Proceedings of the

2023 Geneva Science and Diplomacy Anticipation Summit

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2023 Geneva Science and Diplomacy Anticipation Summit

11 – 13 October 2023

CERN Science Gateway, Geneva, Switzerland

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Acknowledgments

Proceedings of the 2023 Geneva Science and Diplomacy Anticipation Summit

The 2023 Geneva Science and Diplomacy Anticipation Summit was organized by the GESDA Foundation, under the leadership of Peter Brabeck-Letmathe, Chairman of the Board of Directors, Stéphane Decoutère, Secretary General and Sandro Giuliani, CEO, with guidance from members of the GESDA Board of Directors and of the GESDA Committee, with collaboration from the GESDA Executive Team.

For more information on GESDA, please see www.gesda.global

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Geneva, December 2023

Online interactive version

These Proceedings of the 2023 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 2023 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 2023 Geneva Science and Diplomacy Anticipation Summit, please simply scan the following QR with your smartphone.

Executive summary

THE SUMMIT IN A NUTSHELL

The third annual Geneva Science and Diplomacy Foundation Summit took place on 11-13 October 2023 in Geneva, Switzerland, at the European Organization for Nuclear Research, known by its French acronym CERN. The GESDA Summit became the first event to be held at the newly inaugurated CERN Science Gateway center. It confirmed GESDA's ability to design, fund and launch high-profile global initiatives for effective multilateralism in partnership with globally leading institutions. This year's event also convened significant geopolitical powers at a time of rising conflict and war.

The four main objectives were to advance science anticipation, diplomacy acceleration, impact translation and political assessment. For science anticipation, the summit provided a yearly update and inspiring talks on cutting-edge topics of the GESDA Science Breakthrough Radar® produced in partnership with the Fondation pour Genève. Diplomacy acceleration involved interactive sessions to frame the implications of anticipated science for people, society and the planet. Impact translation featured announcements and presentations about GESDA's two most advanced initiatives, the Open Quantum Institute (OQI) in partnership with CERN and UBS and the Global Curriculum for Science and Diplomacy supported by the Wellcome Trust. Political assessment drew on support from high-ranking government officials from across the globe on the topic of Quantum for All.

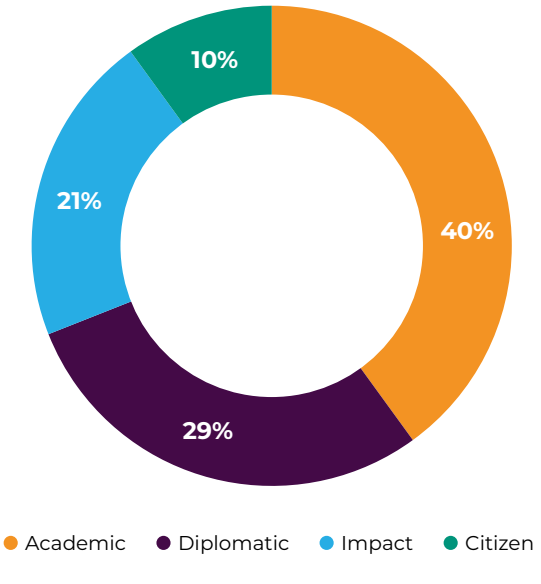
IN NUMBERS

The GESDA Summit drew a diverse crowd from across five continents and four communities: academic, citizen (including youth), diplomatic and impact. Among those seeking to attend in-person or virtually, 1,366 people registered for the summit, up from 1,267 the year earlier and 927 in 2021. A total of 800 attended. Some 89 speakers, 56% male and 44% female, and a youth cohort contributed to 23 sessions, two side events and two open events over three days.

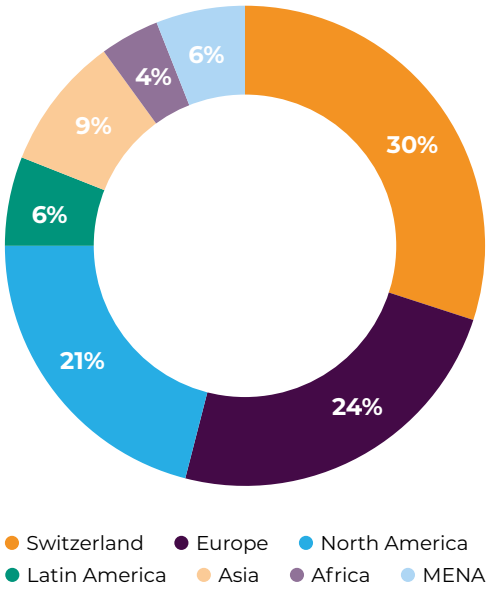
THE PROGRAM

The 23 sessions had three styles: eight plenary sessions presenting GESDA's most mature initiatives and topical affairs through a facilitated discussion involving diverse stakeholder representation; nine anticipatory briefings featuring an expert point of view through a moderated discussion with visual aids about topics from the GESDA Science Breakthrough Radar®; and six interactive discussions with moderated panels of decision-makers discussing the potential impacts of scientific and technological breakthroughs. Two open events were held, one focused on messenger RNA (mRNA) technology, and the other on the legacy and lessons of the late theoretical physicist J. Robert Oppenheimer. Three side events also were held.

Speakers' Community Overview



Geographical Origin of Speakers



PROGRAM HIGHLIGHTS

Opening High-Level Plenary

The summit opened with demonstrable proof that GESDA was shifting from a startup to an active launching pad for global initiatives and solutions. GESDA Board Chairman Peter Brabeck-Letmathe emphasized that the fast pace at which generative AI tools like ChatGPT were being developed and adopted by industry and society showed the clear need for more anticipation of scientific breakthroughs and their potential for profound impacts.

GESDA welcomed the three newest members of its 12-person international Board of Directors: Enrico Letta, former Prime Minister of Italy and President of the Jacques Delors Institute in Paris; Cheryl Moore, Wellcome Trust's Chief Research Programmes Officer; and Henrietta Fore, former Chairperson and CEO of Holsman International, former Executive Director of UNICEF and former Administrator of the U.S. Agency for International Development (USAID).

Launch of the Global Curriculum for Science and Diplomacy

Brabeck-Letmathe announced that the London-based Wellcome Trust, which focuses on health research and is one of the world's largest charitable foundations, will support GESDA and its partners with CHF8 million for one of GESDA's most advanced initiatives, the creation of a Global Curriculum for Science and Diplomacy (GCSD) to define and implement at scale globally accepted best practices for science diplomacy training fostering effective multilateralism.

The funding will allow GESDA to move forward with this initiative, which builds on the success of the first two editions of the Geneva Science and Diplomacy Week.

The 2023 GESDA Science Breakthrough Radar®

The 2023 GESDA Science Breakthrough Radar provides an overview of science trends and breakthrough predictions at 5, 10 and 25 years in 42 science and tech. Presented during the opening high-level plenary, GESDA's flagship product edition 2023 involved 848 scientists from 73 countries, a 56% increase in the number of scientists from the inaugural edition in 2021. The number of emerging topics identified rose to 42, up from 24 two years earlier. It contains three lenses on philosophy, geopolitics and science on three fundamental questions about the future of humanity, debated by 84 scholars from philosophy, social sciences, humanities and geopolitics.

GESDA Board Member Michael Hengartner, who is Board President of the Swiss Federal Institute of Technology Zurich (ETHZ), introduced the third annual edition of Radar, one of GESDA's two main instruments for anticipation and action along with the summit itself. For the first time in 2023, he explained, GESDA included six deep dives into specific areas of the Radar, including neuro augmentation and the future of peace and war, in which experts believe there is a pressing need for policymakers to understand the anticipated impacts in more depth.

The Radar also presented the incubation report on the past two years of work that was undertaken to launch the OQI, GESDA's first Solution Idea ready for pilot implementation.

The GESDA Youth Cohort

The Radar's analysis of over 10 million social media posts and 1.3 million articles in mainstream media takes the pulse of society by assessing what people do and say about emerging scientific topics within five main scientific platforms.

GESDA Board Member Mamokgethi Phakeng, the Chair of GESDA's Citizens Forum, emphasized the need to understand what people think of science and technology and what actions they are taking in relation to these anticipated advances.

To fulfil that need, the summit continued its tradition of gaining fresh perspective from young people, an extension of the Radar's focus on engaging people and its analysis of mainstream and social media to assess public opinion, sentiment and actions related to dozens of emerging topics.

The GESDA Youth Cohort draws 12 young people whose participation is 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 are three participants chosen from the Youth and Anticipation Initiative hosted by Phakeng, who gets African youth involved with the Radar and encourages them to share their experiences of the summit and views on the future of science and diplomacy.

High-Level Political Segment

They strongly endorsed the launch of the OQI in Geneva as a global resource and platform to further the U.N.'s 17 Sustainable Development Goals (SDGs) for 2030. A political roundtable organized by the Swiss Federal Department of Foreign Affairs (FDFA) and GESDA drew high-ranking government officials from countries in Asia, Europe, the Middle East and North America.

Swiss Foreign Minister and Federal Councilor Ignazio Cassis, a diplomat and medical doctor who has championed science and diplomacy as a 21st century theme for sustaining Geneva's relevance as a global hub of multilateralism, said Switzerland wants the OQI to serve as "the umbrella of the quantum national strategies" around the world as it democratizes the access to this game changing future technology and explores potential use cases for quantum technologies that can "maximize the chances while minimizing the risks."

Swiss State Secretary and Ambassador Alexandre Fasel moderated the political discussions on quantum computing and aspects of science and diplomacy among ministers and top-level advisers from Hungary, Japan, Mexico, Slovenia, Switzerland, the United Arab Emirates, the United Kingdom, and the United States, along with Tatiana Valovaya, the Director-General of the United Nations Office at Geneva. "We need to bring the global quantum computing system to fruition, and so this combination of existing scientific excellence and bringing in global talent from all over the world is what we are trying to do," said Fasel, who also is Swiss Special Representative for Science Diplomacy and former Chairman of the GESDA Diplomatic Forum.

Sarah Bint Yousef Al Amiri, the UAE Minister of State for Public Education and Advanced Technology, called the OQI "a milestone effort that drives several factors forward" in the public policy domain of technology development, ensuring it is aligned with societal and economic needs. It's important to multilaterally establish regulations, she said, but not too early because that could stifle innovation and not too late because that could weaken their effect.

Patricia Gruber, the Science and Technology Adviser to the U.S. Secretary of State, said it was "wonderful to see the science and technology community recognizing they need to be more engaged in the fields of diplomacy and governance, and that she looked forward to being able to say a decade after GESDA's launch of the OQI: "You know what? The governments and the ministries around the world got it right on quantum and we're in a good place."

Launch of the Open Quantum Institute (OQI)

At the end of the summit, GESDA – with the backing of the Swiss government, CERN and Switzerland's largest financial institution UBS – formally launched a new global institute in Geneva that will work to ensure that future quantum computing is accessible and used for the common good.

Brabeck-Letmathe said it represents "a real milestone in the young history of GESDA."

After two years of incubation and design by GESDA in collaboration with some 130 experts, the OQI will be hosted by CERN as a new three-year pilot program that will be fully embedded into CERN's wider Quantum Technology Initiative. UBS agreed to support the initiative, providing strategic expertise and funding of up to CHF2 million a year. The OQI is expected to open as a CERN-hosted program on March 1, 2024.

Cassis said science diplomacy is likely to shape Geneva's international hub this century as profoundly as humanitarian aid and human rights shaped it previously. "We live, I believe, at quite an important moment in international Geneva's history," said Nathalie Fontanet, State Councilor of the Republic and Canton of Geneva, which along with the Swiss Confederation co-founded GESDA in 2019. "International Geneva is a unique center for global cooperation."

CERN's Director-General Fabiola Gianotti, who also is a GESDA Board member, said her organization is proud to host the three-year pilot phase of the OQI, which will benefit from CERN's experience in uniting thousands of scientists from around the world. The OQI will develop best use cases that advance efforts to achieve the SDGs which were endorsed by 193 nations, she said, and it also could serve as a "template" for future science diplomacy initiatives.

UBS Group Chief Risk Officer Christian Bluhm said the bank decided to finance the creation of the OQI in Geneva for a "prolonged time into the future" because it firmly believes that the advent of quantum computing will be "probably the most disruptive technology of the decade."

OUTREACH ACTIVITIES

In the Media Sphere

With its announcements of financial support and backing for two concrete GESDA initiatives, the summit drew significant media attention across multiple platforms and featured the highest proportion of original articles compared with the two previous summits. There were 114 original articles published about the third summit in 2023, representing a 17.5% increase from 2022 and 7.5% higher than in 2021.

The most comprehensive coverage in terms of original content revolved around the launch of GESDA's two most advanced initiatives, the OQI and the GCSD. The OQI received the most extensive coverage, making up 45% overall. The reporting peaked when Swiss Foreign Minister and Federal Councilor Ignazio Cassis officially launched the institute.

Articles were published about the summit in at least five languages, but coverage in the main three linguistic regions of Switzerland all rose in 2023, including a 16% rise in French, 30% in German and the first news articles this year in Italian. The most prominent region in terms of coverage was Europe, largely due to extensive reporting by Swiss media outlets. As much as 29% of the overall coverage focused on the UAE's Al Amiri, who called the OQI "a milestone effort" in the public policy domain of technology development.

Some 13% of the coverage were articles on the expectations and agenda. Online media platforms maintained their dominant position, boasting a significant 95.5% share in the media landscape with an overall reach amounting to 145 million. By country, Switzerland and India led with 44% and 15% of the coverage, respectively. The outbreak of a new war in the Middle East four days beforehand affected coverage, but made for timely discussions on the future of peace and war.

Social Networks

During the summit, GESDA had 170 posts using a multi-channels strategy to diversify its digital coverage based on the targeted audience and expected results. It relied on the hashtags #GESDASummit and #ScienceDiplomacy. Notably, tweets that featured or were sent by Phakeng, who has nearly 350,000 X followers, drew 610,000 impressions.

KEY TAKEAWAYS

Closing the summit, Brabeck-Letmathe said GESDA's partnerships are invaluable to accomplishing a shared mission of making technology inclusive and open for everybody. "The Open Quantum Institute stands as an emblem for GESDA's unique approach," he said. "And I think the Open Quantum Institute is the first, hopefully, of many GESDA-born initiatives."

GESDA's ambition is to replicate this success in other areas highlighted in the Radar, said Brabeck-Letmathe. "We already have a pipeline of solutions which we have discussed with you, and there we have received your feedback," he said. "Together we have been setting in motion a future which is based on solid science and filled with limitless possibilities."

Widening the Circle of Beneficiaries

The addition of three new Board members and the momentum of the past year has given GESDA a growing sense of confidence, Brabeck-Letmathe said. "Our definite goal is to widen the circle of people who benefit from scientific and technological advances as it is stated in the Universal Declaration of Human Rights," he said, citing the U.N. declaration's Article 27 that insists on equal participation and sharing in cultural activities, scientific advances and their benefits.

From SDGs to Anticipating the Future of Peace and War

One of GESDA's main goals is to help facilitate solutions that can achieve the SDGs, but in July 2023 a U.N. analysis found only 15% of the SDGs remained on track. Brabeck-Letmathe said the world's multilateral institutions for global governance have not kept up with geopolitical turmoil, disasters, extreme weather events, the pandemic, food insecurity, inflation and other challenges.

"Some reflect power structures frozen in time since the end of the Second World War, and it will take more than multipolarity to bring about peace," he said. "And that's why one of GESDA's newest initiatives is to help the world navigate the future of peace and war."

Letta said the 21st century versions of peace and war are "more complicated than ever" with a number of "frozen conflicts" that could be approached through GESDA's anticipatory science diplomacy. "Anticipation means action," he said, "and that is at the core of GESDA's values."

