of humanity.

I would like to bring the knowledge of GESDA's activities to Estonian scientists and to our region, and hope that this will lead to exciting and useful collaboration. We need to punch way above our current weight when it comes to doing science. The sustainability and success of our digital society is very much dependent on the research and development we conduct, so sustainable financing for R&D activities is pivotal, especially in IT-related areas.

Public-private partnership is one of the most essential tools to create innovation, and that is why industrial doctorate programmes, for example, are becoming even more popular. We have to realize the importance and need to cooperate internationally and to play our part in tackling global challenges. Therefore, science and digital diplomacy have to align our foreign policy approach and unravel the common global problems that we face. We understand that we already have great international cooperation initiatives, for example, the AI Gov Stack or the Nordic Institute for Interoperability Solutions, which, by pooling resources and using them efficiently, are making impactful changes.

The focus on solving global problems has led top scientists to work on the link between plants and climate change; develop smart cities, probiotic bacteria or renewable energy solutions; create data processing solutions that protect privacy; and much more. Estonia's main focus of research cooperation has been our immediate neighbours and European countries. But, let me stress that, in a globalizing world, these cooperative relationships extend everywhere. There is no difference; physical distance no longer matters.

The world is becoming smaller, literally in these times, in these moments. One of the ideas that science carries is contributing to a better world, defending and renewing democratic values, I believe. In Estonia, our e-government and e-state services provide citizens with a fast and direct way to participate in and access services. As part of our technology diplomacy, we have provided these solutions to a large number of countries and have been recognized for our work. However, what drives science and scientific cooperation is trust.

Trust between partners and trust in the outputs of scientific work are both useful. Today's world is a changed place; war has come to our doorstep in Estonia. Although the Russian Federation's aggression against Ukraine is not a world war, it is a war in the world. It has angles which make a difference to all parts of the world. And this trust has become a deficit. Russian science is not the kind of bottom-up freely informing system we are used to in Europe. Their universities and institutes are well-regulated by the state commissions and state model, and hence part of the problem. Results of Russian scientists' work have been used in aggression against Ukraine. Can we even be sure that this aggression has not used technology and knowledge that we have developed for peaceful purposes, for a better future? We can't be sure of that.

The world has changed, and new solutions are expected from science diplomacy. I'm sure we can all make our contribution in supporting our goals, in supporting our joint values and defending peace and justice for the future of mankind.

Thank you very much indeed for the invitation to take part in this event, Mr President. I remember how you asked Estonia to participate in this event, and it was in the corridor of the United Nations General Assembly meetings. Thank you very much, Mr President.

Friday 14 October, 10.45-12.30 CET

High-Level Closing Plenary

Sarah Bint Yousif Al-Amiri

Minister of State for Public Education and Advanced Technology, United Arab Emirates

Keynote Address

Your Excellency, Mr President, thank you for this invitation to come to GESDA and this excellent platform.

First, I'd like to commend the organizers of GESDA. In just three short years – and I love how you've had it here – you've been able to join two conversations that have never been joined before – the pulse of science together with the pulse of society – and address the key question, which is: What's the role of diplomacy in fostering scientific findings, and what is the role of science in enabling diplomatic efforts?

If we are able to summarize the three basic concepts that enable science and technology to be part and a driver for diplomacy and international relations, we need to first understand what areas it falls under.

The first is technology, and science needs to be a means for bilateral and multilateral conversations. Solutions have to be done utilizing science and technology for the core purpose that we all face, fundamentally the same challenges: Growth of population; challenges that have to do with healthcare; the growth of pandemics as we move forward after COVID-19; access to secure food sources, and diverse foods and food sources; access to energy, and again, a diverse set of energy; sustainability – and I'm separating these two conversations for purposeful reasons – and impacts of reduction of climate change on society at large. These are all fundamental challenges that we face as societies around the world, all face from a different lens, and all face in a mechanism that we're only able to circumvent it and move forward from it by using scientific and technological advances.

That is where the role of multilateralism and bilateralism comes into play, as we have seen demonstrated in the I2U2, which is a collaboration between India, the United States, Israel and the United Arab Emirates in bringing together solutions for energy, for diversifying economy and for growth overall, utilizing science and technology. We see that also on multiple fronts where we are able to enable outcomes of science technology to drive prosperity forward.