Speakers

Patrick Aebischer

Vice-Chairman, GESDA; President Emeritus, Swiss Federal Institute of Technology Lausanne (EPFL), Switzerland

Sarah Al Amiri

Minister of State for Public Education and Advanced Technology, UAE

Julia Angeles

Investment Manager and Partner, Baillie Gifford, UK

Anousheh Ansari

CEO, XPRIZE Foundation, USA

Stéphanie Balme

Research Professor, Sciences Po Paris (CERI/ PSIA), France

Chiara Bartolozzi

Senior Researcher Tenured – Principal Investigator, Italian Institute of Technology, Italy

Paolo Benanti

Theologian and Academic, Third Order Regular of St. Francis; Professor, Pontifical Gregorian University; Advisor to Pope Francis on A.I. and Technology Ethics, Vatican City

Jocelyne Bloch

Professor of Neurosurgery, University Hospital of Lausanne (CHUV), Switzerland

Christian Bluhm

Group Chief Risk Officer, UBS, Switzerland

Doreen Bogdan-Martin

Secretary-General, International Telecommunications Union

Andrea Boggio

Professor of Legal Studies, Bryant University, USA

Sylviane Borel

Membre du Conseil, Fondation Defitech, Switzerland

Peter Brabeck-Letmathe

Chairman, Board of Directors, GESDA, Switzerland

Annika Brack

CEO, International Center for Future Generations, Belgium

Viscount Camrose

Minister for AI and Intellectual Property, UK

Ignazio Cassis

Federal Councillor, Minister of Foreign Affairs, Switzerland

Anuradha Chowdhary

Professor of Medical Mycology, Vallabhbhai Patel Chest Institute, University of Delhi, India

Matthias Christandl

Professor, Department of Mathematical Sciences, University of Copenhagen, Denmark

Martin Chungong

Secretary-General, Inter-Parliamentary Union

Mina Cikara

Professor of Psychology, Harvard University, USA

Grégoire Courtine

Professor of Neuroscience, Swiss Federal Institute of Technology Lausanne (EPFL), Switzerland

Alessandro Curioni

Vice President, IBM Europe and Africa; Director, IBM Research Lab, Switzerland

Sylvie Delacroix

Professor in Law and Ethics, University of Birmingham, UK

Daan du Toit

Deputy Director-General, International Cooperation and Resources, South African Department of Science and Innovation, South Africa

William Egbe

Managing Partner, Vibranium Capital Group, Cameroon

Mariam Ezz El-Arab

iGEM Ambassador for Africa, Egypt (Winner of the 2023 GESDA Youth Anticipation Initiative)

Nita Farahany

Professor of Law, Duke University, USA

Alexandre Fasel

State Secretary for Foreign Affairs, Switzerland

Henrietta Fore

Former Executive Director, UNICEF; Chairperson and CEO, Holsman International, USA; GESDA Board Member

Nathalie Fontanet

Geneva Cantonal State Councillor, Switzerland

Itzhak Fried

Professor of Neurosurgery and Psychiatry and Biobehavioral Sciences, University of California, Los Angeles, USA; Professor of Neurosurgery, Tel-Aviv Medical Center and Tel-Aviv University's Sackler Faculty of Medicine, Israel

Claudia Fuentes Julio

Ambassador and Permanent Representative of Chile to the United Nations Office at Geneva

Pascale Fung

Director, Center for Artificial Intelligence Research; Chair Professor, Department of Electronic & Computer Engineering and Department of Computer Science & Engineering, Hong Kong University of Science and Technology, Hong Kong SAR

Meret Gaugler

Healthcare Investor and Advisor, Switzerland

Fabiola Gianotti

Director-General, CERN

Ángel Goñi-Moreno

Researcher, Center for Plant Biotechnology and Genomics, Spain

Mubeen Goolam

Stem Cell Researcher, Department of Human Biology and Neuroscience Institute, University of Cape Town, South Africa

Vera Gorbunova

Doris Johns Cherry Professor, University of Rochester, USA

Thomas Greminger

Former Secretary-General, Organization for Security and Cooperation in Europe; Director, Geneva Centre for Security Policy, Switzerland

Patricia Gruber

Science and Technology Advisor to the Secretary of State, USA

Jean-Marie Guéhenno

"Former UN Under-Secretary General for Peacekeeping Operations; Arnold A. Saltzman Professor of Practice in International and Public Affairs; Director of SIPA's Kent Global Leadership Program on Conflict Resolution, Columbia University, USA"

Laurent Haug

Founder, 200ideas, Switzerland

Jaimie Henderson

Professor of Neurosurgery, Stanford University, USA

Michael Hengartner

Chair, GESDA Academic Forum; President, ETH Board, Switzerland

Joel Hernández

Sub-Secretary of Foreign Affairs, Mexico

Marcello Ienca

Professor of Ethics of AI and Neuroscience, Technical University of Munich, Germany

Alexander Ilic

Executive Director, ETH AI Center, Swiss Federal Institute of Technology Zürich (ETHZ), Switzerland

Matthias Kaiser

Professor Emeritus, Centre for the Study of the Sciences and the Humanities, University of Bergen, Norway

Sami Kanaan

Administrative Councillor; Head of the Department of Culture and Digital Transformation, City of Geneva, Switzerland

Enrico Letta

Former Prime Minister of Italy; President Jacques Delors Institute, France; GESDA Board Member

Robin Lovell-Badge

Head of the Laboratory of Stem Cell Biology and Developmental Genetics, Francis Crick Institute, UK

Yoichiro Matsumoto

Science Technology Advisor to the Minister of Foreign Affairs, Japan

Michael Møller

Former UN Under-Secretary- General; Former Director-General, UN Office at Geneva; GESDA Board Member, Switzerland

Adrian Monck

Editor-in-Chief, Seven Things, Switzerland

Cheryl Moore

Chief Research Programmes Officer, Wellcome, United Kingdom; GESDA Board MemberDirector, Geneva Centre for Security Policy, Switzerland

Ryan Morhard

Senior Director, Policy and Partnerships, Ginkgo Bioworks, USA

Jan Marco Müller

Coordinator, Science Diplomacy and Multilateral Relations, European Commission

Sana Odeh

Clinical Professor of Computer Science, New York University, USA

Marcella Ohira

Deputy Executive Director and Director for Capacity Building, Science Diplomacy Center, Inter-American Institute for Global Change Research, Uruguay

'Funmi Olonisakin

Professor of Leadership, Peace and Conflict, King's College London, UK

Tolullah Oni

Clinical Professor, University of Cambridge, UK

Charles Oppenheimer

Founding Member, The Oppenheimer Project, USA

Kate Oppenheimer

Founding Member, The Oppenheimer Project, USA

Prince Osei

Director, Quantum Leap Africa, Ghana

Mamokgethi Phakeng

Chair, GESDA Citizens Forum; Professor of Mathematics Education; Former Vice-Chancellor, University of Cape Town, South Africa

Laura Piddock

Scientific Director, Global Antibiotic R&D Partnership (GARDP), Switzerland

Mu-ming Poo

Scientific Director, Institute of Neuroscience, Chinese Academy of Sciences, China

Lars Peter Riishojgaard

Director, Global Greenhouse Gas Watch, World Meteorological Organization (WMO)

François Rivasseau

Senior Consultant, Science and Diplomacy, World Intellectual Property Organization

Johan Rockström

Director, Potsdam Institute for Climate Impact Research, Germany

Nicolas Roelofs

Investment Director, Summa Equity, Sweden

Karen Rommelfanger

Founder, Institute of Neuroethics, USA

Barry Sanders

Professor, University of Calgary, Canada Commission

Eduardo Schenberg

Founder & President, Phaneros Institute, BrazilYork University, USA

Ding'li Shen

Professor of International Relations, Fudan University, China

Muriel Siki

Journalist, Switzerland

Amandeep Singh Gill

UN Secretary-General's Envoy on Technology

Urbasi Sinha

Professor, Quantum Information and Computing Lab, Raman Research Institute, India

Martin Smith

Head of Policy Lab, Wellcome, UK

Emilija Stojmenova Duh

Minister of Digital Transformation, Slovenia

Péter Sztáray

State Secretary for Security Policy and Energy Security, Hungary

Chorh Chuan Tan

Chief Health Scientist, Ministry of Health; Executive Director, Ministry of Health Office for Healthcare Transformation, Singapore

Matthias Troyer

Technical Fellow and CVP, Microsoft Quantum, USA

Tatiana Valovaya

Director-General, United Nations Office at Geneva

Ian Walmsley

Provost, Imperial College London, UK

Dominic Waughray

Executive Vice President, Imperatives, World Business Council for Sustainable Development, Switzerland

Lucy Woodall

Associate Professor, Marine Conservation and Policy, University of Exeter, UK

Wednesday 11 October, 12.30 – 13.30 CET

Plenary Session

Opening Plenary: Use the Future to Build the Present

Opening Plenary: Use the Future to Build the Present

Speakers

Moderated by:

Muriel Siki, Journalist, Switzerland

Remarks by:

Peter Brabeck-Letmathe, Chairman, Board of Directors, GESDA, Switzerland

Alexandre Fasel, State Secretary of Foreign Affairs, Switzerland

Fabiola Gianotti, Director-General, CERN, Switzerland

Sami Kanaan, Administrative Councilor, Head, Department of Culture and Digital Transformation, City of Geneva, Switzerland

Launch of the GESDA Science Breakthrough Radar® by:

Michael Hengartner, Chair, GESDA Academic Forum; President, ETH Board, Switzerland

Mamokgethi Phakeng, Chair, GESDA Citizens Forum; Professor of Mathematics Education; Former Vice-Chancellor, University of Cape Town, South Africa

Summary

As the first big event held at the newly opened CERN Science Gateway, the 2023 Geneva Science and Diplomacy Anticipation Summit drew more than 800 participants in Geneva and online for discussions on topics raised by the GESDA Science Breakthrough Radar®. There's a huge need for anticipation, GESDA Chairman Peter Brabeck-Letmathe emphasized, since scientific disruptions are advancing at an unprecedented speed that leaves us with "little time to act" beforehand.

"Exactly a year ago, we were not talking about ChatGPT," he said of the generative AI tool that had 1 million users within a week of its launch in November 2022 and 100 million active users by the end of January 2023. "The fast pace at which it was adopted meant that many of the profound questions about its use were left to be answered after the fact. This is a wonderful example of what we want to try to avoid with scientific breakthroughs in the future. It is too late to talk about it, it is too late to frame it, when the breakthrough already has taken place. I think the world deserves and needs better than that."

Everyone attending – citizens, scientists, political authorities, diplomats, the business community, philanthropists, representatives of NGOs and others – need "more than belated debates about the implications of powerful new technologies" like ChatGPT, he said, but "the only way to do this is by anticipation – and anticipation is la raison d'être du GESDA. By projecting ourselves into the future, we aim to detect in advance the major scientific and technological advances that will change the *way* – not only *how* – we live."

The third annual Summit marked one year since the Geneva Science and Diplomacy Anticipator Foundation began shifting from a startup to an active launching pad for global initiatives and solutions.

"We aim to give society the time it needs to prepare for those changes with the best possible transitions and the best possible concrete projects, and not to have to hold important debates about our future in a rushed atmosphere that is hardly conducive to the emergence of constructive long-term solutions," he said. "We are gathered here with the idea to say, with a certain level of excitement and anticipation, to cultivate the dialogue and future opportunities."

Brabeck-Letmathe welcomed GESDA's three newest Board members: Enrico Letta, former Prime Minister of Italy and President of the Jacques Delors Institute in Paris; Cheryl Moore, Wellcome Trust's Chief Research Programmes Officer; and Henrietta Fore, former Chairperson and CEO of Holsman International, former Executive Director of UNICEF and former Administrator of the U.S. Agency for International Development (USAID).

The addition of these new Board members and the momentum of the past year give GESDA a growing sense of confidence, Brabeck-Letmathe said. "Our definite goal is to widen the circle of people who benefit from scientific and technological advances as it is stated in the Universal Declaration of Human Rights," he said, citing the declaration's Article 27 that insists on equal participation and sharing in cultural activities, scientific advances

Peter Brabeck-Letmathe

and their benefits. The declaration, which was approved by the U.N. General Assembly in 1948 to prevent a recurrence of World War II atrocities, was a milestone achievement in setting the first multicultural standards for universally protecting fundamental human rights.

To propagate that effort, Brabeck-Letmathe announced that the London-based Wellcome Trust, which focuses on health research and is one of the world's largest charitable foundations, will support GESDA and its partners with CHF8 million for one of GESDA's most advanced initiatives, the creation of a Global Curriculum for Science and Diplomacy. "If science diplomacy is to become an effective instrument for strengthening multilateral cooperation, it needs well-trained people. And therefore GESDA, together with a broad coalition of academic, diplomatic and private partners around the world, will develop and implement a global framework for training professionals in science and diplomacy that is based on a set of commonly recognized skills and knowledge," he said.

One of GESDA's main goals is to help facilitate solutions that can achieve the United Nations' 17 Sustainable Development Goals for 2030. In July 2023, however, a U.N. analysis found only 15% of the SDGs remained on track. Progress toward 48% was "weak and insufficient," the U.N. reported, and 37% had "stalled or gone into reverse" including key targets on poverty, hunger and climate. Brabeck-Letmathe said the world's multilateral institutions for global governance have not kept up with the geopolitical turmoil, disasters and extreme weather events, the pandemic, food insecurity, inflation and other challenges. "Some reflect power structures frozen in time since the end of the Second World War, and it will take more than multipolarity to bring about peace," he said. "And that's why one of GESDA's newest initiatives is to help the world navigate the future of peace and war."

Swiss Ambassador Alexandre Fasel, who in June became the State Secretary of Foreign Affairs and also serves as Switzerland's Special Representative for Science Diplomacy, said GESDA has succeeded in its goal of becoming a Swiss initiative that operates in Geneva but benefits all proponents of international governance, both in Geneva and far beyond. "And today we see this is effectively what GESDA has become and what GESDA is," he told the Summit. "So, we are here in the laboratory of 21st century global governance."

Until September 2023, when he took on his new duties overseeing the day-to-day leadership of the Swiss Federal Department of Foreign Affairs (FDFA), Fasel also led the GESDA Diplomacy Forum that GESDA Board Member Michael Møller launched in 2019. Fasel described the Summit as "a unique opportunity" for diplomats, policymakers, politicians and others to get an overview of the latest developments in a wide range of sciences and to understand what the GESDA Science Breakthrough Radar® forecasts for the next 5, 10 and 25 years.

"In a way, the GESDA Summit is an illustration of what my government means when it positions anticipatory science diplomacy as a central instrument of Swiss foreign policy," he said, referring to the Swiss foreign policy white paper for the years 2024 to 2027." Fasel also pointed to the Summit's high-level Geneva Political Talks on Science Diplomacy slated for later in the week. "So, it's a GPT of our own," he quipped. "To give political guidance and protection to the work GESDA is doing."

Just four years after its creation by Swiss and Geneva authorities, GESDA plays an important role in Geneva's multilateral hub and "has already met and even went beyond the objectives" that it set for itself when it formed in 2019, Sami Kanaan, an Administrative Councilor who heads Geneva's Department of Culture and Digital Transformation, told the Summit on behalf of city and cantonal authorities. "The ecosystem that has been developed over decades on our territory is truly unique and contains still an immense potential for synergies that we as host authorities must keep alive and always improve," he said. "More than ever, considering the immense and very complex and difficult challenges our world is facing today and tomorrow, GESDA is one very important pillar in the possible response that we can all of us somehow contribute to face those challenges."

Muriel Siki

Alexandre Fasel

Michael Hengartner

Mamokgethi Phakeng

CERN has taken pride in hosting the GESDA Summit, the first big event to be held in the new Science Gateway center for scientific education and outreach since its inauguration four days earlier, CERN's Director-General Fabiola Gianotti said in welcoming the Summit participants. CERN promotes "open science and open education as a means of reducing inequalities across the world and this mission is pretty much at the foundation of GESDA's work," she said. "So clearly there are strong links between CERN and GESDA."

The Science Gateway center, built to increase the number of visitors up to half a million a year from 150,000 currently, will share research along with "the beauty and the utility of science," said Gianotti. "We want to do so in a very simple and fascinating manner, accessible to everybody, starting with five-year-old kids. We also want to contribute to increasing the trust in science in today's society. We want to inspire the young people to take up careers in STEM: science, technology, engineering and mathematics. We want to instill in all the people who come and visit a curiosity and a passion for science."

GESDA Board Member Michael Hengartner, who is Board President of the Swiss Federal Institute of Technology Zurich (ETHZ)**,** introduced the third annual edition of the GESDA Science Breakthrough Radar®, one of GESDA's two main instruments for anticipation and action along with the Summit itself. The Radar contains 42 scientific emerging topics and 324 breakthroughs expected to occur over the next quarter-century.

"Over the past three years we have worked together with 1,500 scientists from 73 countries around the globe, through dedicated workshops, symposia and surveys, to identify the potential breakthroughs across five different scientific platforms spanning the physical, digital life and social sciences," said Hengartner, who also serves as the Chair of GESDA's Academic Forum. "By becoming aware of potential future breakthroughs, we can make informed decisions today and gain agency over our common future."

As in previous years, he said, the Radar was crafted using a process of science anticipation that relies on three basic principles to identify potential advances in science and technology.

"First, we try to stick to the science. We strive to understand what developments are possible or probable in a scientific field and refrain as scientists as much as possible from considering what might be desirable or preferable," he said. "Second, we apply the rigor of the scientific method to the process of science interpretation, including the principles of in-depth expertise, academic rigor and peer review. And lastly, we recognize that scientific research is itself an agent in science anticipation, in the sense that research is the tool that humanity uses to systematically increase the horizons of our knowledge."

Sami Kanaan

Fabiola Gianotti

GESDA Board Member Mamokgethi Phakeng, who serves as the Chair of GESDA's Citizens Forum and is a mathematics education professor and former Vice-Chancellor of the University of Cape Town, emphasized that science and technology are advancing at an exponential rate but are not happening in a vacuum. It's important to understand what people think about science and technology and what actions people are already taking in relation to these anticipated advances, she said, so we can begin to collectively think about how we can work with science and technology to reshape the future.

Phakeng, who launched GESDA's Youth and Anticipation Initiative to champion young scientific and academic leaders, said the Radar's use of artificial intelligence to take the "pulse of society" by analyzing 10 million social media posts and 1.3 million mainstream media articles helped visualize how sentiment and action around each topic is taking shape and changing, providing insights into society's interests and priorities for the future.

"The advances that we cover in the Radar are reshaping or will reshape how we see ourselves as human beings, the way we interact with each other, and our relation to the environment," she said. "And that means there are applications, there are potentials and implications that need to be discussed broadly, not only with the scientists who are able to come to the Summit, but with people who don't even know that this Summit is happening, including people in developing countries who are often left out from the conversations."

More information

Explore the 2023 GESDA Science Breakthrough Radar®

Session recording on YouTube

Key messages

- The third Geneva Science and Diplomacy Anticipation Summit drew over 800 participants in Geneva at the newly inaugurated CERN Science Gateway and online.
- Three years after its inception, GESDA has solidified its standing as an important pillar in Geneva's multilateral ecosystem, helping to face the complex challenges of today and tomorrow.
- GESDA announced CHF8 million in funding from the Wellcome Trust to launch a Global Curriculum for Science and Diplomacy to ensure that science diplomacy can become an effective instrument for strengthening multilateral cooperation.
- The 2023 edition of GESDA's Science Breakthrough Radar® was launched, containing 42 scientific emerging topics and 324 breakthroughs expected to occur over the next quarter-century.
- Mamokgethi Phakeng emphasized the need to ensure that citizens – and ultimately those who could benefit from scientific and technological breakthroughs – are included in conversations on the potential applications and implications of such advances.

Wednesday 11 October, 14.00–15:30 CET

Plenary Session

Anticipating the Future of Peace and War

Anticipating the Future of Peace and War

Geopolitics has been increasingly volatile in recent years with the war in Ukraine, unravelling Sino-Western relations and increasing food insecurity to name a few. How can new methodologies for anticipation in peace and security be developed to safeguard the future of humanity?

Speakers

Moderated by:

Enrico Letta, Former Prime Minister of Italy; President Jacques Delors Institute, France; GESDA Board Member

Presentations by:

Jean-Marie Guéhenno, Former UN Under-Secretary General for Peacekeeping Operations; Arnold A. Saltzman Professor of Practice in International and Public Affairs; Director of SIPA's Kent Global Leadership Program on Conflict Resolution, Columbia University, USA

Thomas Greminger, Former Secretary-General, Organization for Security and Cooperation in Europe; Director, Geneva Centre for Security Policy, Switzerland

With:

Michael Møller, Former UN Under-Secretary-General; Former Director-General, U.N. Office at Geneva; GESDA Board Member, Switzerland

'Funmi Olonisakin, Professor of Leadership, Peace and Conflict, King's College London, United Kingdom

Dingli Shen, Professor of International Relations, Fudan University, China

Summary

Four days before the start of the 2023 Geneva Science and Diplomacy Anticipation Summit, the Hamas militant group launched a surprise incursion into southern Israel that killed 1,200 people and set off a war and massive humanitarian catastrophe for Palestinians in Gaza that has had a growing risk of drawing in neighboring countries and global powers. The geopolitical ramifications for the rest of the world have been as far-reaching as the impacts of Russia's all-out assault on Ukraine have been since that invasion began seven months before the 2022 GESDA Summit.

Between the onset of the bloodiest conflict in Europe to break out since World War II and the dangerously polarizing and deadly Israel-Hamas war in the Middle East, GESDA and its partners, the Geneva Centre for Security Policy (GCSP) and Columbia University's School of International and Political Affairs (SIPA), joined forces to identify new approaches toward anticipating the future of peace and war, particularly the complexities of longstanding armed conflicts involving multiple outside powers. The 21st century versions of peace and war are "more complicated than ever," said GESDA Board Member Enrico Letta, a former Prime Minister of Italy who also is President of the Jacques Delors Institute in Paris. "And the same for the other frozen conflicts around the world. It's not easy to talk about war and peace today, thinking in an anticipatory way, but it is necessary."

The future of peace and war is featured in the GESDA 2023 Science Breakthrough Radar® with insights from Jean-Marie Guéhenno, Director of SIPA's Kent Global Leadership Program in Conflict Resolution; Thomas Greminger, Director of the GCSP; and GESDA Board Member Michael Møller. They noted that fragmentation, friction and uncertainty are more commonplace today, resulting in unpredictability within many countries and between major power blocs. But with some anticipation, they said, diplomats and policymakers could find more promising approaches to peace and implement better programs and strategies for preventing or containing conflicts.

"Anticipation in that field is not prediction for a very simple reason," Letta, who was selected to serve as the next chairman of the GESDA Diplomacy Forum, told the participants in the 2023 GESDA Summit. "Anticipation means action, and that is at the core of GESDA's values."

One of the biggest challenges to anticipating the future of peace and war is to be able to see above the fog of present-day conflicts and complexities of maintaining peace around the world, according to Guéhenno, a veteran French diplomat and former

United Nations peacekeeping chief from 2000 to 2008. “It’s very difficult not to be a prisoner of the tyranny of the ‘now’ when the ‘now’ is so tragic and the ‘now’ sends very confusing messages,” said Guéhenno, who once oversaw 130,000 staff on 18 missions as part of the biggest expansion in 60 years of U.N. peacekeeping.

Guéhenno noted that conflicts in Africa’s troubled Sahel region, which includes Burkina Faso, Chad, Cameroon, Mali, Niger and Nigeria, have also grown increasingly violent – and more driven by the use of state-of-the-art technology – in recent years. “When we look at Ukraine, when we look at what’s happening in Israel and Palestine, when we look at what’s happening in the Sahel, we see things that remind us of past conflicts. We see the trench warfare in Ukraine. We see the medieval barbarian actions of Hamas in Israel,” he said. “But we see also high-tech. We see drones. We see information warfare. And so, we see that it’s very important, actually, to take a step back and not to be, if we want to understand the conflicts of today, we must not understand them looking at the sort of rear window mirror. That is very dangerous and that’s the way to be continuously surprised. And that is the way not to be able to prevent and to anticipate future conflict.”

To avoid focusing on present-day concerns, one must look at a multiplicity of trends and countertrends on global topics ranging from climate to migration, he advised, since it’s the interaction of these forces at work that makes anticipation so challenging. “If there is something that defines our world, it’s connectivity. In a connected world, there is much more opportunity for disruptions and surprises,” he said. “In a non-connected world, you can look at events in isolation.”

During two high-level workshops in Geneva and New York in 2023, GESDA, SIPA and the GCSP convened experts to apply the method of “scenarios.” Using that method, they worked to establish representations of possible futures for one or more components of a system – the drivers of peace and war in a given place – and to include alternative policies or management options. They also spoke with specialists in anticipation and borrowed Finland’s systematic two-axis approach: a vertical axis for the continuum between war and peace, and the secondary axis for the impact of science and technology on societies from enhancing to disrupting the distribution of power.

“We’re aware this is a reductive approach, but nevertheless it’s an approach that allows us to begin to make sense of a complicated world. The first axis brings us from war to peace. It makes the point that the binary opposition between war and peace does not actually make sense, especially in our confused and ambiguous world. There are multiple ways of achieving peace and, sadly, multiple ways of waging war. There’s a continuum from war to peace and so there are a multiplicity of possible intersecting continuums,” said Guéhenno.

“The second axis that we discussed focuses on technologies as a key variable – and the focus on data technology as a key determinant,” he said. “Will there be concentration or diffusion of technology? Technology and scientific progress are a multiplier of power, and conflicts are about power. And so, we thought that connecting the work on conflict with a broader approach of GESDA in the Radar made sense. In the end, the transformation of conflict over centuries is strongly correlated with the evolution of societies and the evolution of technologies.”

Jean-Marie Guéhenno, Thomas Greminger, Enrico Letta


‘Funmi Olonisakin

The uneven distribution of power and technology, including the massive collection of data, tends to favor a few major political powers and giant corporations, though new technologies can also be an equalizing force for good. Troll farms spread disinformation; mobile banking spreads wealth. The distribution of vaccines using the new mRNA technology reinforced terrible inequalities between wealthy and developing countries but saved tens of millions of lives during the COVID-19 pandemic. Guéhenno said he foresees an expansion in the range of possible types of conflicts, but that “multiple types of peace are possible” including a broader consolidation of an imperfect peace that depends on human agency and the decision on whether to use new technologies for good or bad purposes. New regulatory and policy frameworks formed through a cooperative multilateral process also could help to solve problems that no single country or regional bloc can address in isolation.

“The same technologies that were conceived by their inventors as putting society on a more equal footing can literally become drivers of inequality,” he said. “We have added a new dimension to the separation between the haves and the have-nots: the ones who have the technology and the ones who do not have it. Technology has also created a new distance between the two superpowers and the rest of the world. China and the U.S. between them own the vast majority of AI patents.”

The complicated China-U.S. competition largely is “a relationship between technology and peace,” said Shen Dingli, a Professor and former Executive Dean at the Institute of International Studies at Fudan University in Shanghai, where he also formerly directed the Center for American Studies. He said that most people don’t believe that the spread of nuclear weapons technology will make the world more peaceful, and the world must both “seek to deny the spread of sophisticated technology and also to build a peaceful, harmonious way to respect each other’s survival.”

Greminger, a veteran Swiss ambassador and diplomat who has written widely on military history, conflicts, peacekeeping, development and human rights, said current global trends suggest there is much to fear but a look back at the history of predictions shows much of what was feared in the past about the then-future did not occur. “Fear, as the saying goes, is a poor adviser,” said Greminger, who served as Secretary General of the 57-nation Organization for Security and Cooperation in Europe (OSCE) from 2017 to 2020. “There seems to be a cascading number of threats and challenges that are interlinked – what has been described as polycrises. The unprecedented rapidity of technological change, its transformative effects and its existential implications have never been so extreme. At the same time, our ability to understand and, hence, guide technology has never lagged so far behind. And this gap creates uncertainty; it creates even fear.”

That fear has permeated even the highest levels of technology companies. Facebook’s Mark Zuckerberg went from advocating that the technology company “move fast and break things” in the early 2000s to publicly supporting more government regulation in 2018. Elon Musk, Apple co-founder Steve Wozniak and more than 1,000 others in 2023 called for a six-month moratorium on advanced AI after ChatGPT, the chatbot from OpenAI, reached 100 million monthly users in January 2023 just two months after its launch. But the new technology kept racing ahead, amid growing debate and public unease over the global implications of its hugely disruptive potential.

“As with new technologies, the many new unknowns in geopolitics can give rise to fear. Many of the trends are indeed strengthening,” said Greminger. “The deficit in the requisite geopolitical will between superpowers, also the two greatest carbon emitters, to take action commensurate with what would be required to contain global warming to less catastrophic levels. The return of interstate war. The resurgence of the possibility of the use of nuclear weapons. And then conflict-related deaths reaching an eight-year high after breaking a 20-year decline. These fearful trends create fear-driven responses. For eight consecutive years, defense spending globally has increased, with a record-breaking increase last year in Europe of 13%. And unlike with regards to new tech threats in geopolitics, the countertrends are not yet so visible. But there are other trends, so-called weak signals which perhaps deserve more attention and definitely more encouragement.”

One of those positive “signals” – global youth movements advocating for causes such as climate action and against gender discrimination – has dramatically changed global events, he noted. And on a national level, in countries as diverse as Chile and Iran, it has triggered major changes in policies toward long-established social injustices. The use of social media – despite enabling more

surveillance, societal manipulation and undermining of the integrity of electoral processes – has been used as a tool for direct democracy and facilitating grassroots activism. With a smartphone, every person can potentially become a citizen journalist, documentarian, witness or whistleblower.

"Social media has proven an expeditious tool to bring human rights abuses and corruption to public attention – to have real time information on unfolding events and thus be in a better position to influence them," said Greminger. "For example, as climate change intensifies into more extreme weather events, many lives have been saved through AI-enhanced forecasting and digital tools for information dissemination. Furthermore, digital technologies allow peace processes to be far more inclusive. Digital technologies can be used to gather opinions from all stakeholders to a process. This enhances the durability of peacemaking and peace-building processes."

There have been other positive signals on the multilateral front despite multilateralism's diminished effectiveness, in some instances, due to global schisms. Over the past five years, the 193-nation U.N. General Assembly notched some significant normative achievements – including global treaties on migration, refugees, high seas biodiversity and nuclear weapons – while the U.N. Security Council, the world body's most powerful arm, often was stalemated by its five permanent, veto-wielding members: China, France, Russia, the United States and the United Kingdom. Even the 15-nation council, however, recently agreed to deploy a multinational security mission to Haiti, further defying the notion that the rules-based international order set in the 20th century is broken.

"The question we have to ask is not only how global discord paralyzes multilateralism, but also how to build on islands of cooperation? And I think one of the virtues of our project is the focus on the future of peace," Greminger said of the future of peace and war workshops led by GESDA, GCSP and SIPA. "There are quite some projects that focus exclusively on the future of war from a variety of perspectives. But very few people focus on the future of peace and how to achieve it. Indeed, I see a lot of war gaming as if this were some sort of harmless spectator sport. But who is peace gaming? Yes, bad things do happen and bad things will happen. There seems to be a growing trend to resolve issues by force. But many of the things that occur are unexpected. And that brings me to my second point. We need to think about the future with a degree of humility. We cannot predict it. But we can try to anticipate possible scenarios. Therefore, be more humble."

People have a false sense of security if they put too much faith in technology, Greminger said, and must remember they have agency to change the future by design. "The paradox of our time," he said, calling it his third and final point, "is we have better tools than ever to predict and to anticipate the future, but the future has also become less predictable than ever. We can model economic and demographic trends and the impact of climate change with extreme precision. We have more and better informed social and political scientists than at any other point in human history. And yet still, we know little of what will really happen. Ours is an age of systemic uncertainty."