Secondly, science technology creates opportunity. It deploys solutions as part of our global system. This is something that needs to be developed at large. We need to look at this overarching mechanism of using scientific and technological outcomes to ensure that we don't politicize scientific outcomes. In the absence of diplomatic ties, science connects nations and enables us to have conversations and find modes and mechanisms to develop peacekeeping

and foster that moving forward. This is from a diplomacy perspective, but what about the science technology perspective?

Today the rapid growth of technological advances, and the mechanisms which enable it, mean that technology is becoming vital to our lives; and the speed of that advancement is unprecedented. It means that there are a lot of unknowns that we're dealing with. In the realm of unknowns, there are two reactions that we can have: fear and therefore prohibiting of growth; or an understanding of the opportunities that science and logical advancement can create and the positive impact that it can create with an understanding of the ill uses of scientific and technological outcomes coming into play. With this position, we need to be well aware to be able to proceed.

Allowing science to move forward is a choice that we all need to make: To allow the necessary framework for global collaborations to exist so we don't leave any nation behind; and to ensure that this technological advancement enables growth across countries and between countries.

When we talk about global legislation, I know there's a lot of discussion about data and data-sharing, a lot of concerns and conversation with regard to ethical issues and ethical challenges as we move and progress towards a closer relationship between human society and technology. We need to address that from the lens that we do not know everything today. It is okay. We need some form of mechanism of working and a governance mechanism with the awareness that we don't know everything.

Therefore it is okay to change, to be adaptive, to be transformative and move forward. We also need to work very closely together and ask the right questions so that we're able to address them appropriately for ourselves.

GESDA and hopefully other fora that come into play globally need to be venues for conversation where heads of state, politicians, heads of foreign affairs offices, scientists, researchers and the private sector can actually sit at the same table, have a conversation about the questions that we pose in various sectors, and work together in a complementary way, each with the lens that we bring, to be able to create that positive impact and change.

Thank you.

Friday 14 October, 10.45-12.30 CET

High-Level Closing Plenary

Nasser Bourita

Minister of Foreign Affairs, African Cooperation and Moroccan Expatriates, Morocco

Keynote Address

Mr President of the Swiss Confederation, excellencies, ladies and gentlemen, honourable participants,

First, allow me to express my warmest thanks to Switzerland for the opportunity I'm given to contribute to this important summit. The past few years, and particularly the COVID-19 pandemic, have highlighted the increasing relevance of human-machine interactions. The recent emergence of these new forms of interaction has been mainly featured by a combination of quantum physics, quantum computing and artificial intelligence with the traditional political, economic, social and diplomatic spheres.

While the interlinkage between these groundbreaking technologies has yet to be assessed, the international community holds a collective responsibility to itself to make the best use of these new tools. Designing appropriate policy frameworks and responses is necessary today.

On a global level, new technologies bring both challenges and opportunities. Challenges, on the one hand, as the introduction of these technologies has the potential to question and even undermine the global security landscape. It is accelerating arms races among states, strengthening the capabilities of dangerous non-state actors, and fostering increasing cyberspy risks. It is also an opportunity, on the other hand, as new technologies will impact conflict resolution and the diplomatic profession itself by allowing faster, more secure and increasingly efficient decision-making and early warning processes.

New technologies amount, therefore, to a true international issue *par excellence*. As such, it implies endangering the safety and security of nations and the entire international system in case it fails to face the risks of these new technologies. It implies also international cooperation and international diplomacy. For this reason, Morocco has joined the efforts to make this initiative a success. Indeed, we are aware not only of the challenges that awaits us, but also of the potential gains that come with early adoption of these new technologies.

In this spirit, Morocco has initiated several actions.

His Majesty King Mohammed VI has ensured that Morocco is a part of this new dynamic, first, by increasing the government, by creating the government's support for [efforts] dedicated to digital transition and administrative reform in the current government; second, by instructing

Morocco's digital development agency to establish a strategic public institution and a draft a national road roadmap of artificial intelligence to support the evolution of this technology in Morocco; and finally, by instructing the government to initiate multiple actions to support the emergence of an ecosystem of national players to accelerate the concrete applications of these new technologies to meet the needs of our society in health, education, agriculture, industry and diplomacy.