'Funmi Olonisakin, a Vice-President of International, Engagement and Service (IES) at King's College London, said the future of peace and war workshops have also focused on another missing piece of the puzzle: thinking about how people will live in the future. "And by 'future people,' I mean those who would govern the world in 2050," said Olonisakin, who also is a Professor of Security, Leadership and Development in the School of Global Affairs' African Leadership Centre. "Once you frame the question – how you frame the question, whether in the classroom or in policy, in policy or boardrooms – about how the perspectives of people who will govern the future will change, with that future being


Michael Møller


Dingli Shen

2050, more than 25 years from now, then you begin to separate the youth of today and the policies of today from the potential realities of tomorrow."

Building solidarity among people strengthens institutions and can lead toward peace or war, Olonisakin said. "More often than not, because we are so infused in the tyranny of 'now,' we do not look at what needs to be done – in terms of norms and ethics, of brain science and people – that begins to look at solidarity-building towards peace," she said. "The question of peace is what really sits massively at the heart of all of this. But unless, therefore, we begin to look at the gaps in it and the inequities that are generated by technology and by institutions like mine, we're not alone."

Technology will overtake ideology as the most important determining factor in who becomes a future leader, said Møller, a former chairman of the GESDA Diplomacy Forum and veteran U.N. diplomat who served as Director-General of the United Nations Office in Geneva and Secretary-General of the Conference on Disarmament. Science and technology have an enormous potential to increase the geopolitical tensions that we have today, but they also offer tools and opportunities to mitigate these tensions, he said. "The net effect depends on how we, broadly speaking, choose to harness these advancements on the norms and rules that we will establish and the kind of diplomatic efforts that we're going to invest in," he said. "It can go either way, as far as I can see right now."

Conflicts will become far more dangerous, Møller said, if technologies like autonomous weapons evolve beyond our control and remain in the hands of a few – which is why GESDA's anticipatory approach gives diplomats and policymakers "a futuristic compass" to find a way forward. "We have to look at the technological asymmetry, the fact that a big part of our world does not have access and will not have access at the same speed as the other half or other third or whatever the proportion is going to be," he said. "Which, in itself, is a huge vector of potential conflict. Just as inequalities are in the economic and development sphere, the same will happen in the technological sphere."

More information

Explore the 2023 GESDA Science Breakthrough Radar®

Session recording on YouTube

Key messages

- Whether it be the Israel-Hamas war or Russia's assault on Ukraine, the 21st century versions of peace and war are "more complicated than ever" and an anticipatory approach is needed.
- Anticipation does not come without its own challenges: to avoid focusing on present-day concerns, one must look at a multiplicity of trends and countertrends on global topics ranging from climate to migration and their interactions with one another.
- During two high-level workshops in Geneva and New York in 2023, GESDA, SIPA and the GCSP convened experts who focused on a systematic two-axis approach to anticipation: a vertical axis for the continuum between war and peace, and a secondary axis for the impact of science and technology on societies from enhancing to disrupting the distribution of power.
- Despite rising threats from technology, there are some positive signals which deserve more attention and encouragement, such as global youth movements advocating for causes such as climate action and against gender discrimination, which, in some countries has triggered major changes in policies toward long-established social injustices.
- Thinking about the future of peace and war also requires thinking about how people will live in the future and who will govern the world in 2050, allowing us to separate the youth of today and the policies of tomorrow from the potential realities of tomorrow.
- Conflicts are likely to become far more dangerous if technologies like autonomous weapons evolve beyond our control and remain in the hands of a few, which is why GESDA's anticipatory approach gives diplomats and policymakers "a futuristic compass" to find a way forward.

Wednesday 11 October, 15.30–16:15 CET

Anticipatory Briefing

Living Beyond 100

Vera Gorbunova

Living Beyond 100

From reversing the effects of aging on the brain and editing genes to prevent disease to artificial intelligence and downloading thoughts and memories, science is pushing the boundaries of the human lifespan. Join this anticipatory briefing to hear about the latest advances in longevity research and the opportunities and challenges it presents over the next 5, 10 and 25 years.

Speakers

Moderated by:

Laurent Haug, Founder, 200ideas, Switzerland

With:

Vera Gorbunova, Professor, University of Rochester, USA

Summary

Nearly half a millennium ago, German painter Lucas Cranach the Elder completed his famous portrayal of a mythical spring, Der Jungbrunnen, or The Fountain of Youth, that makes people young again if they drink from or bathe in its waters. In past centuries, the legend captured in the oil painting from 1546 may have inspired explorers to search for magical waters that could restore youth. Today, the universal yearning for rejuvenation inspires scientists to seek evidence-based remedies for aging.

One of those scientists, well-known geroscientist Vera Gorbunova, has spent decades learning why creatures ranging from bats to whales and particularly the naked mole rat have some built-in protections against cancer and other common ailments of aging. Her research looks at one of the biggest and most basic mysteries of biology: Why do we age?

"This is a topic that interests and touches everyone and people have been fascinated with it for centuries," she said, pointing to an image of the oil painting. "The painting shows old people entering the healing waters from one side, and then emerging from the other side rejuvenated. So, that's what we all would like to do. We are also searching for the Fountain of Youth, but we are using science for that."

Most chronic ailments are diseases of aging for geroscience to study, according to Gorbunova, the Doris Johns Cherry Professor of Biology at New York's University of Rochester and co-director of its Rochester Aging Research Center and the Gorbunova and Seluanov Laboratory with her husband, Andrei Seluanov, a Professor of Biology and Medicine.

Their research teams focus on the mechanisms of longevity and genome stability in exceptionally healthy, long-lived mammals. Aging, the biggest risk factor behind morbidity and mortality, is associated with an accumulation of mutations and genomic instability.

"If we learn how to slow down aging, we can potentially prevent or delay all of these diseases," she said.

Age-related changes in the repair of double-strand DNA breaks are common with eukaryotic cells. In their study of human cells and transgenic mice, the research teams have taken a comparative approach to long-lived and short-lived species. Since aging is linked to increased cancer incidence, they've also examined DNA repair in breast cancer cells and anti-cancer mechanisms in long- and short-lived rodents.

Until recently, their research yielded few solutions to chronic "diseases of aging" such as cardiovascular diseases, most cancers, and neurodegenerative and metabolic syndromes. Increasingly, though, their findings have been supporting the conclusion that aging isn't simply a natural process of life but one that can be treated as a risk factor for disease.

In earlier studies, they discovered that the naked mole rats have as much as 10 times the amount of high molecular weight hyaluronic acid, or HMW-HA, in their bodies as what's found in humans and mice. HMW-HA contributes to longevity and cancer resistance.

In a recent study published in Nature, the team led by Gorbunova and Seluanov reported that the positive effects of HMW-HA can be reproduced in other animals. They effectively transferred the gene that's responsible for making it from rats to mice to extend their life span and potentially ward off cancer. Next, they hope to transfer it to people.

"I'm often asked about our naked mole rats that live to age 40. They say, 'What do they die of?' Well, we actually don't know. Because in our colony, they almost never die of old age. Well, we haven't kept the colony for 40 years. We have very few old individuals, and mostly they die because they fight with each other for dominance, because they live in a small society of sorts. So yeah, that's a very difficult question to answer."

Their work on preventing age-associated diseases makes an important distinction between life span, the time between birth and death, and health span, the time we remain healthy and active. But the goal isn't simply to extend our lives for as long as possible. "We want to make people healthy for as long as possible," she said. "This the primary objective."

Health span extension is featured in the GESDA 2023 Science Breakthrough Radar® with insights from Gorbunova and Brian Kennedy, a Distinguished Professor in Biochemistry and Physiology at the Yong Loo Lin School of Medicine at National University Singapore. They noted that future breakthroughs are likely to rely on highly interdisciplinary research.

Aging research can become the ultimate preventative medicine, Gorbunova said, because if aging is the cause of multiple diseases, then "we have to treat the cause, not the consequence, which is what currently most medicine, medical applications are doing. You treat individual diseases, one by one, while aging is actually what caused them."

Just how long could people live? Gorbunova said she can envision it becoming more common for people to live to between 100 and 120 years old in the next quarter century. Most record-keepers have agreed that Jeanne Louise Calment, a French woman, is the only person ever verified to have lived past the age of 120. She died in 1997 at the age of 122. The second oldest, Kane Tanaka, a Japanese woman, died in 2022 at the age of 119. The third oldest, Sarah Knauss, an American woman, died in 1999 at the age of 119.

Their good genes not only helped them to live an unusually long time but also to stay healthy, active and independent for most of their lives.

"That's how we would like people to age," Gorbunova said. "Is it possible to achieve? Science has been developing very rapidly in the aging field. While, if you take, maybe 20 years ago, people thought that you cannot manipulate aging, aging is just something that happens and it cannot be changed – one of the greatest advances happened when it was demonstrated that we can extend life spans of model organisms in the laboratory."

She pointed to a picture of a worm, the nematode *C. elegans*, which usually only survives for about 20 to 30 days. "First, people managed to extend their life span by about twofold, threefold, and then almost tenfold," she said. "It was possible to genetically manipulate the worm so it survives to 100 days. So, now it means aging can be manipulated."

Fruit flies are a bit more complicated than the worms, but by using similar genetic manipulation it's been possible to double the fruit flies' life span. Researchers haven't yet been able to double the life span of more complex creatures, like a mouse.

"But we could make them live about 30% longer, which would, for a human being, mean living to an average 120 to 130, that would be quite amazing," said Gorbunova. Importantly, some manipulations they've done in the lab have not only lengthened lives – they helped lab organisms stay healthy for much longer.

Artificial intelligence also is being used to develop aging biomarkers that can help assess age-related and physiological changes, and to anticipate the onset of pathogens.

"With humans, it's more complicated, because if we want to develop interventions that improve human health span and life span, it just takes a very long time," she said.

By looking at biomarkers such as DNA methylation, metabolites, blood chemistry and facial features, researchers have been able to build a "clock" for personal aging. "This way you can take a blood sample from a person and based on DNA and this blood sample, or even on facial features of a person, predict biological age," Gorbunova said. "And you are able to tell how fast this individual is aging. So, this biomarker is really very powerful."

Her lab looks at healthy, long-lived animals with life spans ranging from 2 years for shrews to 40 years for bats and naked mole rats to 200 years for bowhead whales. People may benefit from a better understanding of particular genes or what she called the "mechanism" behind those numbers. The tiny bat has a high tolerance for diseases and deadly viruses, while the naked mole rat almost never develops cancer or gets cardiovascular disease.

Bowhead whales have high levels of two proteins similar to those found in people. One is "an evolutionary adaptation" that improves the repair of DNA in this extraordinarily long-lived marine mammal and performs similarly when transferred to human cells, she said.

Next it will be tried in mice to see if it helps them to live longer and healthier. Aging is a process where many things go wrong, Gorbunova said, and it may be driven by an accumulation of DNA mutations that could be rectified through a solution comparable to tidying up a dresser full of clothes.

"You can kind of take the sock drawer, throw everything out and then fold it back. The same strategy was then later applied to aging," she said. "Because if you can turn back the time and turn adult cells into embryo cells, maybe you can do it

just enough – not all the way, because we don't want to turn into embryos. We just want to rejuvenate our tissues slightly. And it was shown in mice that you can actually do that."

Another exciting area of study is a molecule derived from a brown seaweed that's a common food in Japan and South Korea, both nations with long life expectancies. When fed to mice, the seaweed supplement made them stronger and slowed their aging. "So right now, we are planning for a clinical trial of the same compound in humans," she said.

Over the next five years, Gorbunova said she expects an "explosion in the area of basic research on longevity and understanding the drivers of aging at a molecular level." Within 10 years, she said, aging will be understood as a disease process and it will be possible to slow down aging using cell and gene therapy. A portfolio of pharmacological interventions will be tested in clinical trials, she said, and anti-aging medicine will become routine.

Within 25 years anti-aging strategies will be personalized, she said, through supplements and therapies that may include gene therapy. "It will also be possible perhaps to not only slow down the aging but maybe even to reverse some of the effects," she forecasted.

Researchers have focused on ways of extending our health span not only because no one wants to live for a long time and be sick but also because the solutions could ease the societal and economic burdens on governments' health and social security systems.

"Life span and, most importantly, health span will be extended so people could remain active for much longer," said Gorbunova. "People would not have to retire because they're just disabled and cannot work. People will work and remain active for much longer. And age-related diseases will be either delayed or eliminated."

More information

Explore the 2023 GESDA Science Breakthrough Radar®

Session recording on YouTube

Key messages

- Recent research challenges the notion that aging is an inevitable natural process and instead suggests that it can be treated as a risk factor for diseases.
- By studying species that exhibit longevity, such as the naked mole rat, scientists can better understand and slow down the aging process, which could prevent or delay various chronic diseases associated with aging.
- Naked mole rats have significantly higher levels of hyaluronic acid, which is associated with longevity and cancer resistance. Transferring the gene responsible for producing hyaluronic acid into mice extended the mouse's life span. Researchers are exploring similar interventions for humans.
- Biomarkers, such as DNA methylation, metabolites, blood chemistry and facial features, are being used to develop a "clock" for personal aging. Artificial intelligence can be used to analyze these biomarkers and predict age-related physiological changes.
- Significant advancements in basic longevity research are expected in the next five years, understanding aging as a disease process within ten years and the routine use of anti-aging medicine within 25 years.
- Personalized anti-aging strategies, including supplements, therapies, and gene therapy, could potentially reverse some aging effects, extending both life span and health span, thus alleviating the societal and economic burdens related to an aging society.

Wednesday 11 October, 15.45 - 16.45 CET

Interactive Discussion

Keeping Check on Earth's Vital Signs

Anousheh Ansari, Lars Peter Riishojgaard, Dominic Waughray

Keeping Check on Earth's Vital Signs

Speakers

Moderated by:

Anousheh Ansari, CEO, XPRIZE Foundation, USA

With:

Lars Peter Riishøjgaard, Director, Global Greenhouse Gas Watch, World Meteorological Organization, Switzerland

Johan Rockström, Director, Potsdam Institute for Climate Impact Research, Germany (virtual)

Dominic Waughray, Executive Vice President, Imperatives, World Business Council for Sustainable Development, Switzerland

Summary

Weather forecasters accurately predicted Hurricane Katrina three days before it slammed into New Orleans in August 2005, but it still became the costliest hurricane ever to hit the United States, causing 1,833 deaths and US$108 billion in damage. The same thing happened in Europe in August 2002. Weather forecasters predicted extreme rain in a Europe-wide flood alert four days ahead of time, but the flooding still caused 232 deaths and €27.7 billion in damage, particularly in Germany.

Both of these efforts by scientists to warn people against the risks of extreme weather provide "examples of when and how it fails" even among some of the richest and most powerful developed countries, said geophysicist Lars Peter Riishøjgaard, the Director of the World Meteorological Organization's Global Greenhouse Gas Watch, a new monitoring initiative launched in 2023 to reduce heat-trapping gases that fuel temperature increase. "You can take these case stories and then you can extrapolate them to the developing countries, and everything is normally worse there."

Two decades later, the disasters still offer lessons to be learned. "It was basically uncoordinated decision-making. The left hand did not know what the right hand was doing," said Riishøjgaard. In Germany's case, rainfall is a meteorological phenomenon, and the weather forecasting is a federal responsibility. But hydrology, or what happens to water once it's on the ground, is a responsibility of the Bundesländer, Germany's 16 states, and "many of the mayors apparently did not know this," he said. "There was a lack of communication across the different levels of the government."

These cases illustrate two ways the system is failing: People aren't persuaded to heed the forecasts and nations aren't prepared for or mitigating the climate crisis. Part of the problem, Riishøjgaard said, is people are becoming jaded when they learn of yet another predicted weather event that's only supposed to occur on average twice in a millennium. "If you read the press, you will see that almost every week there's a 500-year event somewhere on the planet. It probably means that they are no longer 500-year events," he said. "In other words, the climate is changing rapidly, and it is changing rapidly in ways that we don't predict and we don't manage particularly well."

Modeling of feedbacks in and interactions between Earth systems are two of the eco-regeneration and geoengineering topics featured in the GESDA 2023 Science Breakthrough Radar® which anticipates that researchers' use of high-resolution modeling and exascale computing will enable scientists to improve predictions about the biosphere and cryosphere over the next quarter century.

At the U.S. government's observatory 3,396 meters up the northern flank of Mauna Loa, scientists track atmospheric concentrations of carbon dioxide, methane and other greenhouse gases. Charles David Keeling, a climatologist, pioneered the measurement of CO2 in the atmosphere when he installed an experimental manometer on Hawaii's Big Island volcano in 1958. He chose the site, now part of a global network, because the trade winds that blew over it had some of the cleanest air on the planet. His Keeling Curve, the longest running such measurement in the world, provides an eye-opening look at atmospheric CO2 concentrations ticking upward over more than six decades.

"It is 60 years' worth of slowly accelerating rapid growth of CO2 concentrations in the atmosphere. This goes from 320 parts per million to 420 parts per million of CO2 in the atmosphere. For most of the last couple of million years, that number was 280 parts per million. And for the entire human history, up until around 1850, that's where we were," Riishøjgaard said. "Now we are on a very rapid rise, something that is unprecedented over the last 2-3 million years of the history of Earth."

Scientists aren't entirely sure precisely what happens to all of that CO2 when it is absorbed by the ocean,


Johan Rockström

land and atmosphere, he said. “What does that mean for the future? One analogy that I like to think of is that this is the equivalent of trying to drive a car down a road at a fairly high speed while looking only out of the rear window. You don’t have any visibility out of the windshield. You don’t even see anything to the side. This could work reasonably well if the road is straight or curving very slowly and you’re not driving too fast. But that’s not the situation we’re in here. We are driving very, very rapidly and we have no idea what the road ahead looks like.”

WMO’s Global Greenhouse Gas Watch was created to solve that problem by arming negotiators at the U.N. climate summits with sustained, routine global monitoring of the concentrations and fluxes in carbon dioxide, methane and the other main global warming gases. “This is information that we do not have available today. And I won’t guarantee that it will compel parties to take action, because this is painful,” Riishøjgaard said. “Let’s be honest, this is not an easy problem, but we are going to present them with information in real time in a geographically disaggregated way so that they can see exactly why this curve looks the way it does, and hopefully start beating it downwards.”

The panel’s moderator, Anousheh Ansari, CEO of the XPRIZE Foundation, said she has three active competitions to find better ways of dealing with the climate crisis. One has 1,300 teams looking to find ways of removing CO2 from the atmosphere at the gigaton level. The second one focuses on reducing emissions through alternative protein production. The third approaches wildfires both as a byproduct of climate change and a source of emissions. “We have solutions that are hopefully coming along,” she said, “but we need to support a solution and implement some.”

Finding support for climate solutions in the private sector involves navigating the complexities of a world that’s vastly different than it was when the Paris Agreement was adopted eight years ago, according to Dominic Waughray, Executive Vice President of the World Business Council for Sustainable Development (WBCSD) in Geneva. “We have more of a fracturing now in terms of our international relations. We have less of a sense of liberalization and common borders, and we have more of a competing trade zone. We have a different geopolitical system within which to operate.”

He said large companies working to incorporate sustainable goals into their financial plans can use prototype science-based targets for nature but must first build up transition plans, end-to-end value chains for accounting or disclosure mixes. “The build of this has to happen super quickly, super smartly, and at the same time as that science is taking shape,” Waughray said. “We’re not there yet, but it’s starting to happen because all of these pieces are coming together, slowly, to click in.”

Asked by an audience member if he’s seen any backlash when companies exaggerate their own sustainability, Waughray said instead of so-called greenwashing he’s seen a rise in “greenhushing,” when companies downplay their sustainability out of fear it will make them look less competent.

“The challenge is how can we actually crosswalk between what the science is now telling us – to get business friendly data and plug it into that target-setting, transition-planning, accounting and disclosure system?” he said. “That’s our combined task over the next several months: to create these corporate performance and accountability systems that will fundamentally create the foundation for millions of companies to be able to go on this journey, which the science is telling us to go on.”

In 3 million years, our planet has never been 2° Celsius warmer than it was during pre-industrial times but it’s already 1.2° warmer and it’s headed to 2.7° warmer by 2100 which is “unequivocally a path to disaster,” according to Johan Rockström, Director of the Potsdam Institute for Climate Impact Research, Professor at the Institute of Earth and Environmental Science at Potsdam University, and Professor in Water Systems and Global Sustainability at Stockholm University.

“Both human but also ecological systems are simply not able to cope, because we are having a hundred times faster change than anything that we’ve experienced geologically and this is just too fast for adaptation,” he said. The 196 nations that signed onto the legally binding 2015 Paris Agreement – which entered into force in November 2016 – committed to hold warming to no more than 2° above the average temperature for the 1850–1900 period, or preferably no more than 1.5°.

“The remaining global carbon budget for a safe landing to hold to 1.5° of warming is only 250 gigatons of carbon dioxide. That is six years of emissions today,” Rockström said. “So, we’ve entered a decisive decade and we know that we need to

have cut global emissions by half by 2030 and to net zero by 2050 to have any chance of a safe landing."

Two decades ago, Rockström, as founding Director of the Stockholm Resilience Center at Stockholm University, led a team of scientists that identified a set of nine planetary boundaries within which humanity can continue to develop and thrive for generations to come. The center published the Planetary Boundaries Framework in 2009 and has since updated it.

In September 2023, just ahead of the third annual GESDA Summit, Rockström and a team of scientists for the first time quantified all nine processes that regulate Earth's stability and resilience and concluded that six boundaries have been transgressed. For instance, critical biomes such as the Amazon rainforest are degraded. The Amazon now releases more carbon that it absorbs, Rockström said, in a dramatic early warning signal that "we are in the deep red on the resilience of the planet."

The nine quantitative boundaries represent a dashboard for planetary stewardship. Rockström compared Earth to a patient with multiple organ failures who only gets their body temperature checked. "We need to go to the doctor every year and we need to measure all the organs, the living organs and the non-living organs, the climate system and the biosphere," he said. "The key priority now, in my view, is to start phasing out coal, oil and gas in a way that follows the pathway defined by science."

Meantime, heat waves, heavy precipitation and other extreme weather have become the new normal because the absorption of emissions into the biosphere "is not something that the planet does gently and harmoniously; it's a stress response to our energy imbalance," he said. Keeping a closer check on Earth's vital signs will be essential to be able to both deal with and reduce that stress response.

"This is why we need a planetary boundary framework, because it means that the only way to have a livable, stable planet for future generations is that we not only phase out fossil fuels but we also have the energy transition we need to keep within safe boundaries on biodiversity, on land, on fresh water, on nitrogen, on phosphorus, on aerosols, and our air pollutants and our chemicals."

More information

Explore the 2023 GESDA Science Breakthrough Radar®

Session recording on YouTube

Key messages

- Despite accurate predictions, events like Hurricane Katrina and European floods in 2002 and 2005 respectively, demonstrate failures in persuading people to heed forecasts and in coordinated decision-making and preparation by nations, even in developed countries.
- Over the past 60 years, CO2 concentrations in the atmosphere have rapidly increased from 320 to 420 parts per million, an unprecedented rise over the last 2-3 million years. Scientists face challenges in understanding the fate of CO2 absorbed by the ocean, land, and atmosphere, highlighting the urgent need for real-time global monitoring.
- The World Meteorological Organization's Global Greenhouse Gas Watch, initiated in 2023, aims to provide sustained, routine monitoring of CO2, methane, and other greenhouse gases globally. This information is intended to empower negotiators at U.N. climate summits and compel parties to take action against climate change.
- Private sector involvement in climate solutions requires navigating a geopolitical environment that is much more fractured than when the Paris Agreement was made in 2015. Large companies working to incorporate sustainable goals into their financial plans can use prototype science-based targets for nature but must first build up transition plans, end-to-end value chains for accounting or disclosure mixes.
- Earth's stability and resilience are quantified through a planetary boundaries framework. Of the nine identified boundaries, six have been transgressed, indicating critical degradation, such as the Amazon rainforest releasing more carbon than it absorbs. A global shift to net-zero emissions by 2050 is needed to avoid catastrophic consequences.

Wednesday 11 October, 16.30 - 17.15 CET

Anticipatory Briefing

Computing with Living Matter

Ángel Goñi-Moreno

Computing with Living Matter

Optimized by billions of years of evolution, biological computers could allow us to respond to challenges such as environmental remediation, drug discovery, the production of novel materials and medical diagnosis. Join this anticipatory briefing to hear about the latest advances in biocomputing and the opportunities and challenges this presents over the next 5, 10 and 25 years.

Speakers

Moderated by:

Laurent Haug, Founder, 200ideas, Switzerland

With:

Ángel Goñi-Moreno, Researcher, Center for Plant Biotechnology and Genomics, Spain

Summary

The prospect of biological computers – processors made of living matter that can carry out complex computations – isn't as far-fetched as it might seem at first glance. That's because information flows in all living systems, according to Ángel Goñi-Moreno, who is Head of the Biocomputation Lab at the Technical University of Madrid.

Goñi-Moreno, a computer engineer and researcher who studies synthetic biology, biocomputation and DNA computing to design biological computers, said he had come to GESDA to give "a computing talk, just a little bit from an unconventional angle." And since people's understanding of what a computer is has remained fairly constant since the mid-20th century, he explained, "let's try to change that, let's try to move on. There is an opportunity to do so by using not microchip technologies but living matter, DNA, genes, regulators, proteins, living cells, and so on, in order to build computational devices."

Unconventional computing is featured in the GESDA 2023 Science Breakthrough Radar® with insights from Goñi-Moreno; Johannes Schemmel, Head of ASIC Laboratory and the Electronic Vision(s) Group at Heidelberg University; Lena Smirnova, Assistant Professor at Johns Hopkins University and President of the International MPS Society; and Charles Roques-Carmes, a Science Fellow at Stanford University and Visiting Scientist at MIT.

They noted that renewed interest in alternative computing technologies has been driven by a growing appreciation that information processing is a fundamental part of many natural processes, and that clever engineering can help harness these living processes for use in everything from logistics and smart materials to new kinds of artificial intelligence.

The idea of what a computer is revolves around Alan Turing, an English mathematician, logician and cryptographer responsible for breaking the Nazi Enigma code during World War II. That work helped the Allies win the war in Europe and led to the creation of a computer – a "Turing machine" – that still defines our thinking, according to Goñi-Moreno.

"A Turing machine is quite easy. It has a tape with information, with data on it, a head that reads right and moves along the head according to some set of instructions and set of rules. Those are the three items of a Turing machine," he said. "That's our current understanding of computation, that of a Turing machine: If you cannot solve a problem with a Turing machine, that computer won't be able to solve it."

When we look at a living cell, the bacteria inside contain information taken from both the environment and the cell. Compared to a computer, bacteria hold even more information and processing power because the "DNA has a lot of information encoded in it," according to Goñi-Moreno. "You see rules and instructions on how proteins bind the DNA and read the different genes: transcription, translation. Those have rules. Those are instructions that are taking information at input and delivering some of the information at the output."

People's understanding of living systems comes from a computing point of view when post-war electronic engineers made technological tools to build computers that could physically implement what the theoretical model of computation was trying to represent, said Goñi-Moreno, but a computer can never be as powerful as a Turing machine which needs an infinite tape that's impossible to build physically. "Physical implementations are just approximations to what computing machines can do," he said. "The starting point of biocomputing and the starting point of my laboratory is that, okay, we are going to physically build a model of computations, these theoretical mathematical abstractions, but we are not going to use microchips, energy and electricity and all that stuff. We are going to use living technology and genes and genetic networks and living cells."

Ángel Goñi-Moreno

Biological computers may not replace the microchips found in everyday devices like laptops and smartphones, but they could help design new logistics solutions, smart materials and intelligent machines that run on small amounts of energy. "In biology there are plenty of different tools that have evolved through the millions of years in order to process information," he said. "We can edit metabolism in a way that didn't exist before. And at the end of the day, what we have is bacteria with some additions in it, what we call a program. That is going to turn bacteria into a functional piece of a device that didn't actually sit in nature before and it's going to perform the computation that we are after."

Unlike a conventional computer, a programmed cell will divide and grow and copy itself – even evolve. "That machine is not going to evolve. It's not going to adapt to new scenarios, new environments. A cellular computer can, of course, evolve. In fact, it will evolve whether you want it or not. That's another challenge," said Goñi-Moreno. "How to deal with evolution and try to control evolution for the sake of implementing computing machines."

Asked if biological computers might somehow be able to usurp control from humans, Goñi-Moreno said he's "never seen a biological program going to perform a different function than the one it was designed for. I've never seen that. What I have seen a thousand times is the cell just not responding at all. They get the program that you put in but it's just not responding. And if I had to imagine what would happen if you released those cells into the wild, I would say the most probable thing to happen is the cells will die immediately."

His lab tends to see evolution as a computing process that takes a living system as an input; an algorithm that tries to solve a problem. "The problem is solved by being in an environment, and that algorithm goes through mutations, selections and so on, and finally arrives at a solution," he said. "That's the output, and that's a living system that has adapted to life properly in that environment. The solution doesn't have to be always the same. You see four different solutions for that same type of evolutionary algorithm, evolutionary program, and evolution is actually a very, very powerful tool living systems have. That's something that we are trying to control for the sake of building these cellular computers."

In the Radar, the future of cellular computing holds great potential. In the next five years, parts and processes are likely to be standardized. Within a decade, researchers probably will establish ways to harness a cell's metabolism to perform computations that could be applied to pollution remediation, disease diagnosis and atmospheric sensing. On the 25-year horizon, biocomputing is seen as creating a new, post-Boolean set of logic operations and design tools for information processing that combine with quantum biology research.

With more regulatory progress around the world, the Radar found, governments could let synthetic microbes be programmed to bring relief to stressed environments and restore balance in ecosystems full of bacteria. “It’s a completely new paradigm of computing,” said Goñi-Moreno, who believes the promise of a “cellular supremacy” – using cellular computing to target a domain of applications that conventional computers cannot attack – will be demonstrated in the future similar to the talk of a looming “quantum supremacy” with quantum computing. “Now we can routinely write, edit and program living systems. If an ecosystem is collapsing, there is a potential challenge here in order to restore the balance of the ecosystem by providing the bacteria that end in that bottom layer.”

Improving ecosystems through this means relies on “decision problems” that are at the core of computing. “Here the problem is: Is the environment okay for the plants to grow?” he said. “Our cellular computers are monitoring that question and are going to give an answer. If the environment is okay, the plants are going to grow. Happy. If the plants, if the environment is not okay for the plants to grow, because it’s full of pollutants and so on, our cellular computers are going to say, okay, the environment is not correct. And the output of this algorithm is to restore the balance so that the plants are happy again growing in that environment. So that’s the type of applications that conventional computers cannot do.”

More information

Explore the 2023 GESDA Science Breakthrough Radar®

Session recording on YouTube

Key messages

- Our understanding of what a computer is has remained largely unchanged since the mid-20th century, but new tools are giving rise to alternative, or unconventional computing technologies such as biological computing.
- Information processing is a fundamental part of many natural processes, and clever engineering using synthetic biology can help to harness these abilities for use. For example, bacteria hold even more information and processing power compared to a computer because the DNA has a lot of information encoded in it already.
- Biological computers may not replace the microchips found in everyday devices like laptops and smartphones, but they could help design new logistics solutions, smart materials and intelligent machines that run on small amounts of energy and are also capable of evolving and adapting to their environment.
- In the next five years, parts and processes of cellular computing are likely to be standardized. Within a decade, researchers probably will establish ways to harness a cell’s metabolism to perform computations that could be applied to pollution remediation, disease diagnosis and atmospheric sensing. On the 25-year horizon, biocomputing is seen as creating a new, post-Boolean set of logic operations and design tools for information processing that combine with quantum biology research.