Excellencies, ladies and gentlemen, today's challenges are transnational. The involvement of scientists in the political and diplomatic process is essential at a time of accelerated change. Therefore, the principles of inclusiveness and equal access to quantum technology and artificial intelligence must be guaranteed in order to benefit all humankind. More specifically, the potential use of new technologies for preventive diplomacy, peace, peacekeeping and international development are critical to our future.

In this regard, concrete actions and changes, including to the international legal regime and institutions, are needed; for example, by considering setting up an international body dedicated to monitoring and controlling the use and applications of these new technologies; by exploring the idea of putting in place an international treaty convention to regulate the organization and proliferation of such technologies; and by focusing investments on the use of these technologies in preventive diplomacy.

The challenges of today's world need scientific contribution to enable humanity to overcome the major threats they are facing. That is why we appreciate the initiative that gathers us today in view of the launching of the Open Quantum Institute, which we hope will help us anticipate and promote the benefits that quantum science will offer.

I thank you for your attention.

High-Level Closing Plenary

Martha Delgado Peralta

Undersecretary of Foreign Affairs for Multilateral Affairs and Human Rights, Mexico

Keynote Address

"I'd like to thank the organisers of the GESDA Summit 2022 for their invitation to this high-level panel in representation of the Minister of Foreign Affairs of Mexico. It is significant that Geneva hosts this initiative as the headquarters of a number of specialised international and regional organisations, including CERN itself, which is directly and indirectly linked to the issue of quantum technologies within its broad portfolio of projects. The human ability to create tools and knowledge is one of the factors that has allowed for the emergence and accelerated development of our civilisation.

This ability has also endangered our own existence and that of our planet, since scientific advancement and new technologies produces social, economic, cultural, political and also environmental transformations. Technology can therefore be the bearer of progress and hope, but also of damage and destruction when its use is inappropriate. That is why diplomacy, and particularly the multilateralism, must not only go hand in hand with these changes, but also be able to anticipate them in order to generate better decision making, regulate both, its positive and negative effects, and channel them towards the common good of humanity.

Mexico is a country with a firm conviction that cooperation and diplomacy are essential to find common solutions to shared challenges, as has been evidenced by the crisis caused by COVID-19 pandemic, climate change, amongst other challenges. These highlight the importance of integrating scientific research and data management and evaluation from the various disciplines of knowledge at the centre of decision-making at the international level, guiding mitigation, evidence-based response and recovery strategies.

For example, the development in record time of vaccines against COVID-19, which allowed them to be applied in time, is largely due to international scientific cooperation enabled by diplomacy, thus saving millions of lives. However, the situation has also revealed that multilateral efforts must be coordinated to ensure results that are not only efficient but also equitable for the benefit of the entire international community and not just some states.

These Sustainable Development Goals were adopted by the United Nations organisation in 2015 as a universal call to end poverty, protect the planet and ensure that by 2030 all people enjoy peace and prosperity. As the UNDP itself has highlighted, the creativity, knowledge, technology and financial resources of the entire society are necessary to achieve the SDGs in all contexts. So it is necessary that access to scientific information is not the privilege of a minority and that its use is not contrary to the very principles of the multilateral system. Reconciling both principles without restricting the freedom of research is a great challenge, but it makes it more evident that requires effort and especially multilateral diplomacy.

In this sense, I welcome the timely initiative of the Geneva Science and Diplomacy Anticipator. And I reiterate that Mexico is committed to the advancement of science and technology cooperation for the benefit of humankind."
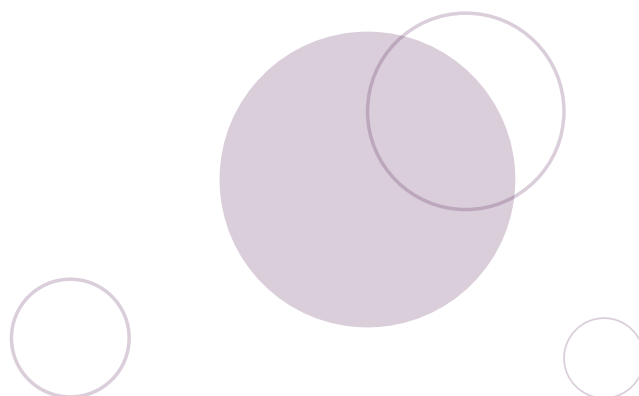
Friday 14 October, 10.45-12.30 CET

High-Level Closing Plenary

Martina Hirayama

Swiss Secretary of State for Education, Research and Innovation

Keynote Address

Mr President, excellencies, ladies and gentlemen,

Allow me to take up three topics and to point out the role and importance of GESDA: Anticipation, resilience and sustainable development.