Wednesday 11 October, 17.15 - 18.15

Interactive Discussion

Investing in Emerging Science

Meret Gaugler, Julia Angeles, William Egbe, Henrietta Fore, Nicolas Roelofs, Ian Walmsley

Investing in Emerging Science

The emergence and impact of scientific breakthroughs are not only steered by academic or political interests but also follow the economic logic of market forces. Join this interactive session to learn which emerging topics mapped in the GESDA Science Breakthrough Radarâ are likely going to be driven by an investment perspective – and which ones are not.

Speakers

Moderated by:

Meret Gaugler, Healthcare Investor and Advisor, Switzerland

With:

Julia Angeles, Investment Manager and Partner, Baillie Gifford, United Kingdom

William Egbe, Managing Partner, Vibranium Capital Group, Cameroon

Henrietta Fore, Former Executive Director, UNICEF; Chairperson and CEO, Holsman International, USA; GESDA Board Member

Nicolas Roelofs, Investment Director, Summa Equity, Sweden

Ian Walmsley, Provost, Imperial College London, United Kingdom

Summary

The world pledged to substantially raise investment in R&D and bolster research capacity as part of the U.N.'s 17 Sustainable Development Goals (SDGs) for 2030. One of GESDA's top priorities is to boost investment in emerging science and technologies that serve the SDGs, which are only 15% on track due to multiple factors. But scientific and technological breakthroughs do not only flow from academic and political interests; market forces and sometimes philanthropies play a major role.

Global spending on R&D has edged upward to around 1.8% of GDP but the figures break down along the usual fault lines of wealth and geography: in the United States, Europe and Southeast Asia they are above 2%. In a few countries like Germany and Japan, they are over 3%.

Countries have an average of 1,350 researchers per million inhabitants but in North America that figure is 4,400 and in Germany and Japan it's over 5,000. China and Russia, by comparison, have 1,300 and 2,780, respectively, according to UNESCO figures.

The emerging topics mapped out in the GESDA 2023 Science Breakthrough Radar® that are most likely to be driven by an investment perspective are in sectors that are "heavily focused on driving technology to improve commodities or consumer goods where they can sell at good margins," said William Egbe, Managing Partner at Vibranium Capital Group, former President of Coca-Cola in Sub-Saharan Africa and Southern Africa and former Chairman of the Coca-Cola Africa Foundation.

Egbe pointed to eco-regeneration and geoengineering, which is featured in the Radar, as "a top area where there's a lot of leverage in some of the breakthroughs" ranging from decarbonization and Earth systems modeling to future food systems and space resources. One of the prime areas is the future of education, he said, which the Radar forecasts will bring breakthrough advances in learning analytics, educational sensing, out-of-school learning and neuroscientific aspects of learning.

Science and diplomacy are other areas where the expected advances will "help build more robust democracies in Africa and in Latin America," Egbe said, emphasizing the important role particularly of emerging science "that can transform lives today very quickly, even with very little breakthroughs. Just by transferring some of the knowledge and expertise, you could really accelerate the reduction of poverty, of loss of life, just by scaling up the health care system."

The Radar's anticipated breakthroughs affecting education, finance and agriculture that improve people's daily lives are areas that could draw more investment, according to GESDA Board Member Henrietta Fore, Chairperson and CEO of Holsman International, former Executive Director of UNICEF and former Administrator of the U.S. Agency for International Development, or USAID.

"I look at the things that save energy, that are inexpensive, that can be done at room temperature that last longer. All of these. It has to do with materials science, membranes that allow blood to be deoxygenated, yet you could hold it longer rather


Nick Roelofs


Meret Gaugler

than having us throw out blood after six weeks. It just goes on and on. Health, I think, is one of the most important," said Fore.

Geneva's financial hub could facilitate more public-private support for topics in the Radar, which serves as "a treasure for all of us to put public and private initiative behind areas that can work for the betterment of the world," she said. "GESDA is made for great partnerships and that brokering, that connection is the secret sauce for moving these wonderful breakthroughs out into the world."

Many of the most impactful topics "actually have very deep roots in old ideas," said Ian Walmsley, the Provost of Imperial College London where he is also the Chair of Experimental Physics. During a lecture at MIT Computer Science and Artificial Intelligence Laboratory in 1982, for instance, physicist Richard Feynman proposed using quantum mechanics to make calculations that were impossible with classical computers. His idea led to quantum computing.


Ian Walmsley

Also that year, physicist John Hopfield constructed a spin glass system and recurrent artificial neural network, a form of artificial intelligence based on a model created by Wilhelm Lenz and Ernst Ising. The Hopfield network of nodes connected by links can store and use memory to make decisions and solve problems, helping computers process complex information intelligently.

Walmsley said research, skills and training development, and innovation all generate revenue in "an ideas ecosystem," but first a critical mass of collaboration, competition and resources is needed to provide "the energy to drive that system." It's also important to support ideas that have "some immediacy for impact," he said, because the chance of success is small "but if you have enough of them, the probability that some number will be successful is high. And that's where we need to be."

It takes a lot of creativity and imagination – and quite a bit of research – to find suitable long-term investments, said Julia Angeles, an economist who is a Partner and Portfolio Manager specialized in health care innovation at investment management firm Baillie Gifford. "Serendipity favors prepared minds," she said. "We prepare our minds by talking to academia, by building those relationships."

Angeles said her firm invests in emerging science by building scenarios about possible discoveries over the next two decades, then calculating what will need to happen for them to materialize and what companies might be able to use them to drive change. "You start top-down, you take a real science fiction view almost to the future, and then you try to bring it to the reality and try to think about what actually de-risking stages towards that kind of science fiction future are," she said. "We know that science fiction very often becomes a reality, and that's what we are investing in."

Some companies and universities "can't get enough funding because they're redundant," said Nicolas

Roelofs, an organic chemist and veteran life sciences and diagnostics industry executive who is a Partner at investment firm Summa Equity. “The free flow of money has created a lot of zombie companies that are now out there in the marketplace that the funding has been forced to rationalize and those companies may not survive well. That’s a problem we’re seeing, because as an investor I certainly want to bring a new technology to market,” he said. “If it’s too diffused across too many companies, they may all fail. If it is a complete redundancy, I guarantee many will fail.”

That happened often during the COVID-19 pandemic, he added, and it wasted “hundreds of millions of dollars that could have gone somewhere else.” The panel’s moderator, Meret Gaugler, a neuroscientist who serves on the Investment Committee of the ETH Foundation in Zurich, recalled a similar situation in which others’ projects appeared to lack a legitimate “real-world use case” but had the backing of a major company, nonetheless. “It’s the blind leading the blind,” she said.

Several years ago, Roelefs said, the “multi-omics” approach to research on human health and disease became “a super-hot idea.” Multi-omics incorporates several “-omics” data types taken from research areas such as genomics, epigenomics, transcriptomics, proteomics and metabolomics. Several multi-omics companies won a lot of funding and went public in the U.S. even though their technologies were “highly unlikely to become fundamental tools in drug discovery or fundamental tools in diagnostic,” he said. The companies’ valuations rose to an aggregate US$15 billion before collapsing to a few hundred million just two years later, providing what Roelefs cited as an example of how “money went in chasing a technology that didn’t really have a yet proven application.”

Angeles, however, said projects that initially seem unjustified can turn out later to be extremely valuable. She pointed to the revolutionary Human Genome Project, which the biomedical research community initially viewed with deep skepticism. “Sometimes what seems redundant and useless at this stage – if we give it enough time – can actually prove very valuable,” she said.


Henrietta Fore

Roelofs agreed that “we shouldn’t condemn things until we understand the output” but said it’s still a legitimate question to ask about “the exuberant funding that we’ve seen in the last few years” flowing into private companies. He said the key is the company’s intellectual property. “If there’s no IP, then you have no company to start with,” said Roelofs. “Investors understand IP is valuable.”


William Egbe


Julia Angeles

More information

Explore the 2023 GESDA Science Breakthrough Radar®

Session recording on YouTube

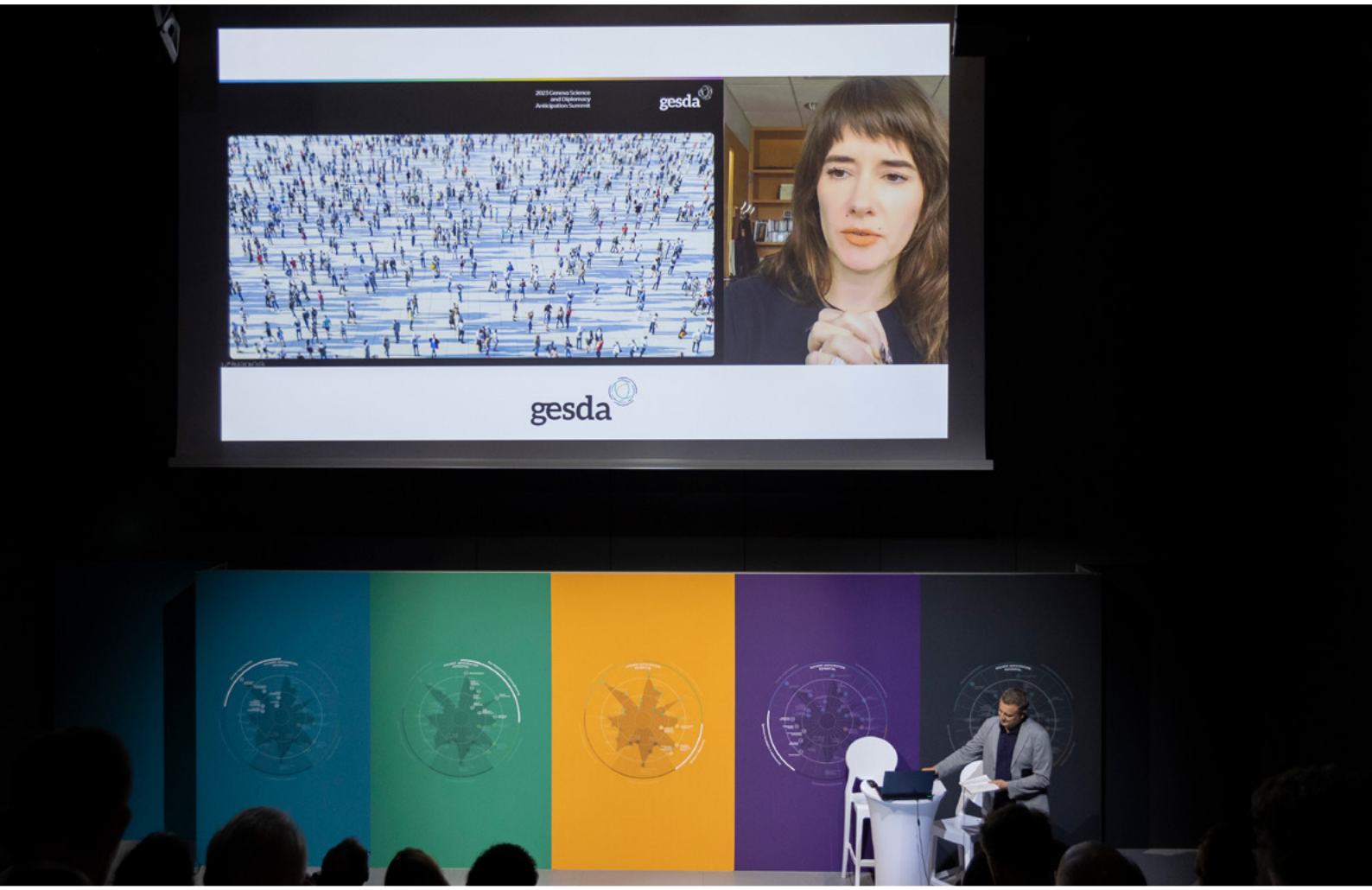
Key messages

- The world pledged to substantially raise investment in R&D and bolster research capacity as part of the U.N.'s 17 Sustainable Development Goals (SDGs) for 2030 yet only 15% of them are on track for completion.
- Both global spending on R&D and research capacity vary wildly between countries, with some such as Germany and Japan investing over 3% of their GDP in R&D and having more than 4,400 and 5,000 researchers per million inhabitants respectively.
- The emerging topics mapped out in the GESDA 2023 Science Breakthrough Radar® that are most likely to be driven by an investment perspective are in sectors that are heavily focused on using technology in commodities or consumer goods.
- Science and diplomacy is another area where expected advances could help build more robust democracies in Africa and in Latin America, which in turn could transform lives very quickly and accelerate the reduction of poverty, or indeed loss of life through scaling up the health care system.
- Geneva's financial hub could facilitate more public-private support for emerging science so that breakthroughs can move out of the lab and into the market.Challenges to funding for emerging science remain, including what is provided for redundant projects or those without a real-world use case. Understanding the potential output and value as well as intellectual property potential are paramount to good investment

Wednesday 11 October, 17.30 - 18.15 CET

Anticipatory Briefing

From ‘Me and You’ to ‘Us and Them’: The Physics of Groups



Mina Cikara, Laurent Haug

From ‘Me and You’ to ‘Us and Them’: The Physics of Groups

By default, humans are cooperative, moral, and deeply averse to harming others yet in the last century alone, over 200 million civilians have been killed in acts of genocide, war, and other forms of collective conflict. Join this anticipatory briefing to hear about the latest advances in social psychology and the opportunities and challenges this presents over the next 5, 10 and 25 years.

Speakers

Moderated by:

Laurent Haug, Founder, 200ideas, Switzerland

With:

Mina Cikara, Professor of Psychology, Harvard University, USA (virtual)

Summary

People have formed groups to survive for millennia. The benefits, however, go beyond survival. Groups provide us with material and psychological benefits, such as identity and values, but the fields of psychology and neuroscience provide recent evidence that people acting as part of a group become more ruthless than those who act alone.

That’s led researchers like Mina Cikara, a Professor of Psychology at Harvard University, to look for new ways of reducing conflict by better understanding what happens when we shift from a ‘me and you’ to an ‘us and them’ mindset.

The neuroscience of group relations, including the psychological and biological factors behind cooperation and conflicts, is opening up promising avenues of study into how we identify with or stand apart from others. For Cikara, shared goals are the key to cohesion.

“Just the presence of contact of other people is not necessarily going to lead to a good thing,” said Cikara, who uses lab experiments, behavioral measures, functional magnetic resonance imaging (fMRI) and psychophysiology to study how our shift in thinking plays out in our minds, brains, and behavior.

“If people are interspersed with one another to actually get to be each other, you know, taking each other’s kids to school, working on a community garden or participating in various other community activities, that obviously leads to a different way of thinking about your neighbors, which is that they’re both community members,” she said. “And though they have different demographic backgrounds or different belief structures, they still have something in common. They’re still working to coordinate with you and pursue some goal.”

Collective intelligence including large-scale collaboration and building smarter teams is featured in the GESDA 2023 Science Breakthrough Radar® with insights from Geoff Mulgan, a Professor of Collective Intelligence, Public Policy and Social Innovation at University College London. The Radar noted that the dynamics underpinning human collaboration is an active field of research in which human-computer interaction and small-scale collaboration are likely to have the largest impact across business and communities.

Sociologists have long been fascinated with the mechanisms of how social groups form, theorizing that homophily – our tendency to be drawn to others who are similar to us – drives group formations to socialize or avoid stress. In January 2023, scientists at Complexity Science Hub Vienna, a research organization dedicated to making sense of Big Data in ways that are valuable for science and society, published how they used theories of particle physics to predict the group sizes of people in a computer game.

They modeled the formation of social groups using the average number of friends each person had, drawing on a notion that people with similar opinions interact with each other like the self-assembly of nanoparticles in small thermodynamic systems. Using this model – homophilic humans that self-organize in ways resembling particles with spin – they predicted the distribution of group size in Pardus, an online game with multiple players.

And in June 2023, scientists reported using another physics-inspired model to predict the online information dynamics of harmful content. They drew on a “first principles” theory from nonlinear fluid dynamics and nonequilibrium statistical physics to reproduce the dynamics of online communities

that spread hatred along the lines of ethnicity, race, religion and science.

Amid growing efforts to address the overheating planet, the surge in youth- and citizen-led movements to fight climate change presents another opportunity to study the physics of groups, said Cikara. A research project that she is part of has been studying how to communicate the "positive" aspects of policy to combat human-induced climate change.

"These narratives, these norms, they shape our beliefs, the reality," she said. "If I think I'm the only person in my community who cares about this, it's incredibly demotivating to actually try to make a difference. If, on the other hand, I believe that 90% of my community feels the same way I do, perhaps that's going to engender more motivation for me to try."

Trusted information is another challenge, with education often a battleground, raising the importance of the independent "third-party information broker" to strengthen societies, Cikara said.

"It's an institution we should work on building. You know, journalism, in theory, *is* that in many places," she said, but what's needed are more "data heavy" news providers that help people get "a sense of the distribution of people's beliefs" rather than "particular exemplars that tell a particular story" – the tendency for news to conform to anecdotal evidence.


Laurent Haug


Mina Cikara

Our cognitive biases make us "pay slightly more attention to, encode, and better remember negative information, at least in the short term. We do tend to also exhibit memory bias; whereby negative memories fade more than positive memories do. Which is why you end up with nostalgic preferences like music, and movies are better in your youth than they are today," she said. "It's an uphill battle against those tendencies."

Imagery is important. For example, American political and religious factions are changing "the way that we talk about politics on both the progressive and the more conservative side, having morphed the metaphor from negotiation – where you have two parties at the table who are trying to reach a mutually beneficial agreement – to a war," she said.

"The primary metaphor for politics in the U.S. today is war," Cikara said in describing how imagery can lead opposing sides to demonize each other. "That metaphor has taken us down a very, very difficult and dark path. It's in part how we ended up in such an incredibly polarized situation within the U.S."

Negative content is more physiologically activating than positive content, according to research such as a 2019 study of people's reactions to positive and negative news that included more than 1,100 respondents across 17 countries and 6 continents. Respondents watched randomly selected BBC World News stories on a laptop while wearing noise-canceling headphones and finger sensors for skin conductance and blood volume pulse.

On the other hand, people tend to be happy even when they get just a little bit of good news, said Cikara, and "so my hope is that, though we have this bias, generally speaking, to pay attention to and remember negative information more than neutral or positive information, that perhaps the desire for positive news these days gives us a little bit of more of an advantage than you have in otherwise more quotidian times."

More information

Explore the 2023 GESDA Science Breakthrough Radar®

Session recording on YouTube

Key messages

- Being part of a group provides us with material and psychological benefits, such as identity and values, but recent work from the fields of psychology and neuroscience shows that people acting as part of a group become more ruthless than those who act alone.
- Researchers are undertaking lab experiments, behavioral measures, functional magnetic resonance imaging (fMRI) and psychophysiology to study the neuroscience of group relations and what happens in our minds, brains and behavior when we're in the presence of others: how do we identify with or stand apart from others.
- Better understanding of what happens when we shift from a 'me and you' to an 'us and them' mindset could help to reduce conflict.
- Sociologists have long been fascinated with the mechanisms of how social groups form, theorizing that homophily – our tendency to be drawn to others who are similar to us – drives group formations to socialize or avoid stress.
- Cognitive biases mean that we pay slightly more attention to, encode, and better remember negative information, at least in the short term. We do tend to also exhibit memory bias; whereby negative memories fade more than positive memories do.

Wednesday 11 October, 18.30 – 19:00 CET

Plenary Session

Thought-Controlled Walking: A Swiss World Premiere

Grégoire Courtine, Jocelyne Bloch

Thought-Controlled Walking: A Swiss World Premiere

Speakers

Hosted by:

Sylviane Borel, Membre du Conseil, Fondation Defitech, Switzerland

With:

Jocelyne Bloch, Professor of Neurosurgery, University Hospital of Lausanne (CHUV), Switzerland

Grégoire Courtine, Professor of Neuroscience, Swiss Federal Institute of Technology Lausanne (EPFL), Switzerland

Summary

More than a decade after suffering a spinal injury from a motorcycle accident in China that left him paralyzed, 40-year-old Gert-Jan Oskam of the Netherlands regained the ability to walk fluidly and naturally with the help of a new Swiss-engineered brain-spine interface.

The new "digital bridge" – implants allowing Oskam to wirelessly transmit his thoughts to his legs – was the work of Grégoire Courtine, a neuroscientist at the Swiss Federal Institute of Technology in Lausanne (EPFL), and Jocelyne Bloch, a neurosurgeon at the University Hospital of Lausanne (CHUV. After they demonstrated that spinal stimulation plus intensive training could help people with partial paralysis to walk again, Oskam took part in a clinical trial. In May 2023, the results of that groundbreaking work were published in Nature.

The story behind Oskam's astonishing new mobility drew on two decades of innovative collaboration among engineers, neuroscientists and medical doctors, Courtine and Bloch told an audience at the 2023 GESDA Summit. The journey began with Courtine going to the United States to study how the lower part of the spinal cord could activate the legs.

"It was very rudimentary at the time. Imagine the rats completely paralyzed. And at the time we were just applying wide-field stimulation of the spinal cord to restore walking," Courtine recalled. "Then I had the dream of the scientist that I would take this to a human."

Electrical therapies are featured in the GESDA 2023 Science Breakthrough Radar® which noted that new designs of brain implants – such as neurograins and neuropixels that do less damage when being implanted – are expected to be tested in more clinical trials in the coming decade. The devices can lead to better understanding of neural pathways.

Courtine first modeled the structure of the spinal cords and electrical field elicited by stimulation. He discovered electricity did not penetrate the spinal cord but flowed beside it, he said, stimulating "social interference, specifically coming from muscle, from receptive interference, because they are the less resistant to current." That led him to "propose a transition from this object stimulation to a mechanism-driven stimulation."

That was also the turning point, he said, but he soon realized some big challenges remained: he would need to develop the technology for a human and find a clinical partner. Courtine learned from Patrick Aebischer, a former President of EPFL who is now Vice-Chairman of GESDA, about EPFL's Center for Neuroprosthetics, an interdisciplinary research center. "He told me also, 'Don't worry, I also found a wonderful neurosurgeon and she will be able to help you to operate the path from rats to humans," Courtine recalled.

Bloch, the neurosurgeon, said she first met Courtine in his office where she could see for herself that the rats were "walking very enthusiastically." It was then that he posed the question: Could we do this with humans? "And I was also very enthusiastic," she said.

Through Aebischer, Courtine and Bloch met Sylviane Borel, who with her husband, Daniel Borel, created the Fondation Defitech in 2001 to contribute to R&D that helps people with disabilities. "We have been impressed immediately by their dream to have paralyzed people walk again," Borel said in explaining why her foundation supported their work. "Since then, starting with rats, they are now able to have paralyzed people walk again."

Applying biomimetic stimulation so people could walk naturally "was impossible with the implants we had available" then, Bloch said. "We had to think about it and to partner with Medtronic to repurpose implants that they already had. So, we used other leads, electrodes, that are normally used to treat chronic pain, and we used a stimulator that is normally used to treat people with Parkinson's

disease. And together with many engineers and a complicated chain of command, for the first time we had a device that was able to do what we call a closed loop. It means that we can take into account what the person wants to do and stimulate, at the right time, at the right spot, in order to make him walk."

In 2014, Courtine and Bloch formed ONWARD Medical to create their own purpose-built platform for precise neurostimulation of the spinal cord. The platform is essentially a computer that communicates wirelessly with an implantable pacemaker, allowing the patient to have real-time control of the stimulator with a watch. "Everything became simpler and also much more personalized," Bloch said. "For each patient, you have the dedicated electrode. You put it right on the right place and you have very good results immediately."

By 2016, they were ready for their first surgery. The new implant in their patient, David Mzee, immediately worked. Mzee, who had a partial spinal cord injury from a gymnastics accident in 2010 that left him unable to walk, already had recovered the use of his upper body and some control of his right leg during intensive rehabilitation at a paraplegic center in Zurich. With the new implant, he could now get up from his wheelchair and begin to walk. There was only one problem: whenever the stimulation stopped, he stopped walking. That's when Courtine and Bloch decided that they needed to simplify the system.

"We thought, why do we make it so complicated? Do we need such a complicated, biomimetic stimulation, or would we also be able to apply a current all over the spinal cord, and would it work the same?" Bloch said. "So, we knew, testing both stimulation patterns, that this biomimetic stimulation was the way to go, you see, and there is a continuous stimulation. David cannot walk properly. With this complicated but very efficient way to stimulate, he was able to walk."

With the help of artificial intelligence, they developed a stimulation strategy that everybody would be able to use outside the environment of a carefully controlled lab. Physical therapists could even personalize the stimulation, and the patients would be able to direct it themselves using a watch. "For the first time," Courtine said, "an individual with paralysis is able to take a voluntary step independently outside the laboratory environment."

In 2018, Courtine and Bloch published the findings from their STImulation Movement Overground (STIMO) study. The research laid the groundwork for a new therapeutic framework to improve recovery from spinal cord injury. Using targeted electrical stimulation of the spinal cord controlled by a pacemaker and an intelligent bodyweight-support system, it helped eight paraplegic patients take a few steps unassisted.

To make the technology more accessible, they founded the NeuroRestore center in 2018 with help from Defitech, EPFL, Lausanne Hospital and the University of Lausanne. "I'm more like a neuroscientist engineer, she's a neurosurgeon. When we created NeuroRestore, we really wanted

Sylviane Borel, Jocelyne Bloch, Grégoire Courtine

to leverage this synergy," Courtine said. "In all the studies we perform at NeuroRestore, we go all the way from understanding the mechanism of action – a lot of work in mice, rats – scaling them up in non-human primates, eventually proof of concept. And because it is ONWARD, we can really scale up to therapy when we see that they're effective in humans. This development model has been incredibly effective."

By digitizing thought into action, they were able to help Oskam, the Dutch patient, move in a way that felt more natural to him. He already had been given stimulation procedures that helped him regain some ability to walk, but he had still felt a strange disconnect between his mind and body.

Bloch inserted an electrode in the region of Oskam's motor cortex that anchored leg movement and for the first time delivered a wireless recording to an external computer that ran in AI. It decoded his intentions – a new digital way of turning thought into movement.

A team in Grenoble, France, helped create an implant for use above the motor cortex to record activity and transmit it to spinal implants. The device, called IMAGINE, "is exactly doing what we wanted," Bloch said. "It's a passive design and everything is closed. No battery to change when it's put in. You just close the skin and then it's done."

The brain-spine interface immediately helped Oskam walk more naturally, he recounted. "I can start the stim with my brain. I can talk while doing

it," he said as he demonstrated his new capabilities in a pre-recorded video. "And if I want, I can also maintain the stimulation while talking and maintaining now. Now, this feels more natural. I can control the step. Like, I can stop here. I can make it bigger. It's freedom, which I didn't have with the foot sensor before. I can stop right now, and I can continue whenever I want."

Courtine acknowledged that the notion of being able to translate someone's "intention" into action through a digital bridge may at first sound crazy, but he said that learning how to decode the "beautiful symphony that's called walking" stands as perhaps "the most emotional moment of my career. It was so complicated to make this work technologically."

More information

Explore the 2023 GESDA Science Breakthrough Radar®

Session recording on YouTube

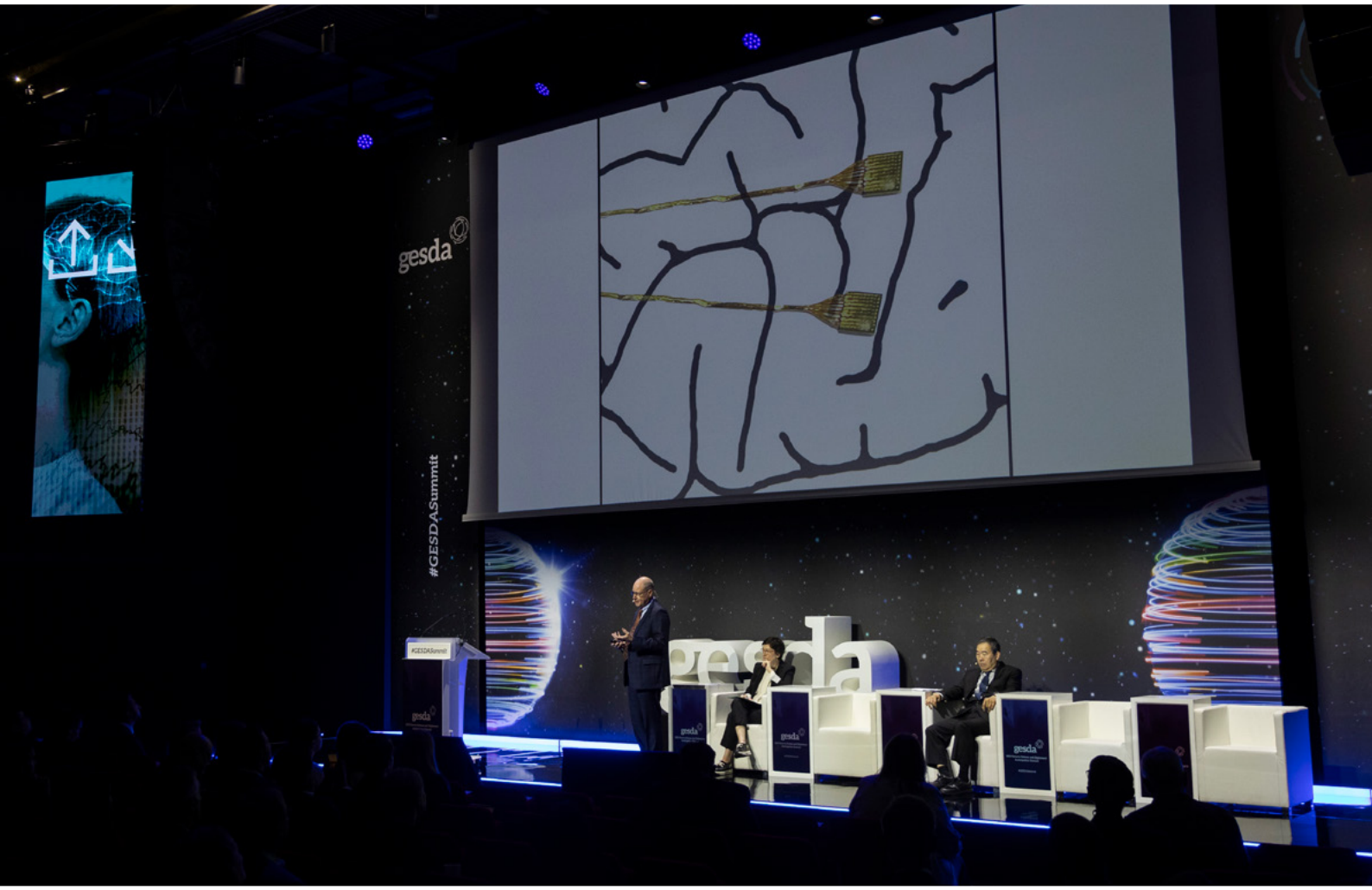
Key messages

- A groundbreaking brain-spine interface developed by Swiss researchers, Grégoire Courtine and Jocelyne Bloch, enabled a paralyzed individual, Gert-Jan Oskam, to wirelessly transmit thoughts to his legs, allowing him to walk fluidly and naturally after being paralyzed.
- The brain-spine interface, or "digital bridge," involved implants that allowed wireless transmission of thoughts from the patient's brain to his legs. The technology represents a significant advancement in neurostimulation and spinal cord injury rehabilitation.
- The success story originated with Courtine's study in the United States on activating the lower part of the spinal cord in paralyzed rats. The collaboration involved interdisciplinary efforts, including neurosurgeons, engineers, and medical professionals, with pivotal support from Fondation Defitech, in order to progress to humans.