First, being able to anticipate challenges and opportunities as early as possible is important for the future. Scientists and researcher do this, in many cases with a focus on their respective areas of expertise. But it is important to have an overall picture, across different disciplines. This means that political, societal and legal aspects have to be anticipated. All the implications for society are really important. This is the role of GESDA: To bring the worlds of politics, diplomacy and science together to reflect on our future, on the challenges and opportunities.

Second, resilience. During the last two-and-a-half years, we have experienced fast and dramatic changes, shining a light on the importance of attaining a resilient society. To this point, basic research plays a crucial role. Take as an example the development of mRNA [the technology used in some of the vaccines against Sars-CoV-2]. This has not been developed only within a year or two. A long period of basic research was necessary – prior to being ready when COVID-19 came up. Also crucial is the ability to identify and to transfer knowledge,

to be able to design products and to bring the products to the market. Another point concerning resilience is to make knowledge, know-how and products accessible. That is another important role of GESDA. Yesterday, you discussed the Open Quantum Institute, which is exactly about the accessibility of quantum technology for the future.

Third, there is sustainable development. A lot has been done with regard to the Agenda 2030, but now we have to prepare for the 2030s to 2045s. Science, diplomacy and politics have to set ambitious and clear goals on what we want to achieve in the future, and GESDA could play and should play an important role in this context as well.

Thank you.
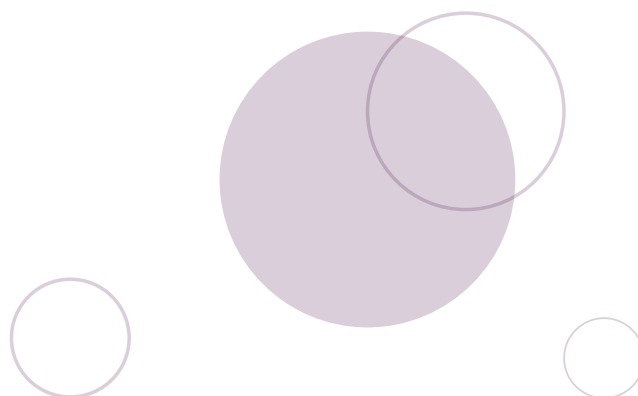
GESDA & Leman Bleu TV Studio Interviews

Over three days, GESDA's Communications Manager Laurianne Trimoulla brought together five technicians, one make-up artist and one coordinator from Geneva regional TV channel Léman Bleu, along with seasoned Swiss journalist Muriel Siki to work their magic and run a TV studio onsite. The studio allowed participants passing by to watch the interviews being recorded. The large windows and closed configuration of the booth – as opposed to an open set-up in 2021 – and the comfortable furnishings allowed a more robust experience at the sound, atmosphere, and branding consistency levels.

In 2022, GESDA's legitimacy appeared fully established in the eyes of the guests. Thirty-one speakers – Summit participants from around the globe – shared their impressions and experiences at the second GESDA Summit. They provided their insights – mainly after their respective sessions, to remain in the heat of the moment – on the role that the Foundation is already, or will be, playing in the science diplomacy field.

Guests covered a broad range of topics at the Summit: from artificial intelligence to quantum computing, from polar research to decarbonisation, from inclusivity to role models, and much more. Muriel Siki expertly navigated these topics and touched on the essence of their expertise in the space of very short time. The interviews added a much richer set of perspectives to an already outstanding set of science and technology discussions.

All the videos are available on the GESDA YouTube channel: https://www.youtube.com/playlist?list=PLx_MQeZFozYxEwuUein-HQd1OnYZq2GJZ

People interviewed, in alphabetical order (total 31):

Speakers:

Doaa Abdel Motaal, Author of "Antarctica, the Battle for the Seventh Continent"; Senior Counsellor, World Trade Organization

Andrea Boggio, Professor of Legal Studies, Bryant University

Lidia Brito, Regional Director, Southern Africa, UNESCO

Ignazio Cassis, President of the Swiss Confederation

Belinda Cleeland, Head, Research & Innovation, International Organization for Standardization (ISO)

Niva Elkin-Koren, Professor of Law, Tel Aviv University

Katarina Gårdfeldt, Director-General, Swedish Polar Secretariat

Jean-Marie Guéhenno, Kent Visiting Professor of Conflict Resolution, Columbia University; Former UN Under-Secretary-General for Peacekeeping Operations

Jim Hagemann Snabe, Chairman, Supervisory Board, Siemens AG

Lydie Hakizimana, Chief Executive Officer, AIMS-The Next Einstein Initiative

Yeadong Kim, President, Scientific Committee on Antarctic Research (SCAR)

Jürg Lauber, Ambassador, Permanent Representative of Switzerland to the United Nations and other international organizations

Kobi Leins, Visiting Honorary Research Fellow, Centre for Science and Security Studies, Department of War Studies, King's College London

Wendy Mackay, Research Director, Classe Exceptionnelle, Inria

Peter Maurer, Former President, International Committee of the Red Cross

Sana Odeh, Clinical Professor of Computer Science; Faculty Liaison, Global Programs of Computer Science, New York University

Scott O'Neill, Chief Executive Officer, World Mosquito Program

Eric Salobir, Chairman, Executive Committee, Human Technology Foundation; President OPTIC

Urbasi Sinha, Professor, Quantum Information and Computing Lab, Raman Research Institute

Massamba Thioye, Project Executive, Global Innovation Hub, United Nations Framework Convention on Climate Change

Matthias Troyer, Technical Fellow; Corporate Vice President, Microsoft

[Valentine von Toggenburg](#), Lawyer, Swiss Federal Office of Justice, World Economic Forum Global Shaper

Participants:

[Dušan Matulay](#), Permanent Representative of Slovakia to the United Nations Office at Geneva

[Deborah Nas](#), Professor, Delft University of Technology, Faculty of Industrial Design Engineering

[Barry Sanders](#), Director, Institute for Quantum Science and Technology, University of Calgary

[Florence Tinguely](#), Ambassador of Switzerland in Denmark, Federal Department of Foreign Affairs

Youth Cohort:

[Olivia Avalos Villar](#), Student, Physics, Sciences and Economics, International School Basel

[Sofiia Martianova](#), Villars Fellow; Student, Electrical Engineering, ETH Zurich

[Jordan Naddaf](#), Foreign Policy Youth Collaborative Association

[Bekithemba Ntoni](#), Master's Candidate, University of Cape Town

[Eloise Westfeldt](#), Collège du Léman

Quotes from interviews

Voices from the #GESDASummit – Ignazio Cassis

We have here (with GESDA) not just the good idea, but also the good team, the good Board of Directors, the good members. Because the human dimension of this foundation is as important as the good idea at the beginning of the organisation» – *Ignazio Cassis, President of the Swiss Confederation.*

Voices from the #GESDASummit – Belinda Cleeland

We need a platform with high-profile voices capable of bringing together the different communities that have an interest in decarbonization: the scientists, the policy-makers, and the business. GESDA is able to bring these people together and to have this dialogue that can really move decarbonization forward» – *Belinda Cleeland, Head, Research & Innovation, International Organization for Standardization (ISO).*

Voices from the #GESDASummit – Jean-Marie Guéhenno

The goal in life of real scientists is the search for truth, and that creates a shared, common ground. In human societies, many people are not looking for truth but for power. It's a very different goal that can lead to conflict and tensions» – *Jean-Marie Guéhenno, Kent Visiting Professor of Conflict Resolution, Columbia University; Former UN Under-Secretary-General for Peacekeeping Operations.*

Voices from the #GESDASummit – Kobi Leins

We are seeing people change how they engage with the world. They're increasingly talking to themselves. It's not just the risk of people being forced into positions of extremism online, but also people being forced into bubbles of 'normality' that they think represent the world [...] We don't have the data literacy globally to be able to interrogate the systems, or the understanding of the data that's been collected about us and could be used against us" – *Kobi Leins, Visiting Honorary Research Fellow, Centre for Science and Security Studies, Department of War Studies, King's College London.*

Voices from the #GESDASummit – Lydie Hakizimana

Today we really need to understand that we have to work together, include everyone in this search for breakthrough discoveries. Because, guess what? The West doesn't have the monopoly of science [...] It is about time to start implementing collaboration" – *Lydie Hakizimana, Chief Executive Officer, AIMS-The Next Einstein Initiative.*

Voices from the #GESDASummit – Massamba Thioye

The problem of decarbonization is mainly the lack of radical collaboration among nations and within nations [...] The big challenges that we are facing such as climate change and sustainability can only be addressed if we have radical collaboration and diplomacy, hence the relevance of the vision of GESDA" – *Massamba Thioye, Project Executive, Global Innovation Hub, United Nations Framework Convention on Climate Change.*

Voices from the #GESDASummit – Andrea Boggio

The human right to science is considered as a cultural right because science is one of the cultural expressions of humans. This is sort of an intrinsic value of science as an expression of who we are. [...] The goal of the United Nations is to improve life on the planet and science seems to be an important part of that" – *Andrea Boggio, Professor of Legal Studies, Bryant University.*

Voices from the #GESDASummit – Katarina Gårdfeldt and Doaa Abdel Motaal

" If you do not understand the climate change in the Arctic, you will not understand global environmental change" "Polar research will have an increasingly importance in the near future. [...] The topic is so broad, it's multidisciplinary, it engages a huge community of world-leading scientists now." – *Katarina Gårdfeldt, Director-General, Swedish Polar Secretariat.* "

" The biggest crisis before us is the climate crisis, and I don't think we can afford to lose sight of that. That really has to be our priority in both Poles" "Science does not happen independently of politics in either Poles. The geopolitical component is likely to rise and we shouldn't be naïve about that" – *Doaa Abdel Motaal, Author of "Antarctica, the Battle for the Seventh Continent"; Senior Counsellor, World Trade Organization.*

Voices from the #GESDASummit – Jim Hagemann Snabe

" GESDA is exactly the opportunity to bring practitioners from business who can provide scale, with the scientists who provide the technologies. When we match those two, we get the necessary breakthroughs and speed in order to decarbonize the world fast enough. And then we add the diplomacy because we need to do this in collaboration" – *Jim Hagemann Snabe, Chairman, Supervisory Board, Siemens AG.*

Voices from the #GESDASummit – Lidia Brito and Jürg Lauber

" The NeuroTech Compass is a tool that allows conversation between the different stakeholders about neurotech and neurosciences, and can we make sure that these wonderful discoveries are really beneficial to human societies" – *Lidia Brito, Regional Director, Southern Africa, UNESCO.*

In order to formulate regulation that makes sense and fulfill its purpose, those who do the regulations – the diplomats on international level, the law makers on national level – need to have access to the best possible information and science, and there the Compass and GESDA come in" – *Jürg Lauber, Ambassador, Permanent Representative of Switzerland to the United Nations and other international organizations. .*

Voices from the #GESDASummit – Matthias Troyer

" Quantum machines will be able to solve problems that no classic computer will ever solve. With those, we will be able to tackle some of the hardest challenges for the planet: find a catalyst and material to capture carbon from the air, help with global warming, make better batteries and solar panels..." – *Matthias Troyer, Technical Fellow; Corporate Vice President, Microsoft.*

Voices from the #GESDASummit – Niva Elkin-Koren

" Democracy nowadays is in decline and it's not due to technology. And technology is nor the solution for the decline of democracy" – *Niva Elkin-Koren, Professor of Law, Tel Aviv University.*

Voices from the #GESDASummit – Peter Maurer

" Ukraine is an emblematic conflict in which everything a conflict can represent in the future is now for the first time coming to the surface much clearer than any time before: cyberspace, space, cognitive conflict, misinformation, disinformation, hate speech, which is contributing to and driven by the polarization of the conflict in a very dangerous way" – *Peter Maurer, Former President, International Committee of the Red Cross.*

Voices from the #GESDASummit – Sana Odeh

" Everybody talks about how women are not in technology, but for me, that is not really the case because that is not the international pattern. We need to make sure that those in the "West" be able to enlighten themselves that this is not the pattern. It's some of the cues in the culture that pushes women out and we have to be careful about that and how to narrate that story" – *Sana Odeh, Clinical Professor of Computer Science; Faculty Liaison, Global Programs of Computer Science, New York University.*

Voices from the #GESDASummit – Scott O'Neill

" GESDA has been a bit of an eye-opener for me. There is a clear need for channels to be opened up like GESDA is doing. We represent a case study or an example of the technologies going much faster than the regulations or the governments or an understanding of even how to utilize the technology" - *Scott O'Neill, Chief Executive Officer, World Mosquito Program.*

Voices from the #GESDASummit – Wendy Mackay and Eric Salobir

" Using those [AI] technologies, we have to not endanger people but to push them a little bit out of their comfort zone so they can develop new skills and do better things. In such a way, probably, it [AI technologies] would be very beneficial" - *Eric Salobir, Chairman, Executive Committee, Human Technology Foundation; President OPTIC.*

" The challenge is: how do we create a society in which we empower people rather than deskill them or even replace them?" - *Wendy Mackay, Research Director, Classe Exceptionnelle, Inria.*

Voices from the #GESDASummit – Yeadong Kim

" Our concern [at SCAR] is that geopolitical tensions outside of Arctic spill over to the Antarctic" "The challenge we have now is not from the resources [in Antarctica, that are well protected], but from climate change. It's a very big issue in Antarctic like all around the world" - *Yeadong Kim, President, Scientific Committee on Antarctic Research (SCAR).*

Voices from the #GESDASummit – Valentine von Toggenburg

" It was a concern [for GESDA in the discussions] to make sure that civil society, meaning also non-experts in science and in diplomacy participate in the Summit. A small group of this civil society is the young generation" - *Valentine von Toggenburg, Lawyer, Swiss Federal Office of Justice, World Economic Forum Global Shaper.*

Voices from the #GESDASummit – Dušan Matulay

" With quantum technologies, we need to avoid having this large spectrum of use and end up with some narrow, commercially-used space. We should use it in its whole broadness" - *Dušan Matulay, Permanent Representative of Slovakia to the United Nations Office at Geneva.*

Voices from the #GESDASummit – Barry Sanders

" Like every technology, the impact of quantum on our lives can be positive and negative. If things go well, from a scientific perspective, there will be impact, some of it could be negative. It's like nuclear power. [...] There is always this Frankenstein aspect to every technology" - *Barry Sanders, Director, Institute for Quantum Science and Technology, University of Calgary.*

Voices from the #GESDASummit – Urbasi Sinha and Deborah Nas

" The fact that this [GESDA Quantum] Task Force has such good representation from different communities, including different genders, it becomes a very nice role model for the quantum field in general and even beyond that" - *Urbasi Sinha, Professor, Quantum Information and Computing Lab, Raman Research Institute.*

" If we get quantum technologies on a commercial scale, we will need a talent pool of diverse people working in a quantum space. So we already need to start triggering an interest with high school children now" - *Deborah Nas, Professor, Delft University of Technology, Faculty of Industrial Design Engineering.*

Voices from the #GESDASummit – Florence Tinguely

" What I like with GESDA is that it's proposing ideas and solutions like the Open Quantum Institute. It's not that we only debate, but we look already into possible responses to the challenges and opportunities that are coming" - *Florence Tinguely, Ambassador of Switzerland in Denmark, Federal Department of Foreign Affairs.*

Voices from the #GESDASummit – Bekithemba Ntoni

" The next step should be: How are we using this information that we have gathered here and repatriate back to our communities? What does that look like in our context? How do we inform our policymakers in making sure that they are implementing science-based policy decisions for effective development?"- Bekithemba Ntoni, Master's Candidate, University of Cape Town.

Voices from the #GESDASummit – Jordan Naddaf

" It's a really important space to start including youth in. Everything I have been learning about [at the Summit], the sessions I have been sitting in and the way these subjects are being studied as interdisciplinary subjects, it's so important to expose youth to this perspective in this angle [...] It makes me very hopeful and excited to see what comes of this" - *Jordan Naddaf, Foreign Policy Youth Collaborative Association.*

Voices from the #GESDASummit – Sofiia Martianova

❝ Democracy itself is a really unclear subject, even without technologies, it's so philosophical. It means something different for each person. I liked that during the session we had speakers with different backgrounds and they engaged together to come to one solution [...] to the problem of digitalization of democracy" - *Sofiia Martianova, Villars Fellow; Student, Electrical Engineering, ETH Zurich.*

Voices from the #GESDASummit – Olivia Avalos Villar

❝ AI becomes so complex that it's like a black hole of information. It's really interesting how humans are so heavily reliant on AI now [...] They start following AI's footsteps and start making similar mistakes to AI without realizing it" - *Olivia Avalos Villar, Student, Physics, Sciences and Economics, International School Basel.*

Voices from the #GESDASummit – Eloise Westfeldt

❝ Participating and being here is incredible. It really puts the emphasis on everything that I don't know, that is left to learn. Even the experts here, there is so much that they don't know and that really puts everything into perspective" - *Eloise Westfeldt, Collège du Léman.*
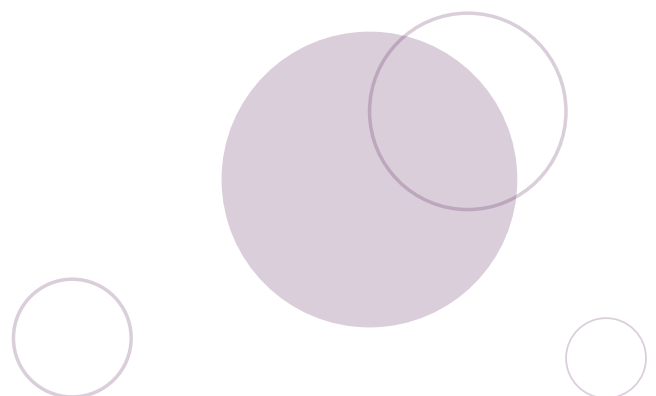
FIRST Global Robotics Demonstration at 2022 GESDA Summit

Robotic Demonstration

Geneva brought together, for the first time since 2019 and the very first time in Europe, high school teams from more than 180 countries to compete in the FIRST Global Challenge – an Olympics-style robotics competition that showcases student talent and technology skills from across the world. The FIRST Global team partnered with GESDA and provided a fantastic demonstration of what their youth and robots can do during the GESDA Summit's Opening Cocktail. The teams from Afghanistan and Ethiopia wowed participants with examples of robotic carbon capture, and gave accounts of their process in engineering and developing the robots. FIRST Global held their competition concurrently with the Summit at Geneva's Palexpo Exhibition Centre. Summit participants were invited by the FIRST Global team to visit and take a tour of the event. GESDA is proud to have this collaboration with FIRST Global to show the world that global youth and diplomats, alike, are concerned with future technologies and believe in learning from dialogue and cooperation with one another.

Summit Excursions

Summit participants took part in a variety of post-Summit excursions offered by partnering institutions. Participants were able to experience breakthrough science and innovative diplomacy beyond the convening halls and inspiring discussions of the Summit. Geneva is where multilateral collaboration comes together to tackle global challenges.

CERN

Participants spent an afternoon at CERN, the European Organization for Nuclear Research, one of the global flagship examples of successful science diplomacy. The 3-hour tour took participants on the tracks and the mysteries of particle physics. It consisted of a video introduction to CERN, followed by a visit to areas on site, such as control rooms, research facilities, and engineering facilities.

Headquarters, United Nations Office at Geneva

For a view into the world of diplomacy and international affairs, participants toured the United Nations Office at Geneva headquarters. The Palais des Nations hosts more than 10'000 meetings per year and is driving collaborative work to achieve the Sustainable Development Goals (SDGs). This 1-hour tour of the Palais des Nations provided information about the United Nations and the United Nations Office at Geneva. Participants explored the Palais des Nations, a unique building, formerly the headquarters of the League of Nations, the Library and the UN Museum. An outstanding testimony to twentieth century architecture, it is situated in the beautiful Ariana park in Geneva.

FIRST Global Challenge – Palexpo

Youth and innovation were on show at the FIRST Global Challenge. GESDA was extremely proud to host them during the opening networking cocktail, where they presented their robots to the Summit participants. In addition to this exposure, the FIRST Global team provided a tour of the international robotics competition for youth taking place at the Palexpo in Geneva concurrent with the GESDA Summit. High-school age innovators from about 190 countries were there competing, cooperating, and communicating, gaining important crosscultural experiences.

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GENEVA, SWITZERLAND, 12-14 OCTOBER 2022

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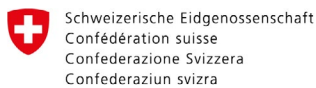
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