Wednesday 12 October, 08.30 – 09.45 CET

Plenary Session

Neuro-Augmentation: Hype or Hope?



Jaimie Henderson, Karen Rommelfanger, Mu-ming Poo

Neuro Augmentation: Hype or Hope?

Advances in neurotechnology such as brain-machine interfaces or genetically engineered brains could have the potential to augment human cognitive abilities, raising fundamental questions for humanity and society. With such rapid developments underway, what are the opportunities and challenges for science to positively impact the world we live in by anticipating global governance?

Speakers

Moderated by:

Karen Rommelfanger, Founder, Institute of Neuroethics, USA

Presentations by:

Jaimie Henderson, Professor of Neurosurgery, Stanford University, USA

Mu-ming Poo, Director, Institute of Neurosciences, Chinese Academy of Sciences, China

With:

Nita Farahany, Professor of Law, Duke University, USA (virtual)

Claudia Fuentes Julio, Ambassador and Permanent Representative of Chile to the United Nations Office at Geneva

Marcello Ienca, Professor of Ethics of AI and Neuroscience, Technical University of Munich, Germany

Summary

From the arrival of the wheel to the rapid adoption of generative AI, people have leaned on technology to enhance their lives, primarily their cognitive abilities, since ancient times. In recent years, advances in neuro augmentation – such as brain-machine interfaces, engineered clusters of cultured human brain cells connected to robots, or genetically engineered brains that can augment primates – have become a trending topic because of their potential to improve the skills our brains use for everyday tasks like thinking, learning and remembering, but they also raise questions about how best to take advantage of the opportunities and challenges. Governments invested US$6 billion in neurotechnology since 2013, UNESCO estimated, as private investment in neurotech companies like Elon Musk's Neuralink rose 20-fold to US$7.3 billion in 2020, up from US$331 million a decade earlier. Neurotechnology is expected to become a major industry soon with growth in the neurotech devices market likely to reach US$24.2 billion in 2027, up from US$11.3 billion in 2021.

Neuro augmentation is featured in the GESDA 2023 Science Breakthrough Radar® with insights from GESDA Vice Chairman Patrick Aebischer and ETH Board President Michael Hengartner. They noted that the technology for reading and writing signals of the brain is predicted to become wireless within five years. Enhancing the depth and quality of sleep with a closed loop implant or wearable EEG device is an especially promising area. Within 10 to 25 years, brain-computer interfaces are likely to provide better readouts of brain states and, combined with closed loop neurostimulation, may help patients coping with issues of dementia, sensation and bowel control.

Both in university research and clinical applications, the advent of devices that can measure and influence brain activity and the nervous system are on the cusp of widespread adoption across society, raising profound questions ranging from human rights to data privacy. "Their ubiquity could change everything from workplace rights to what it means to be human," the GESDA 2023 Science Breakthrough Radar® said. Organizations such as UNESCO and GESDA have begun discussions about the need for global governance of companies and institutions that are rapidly gaining the ability to control and store a client's neural data, and to use artificial intelligence to decode it. GESDA hosted a high-level Anticipation Workshop at Villars, Switzerland to gather experts who could provide informed insight about neuro augmentation's direction and speed.

Neuro augmentation can have "awe-inspiring impacts such as helping someone with disease or catastrophic injury regain their independence to walk" and "even restore abilities to communicate with loved ones," said the panel's moderator, Karen Rommelfanger, Founder and Director of the Institute for Neuroethics, Program Director of Emory University's Neuroethics Program at the Center for Ethics, and Associate Professor in the Departments of Neurology and Psychiatry. "We also want a future where we are not blindsided by the fundamental ways in which we view ourselves in relationships with one another," she said. "Unlike

other technological advances such as social media or even AI to some extent, our governance is struggling to catch up with a runaway train of how entrenched these techs are for how we interact as people and as nations."

Soon there will be wireless and fully implantable systems with more channels for accurately reading and decoding brain cells and better biocompatibility, said Jaimie Henderson, a Professor of Neurosurgery at the Stanford University School of Medicine and Director of the Stanford program in Stereotactic and Functional Neurosurgery. "We need for these systems to last for decades, for the entire life of the person who has the implant. But perhaps more important are the advancements in neuroscience. We have to better understand how language and cognition are represented in the brain, and even potentially understand consciousness. There are efforts in a number of labs across the world that are looking at these very problems. I think really the limit here are the neuroscientific questions. The technology has been demonstrated. We know that we can do this. So how do we advance to the next level? How are concepts in language represented in the brain?"

"If you listen, for example, to Elon Musk, who predicts a future where we'll be able to communicate telepathically by transmitting our thoughts to others' brains, it makes one wonder, well, what is a thought? How do we actually communicate things between people?" Henderson continued. "We have to understand how that's represented. How does the brain do that? Can we ever really understand it? I mean, I think that's a fundamental question. And what scale is needed for us to be able to accurately decode? Would we have to record every single neuron in the brain in order to understand this? Or would that actually hinder our understanding? Do we need to simplify things to a much more human scale? Is mind-reading really possible? There's been some work that shows that semantic and conceptual maps are broadly distributed throughout the brain."

Brain-machine interfaces can monitor, decode and manipulate human activity for medical purposes and even for augmentation. Some companies are developing cognitive-enhancing drugs. Neuromodulations can directly manipulate sensory and cognitive functions. "The danger of this is that, although it's an augmentation that assisted in scientific studies in education, it would, by having this assistance – the human brain would be deprived, gradually lose the ability to distinguish facts from fiction," said Mu-ming Poo, Scientific Director of the Institute of Neuroscience at the Chinese Academy of Sciences Center for Excellence in Brain Science and Intelligence Technology, and Paul Licht Distinguished Professor in Biology Emeritus at the University of California, Berkeley. "And in fact, the main purpose of all human brains is to be able to determine for ourselves the events in the environment. If with this assistance, our ability would be homogenized and even affected in the long run, we may even lose our ability to interact with the environment correctly. This new disorder would be the peril of the future new modulation technology."

Five years ago, he was a co-author of a study in which researchers – using the same cloning method, known as a somatic cell nuclear transfer, that created Dolly the sheep in 1996 – for the first time successfully cloned two macaque monkeys that can be used to study and accelerate treatments for diseases such as Parkinson's, Alzheimer's and cancer. Although species of cats, dogs, pigs and rats, along with the sheep, were previously cloned, monkeys are valuable because of the similarity between human and chimp DNA. The Chinese Society of Psychiatry and Chinese Medical Association recently issued ethical guidelines for research on neurotechnology, including for the safe use of brain-machine interfaces. "These neuromodulation techniques, you need to try it out on animals, closer to humans, before you apply it in humans," he said. "We can see how a monkey can be used for studying how human brains actually evolved to acquire its capability. Now, this has obviously created a lot of


Jaimie Henderson

Karen Rommelfanger

Mu-ming Poo

Claudia Fuentes Julio

concern in headlines of newspapers saying this is the *Planet of Apes* scenario, you are manipulating monkeys. But from the basic frontier science point of view, this is what we need to do to understand the human brain evolution of human brain."

"We should have a global consensus of ethics. Now we have to balance the frontier scientific pursuit with the societal needs. We also have to consider universal human values and the cultural and religious differences. Can we reach a universal consensus on how to use a new augmentation technology?" he continued. "GESDA would be very useful in pioneering these international conversations on the future technology. I think this is really an area that needs more discussion among scientists and all sectors of society, all the stakeholders, not just the policymakers. There are discussions within the United Nations and a high level of discussion, but the participation of scientists and especially people who are working on the frontier, who know the technology, how it's developing, to be really actively engaged in discussion – that would be great."

As an outspoken champion of what she called "the broad concept of cognitive liberty" as a human right, Nita Farahany, a Professor of Law at Duke University, said there also are difficult questions of privacy and identity, agency and responsibility to be examined. "Is it really ever possible to map the full sense of self that we might be looking at from decoding speech or coding thought?" she asked. "And the answer to that is it may never be possible. It may never be possible to fully understand the concept of self or the full concept of thinking or metacognition, thinking about thinking. We may be able to decode, for example, intention to communicate language or what somebody is imagining in a moment, but not how they feel about what they're imagining or how they're reflecting on it, or the kind of multiple layers of depth of thought and self."

Farahany argued in her new book, *The Battle for Your Brain*, that a public debate is long overdue on neurotechnologies intrusive to our brains, and legal guarantees of thought are needed. From an ethical and regulatory perspective, however, it's unclear whether brain data that's collected today or in the future is uniquely sensitive, Farahany told the panel, and an anticipatory framework should be laser-focused on that question. "Breaching what I think of as the final frontier of privacy, that space, the inner sanctum, the place for private reprieve, fundamentally changes our relationship to others in ways that we have to include within any ethical framework. I think it's also important for us to move beyond traditional models of autonomy and self to really be having more robust conversations about the concept of relational autonomy," she said. "We are in many ways co-evolving with technology, whether that's something like our mobile phones or the fact that I can join you all by a video feed today with earbuds in my ears, my understanding of myself and your understanding of me is mediated by technology. Whether we're losing our hearing and have different hearing aids, which change our perception of the external world, or we use a neurotechnology device, our relationship to ourselves and our relationship to the world as both in relationship to others and our understanding of self as in relationship to others, as well as in relationship to technology. And I think understanding that concept of relational autonomy should be part of how we think about governance going forward and how we think about the ethical issues that are at stake."

In 2021, Chile became the first nation to constitutionally protect brain rights. The law applies to mental integrity, free will and neurotechnology access, treating brain data as an organ that's illegal to buy, sell, traffic or manipulate. The Chilean Senate's decade-old Committee on Challenges of

Future, Science, Technology, and Innovation provided an important opportunity for anticipatory science and diplomacy, connecting politicians with epistemic communities, universities and think tanks to allow everyone to clarify the discussion terms, objectives and purpose. “It was precisely the very close and tied work together between scientists, politicians and diplomats that made possible this law in order to protect neural rights. We need to be working more closely together instead of breaching the existing gap,” said Claudia Fuentes Julio, Chile’s Ambassador and Permanent Representative to the United Nations Office and other international organizations in Geneva.

However, participants in some of the discussions at the 47-nation U.N. Human Rights Council in Geneva and other multilateral forums are finding that “the minimum protection for the dignity of human beings is something that is questioned today in an international realm,” she said. “These are the kind of debates that we should be having these days. In particular, we are concerned about the ethical dimensions of research. We are also concerned in terms of who gets these new technologies and which countries have an advance in these technologies, as opposed to other countries that don’t have access to those technologies. The difference between and within countries in terms of having access to those technologies, those are issues that are a great concern for countries like mine.”

Professor Marcello Ienca, a Professor of Ethics and AI and Neuroscience at the Technical University of Munich, said the governance landscape is quickly shaping up internationally. “We see some kind of synchronicity, some kind of chronological alignment between the progress in technology and the progress in policy and governance,” he said. “We can cluster the governance landscape on neurotechnology into three main categories. One is self-regulation by the scientific community. Another one is soft law instruments by intergovernmental organizations. And then, as we have heard from the example of Chile, we also have the first examples of legally binding frameworks. Now, self-regulation is a very broad definition, but what is happening is that a lot of international societies, professional associations and so on are attempting to introduce codes of conduct and ethical guidelines for the ethical use and development of these technologies.”

The IEEE Standards Association has been developing standards for brain-computer interfaces. Some industries and companies are developing ethical codes for neurotechnology and implementing them in their day-to-day practices. At the level of soft law, international organizations such as the Organization for Economic Cooperation and Development have been on the frontlines. The first international standard, the OECD Recommendation on Responsible Innovation in Neurotechnology, set

Nita Farahany

a high standard for its 37 member democracies with market-based economies in 2019.

"If the OECD is focusing more on responsible innovation, other organizations like the Council of Europe and the United Nations are focusing more on human rights protection and promotion for neurotechnology," said Ienca, who wrote a report on behalf of the Council of Europe about the applications of technology to biology and medicine, because the council's focus is on a potential revision of the Vienna Convention that regulates the participation of human rights in biomedicine.

"We have heard from Chile that some countries are pioneering the introduction of legally binding frameworks. Now the question is what challenges are we facing here? I think first of all, we have to emphasize that the scientific community is very aware of the ethical sensitivity of neurotech. And I think all these examples, this increasingly rich landscape of governance tools that is emerging is the proof that both the scientific and the policy community are aware of this sensitivity. But on the other hand, there are some challenges, and I think the topic of our panel is a good example of the challenges that we're facing," she said. "What GESDA's really created is becoming a catalyzer for an international global debate on emerging technologies, and I think this is really important because we need these kinds of international platforms where the global community can convene."


Marcello Ienca

More information

Explore the 2023 GESDA Science Breakthrough Radar®

Session recording on YouTube

Key messages

- From the invention of the wheel to the current era of generative AI, humans have relied on technology to enhance their cognitive abilities since ancient times and the recent trend of neuro technologies is no exception; both public and private investment in the technology has grown rapidly and the neurotech devices market expected is to reach US$24.2 billion in 2027.
- Technology for reading and writing signals of the brain is predicted to become wireless within five years. Within 10 to 25 years, brain-computer interfaces are likely to provide better readouts of brain states and, combined with closed loop neurostimulation, may help patients coping with issues of dementia, sensation and bowel control.
- The speed of neuro technology development is moving so quickly that it's almost outpacing our scientific understanding of the brain. The technology itself has been demonstrated but better understanding of how language and cognition are represented in the brain, and even consciousness, could help to advance it even further.
- The advent of devices that can measure and influence brain activity and the nervous system are on the cusp of widespread adoption across society, raising profound questions ranging from human rights to data privacy. What's now needed is a global consensus of ethics that balances frontier scientific pursuit with societal needs.
- The governance landscape is trying to keep pace with the development of neuro technology and can currently be broadly categorized into three areas: self-regulation by the scientific community, soft law instruments by international organizations and legally binding frameworks.

Wednesday 12 October, 10.00 – 10.45 CET

Anticipatory Briefing

Psychedelic Medicine

Edurado Schenberg, Laurent Haug

Psychedelic Medicine

From ecstasy to psilocybin, psychedelics offer the potential to provide relief for debilitating mental health disorders including PTSD, major depressive disorder and addiction, which cost thousands of lives and billions in lost productivity every year. Join this anticipatory briefing to hear about the latest advances in psychedelic research and the opportunities and challenges this presents over the next 5, 10 and 25 years.

Speakers

Moderated by:

Laurent Haug, Founder, 200ideas, Switzerland

With:

Eduardo Schenberg, Founder & President, Phaneros Institute, Brazil

Summary

Most nations still view psychedelic substances as drugs that have a high potential for abuse and no recognized medical value, but in recent years and particularly since the COVID-19 pandemic there has been a resurgence of interest around the world in clinical research about their potential uses for treating illnesses like addiction, anxiety, depression and post-traumatic stress disorder (PTSD).

That has led to a growing body of evidence – based on controlled clinical studies of their psychopharmacological properties and therapeutic efficacy, when added to current psychotherapeutic approaches – suggesting that psychedelic substances such as psilocybin and ayahuasca may help in the treatment of a range of mental health and physical conditions.

The future of psychedelic medicine is featured in the GESDA 2023 Science Breakthrough Radar® with insights from Eduardo Schenberg, a neuroscientist who is the Founder and President of the Phaneros Institute, and David Nutt, the Edmond J. Safra Professor of Neuropsychopharmacology and director of the Neuropsychopharmacology Unit in the Division of Brain Sciences at Imperial College London. They said "the psychedelic revolution is starting up again" with research by an extensive network of academic labs and dedicated university centers at prestigious institutions.

"What we're now learning through science is that some of these non-ordinary states of consciousness, they're not pathological and they're not dangerous and they can carry healing potential and transformative potential in a positive way for individuals, families and communities," said Schenberg, who believes the growing acceptance of legal cannabis use in the United States and other countries has helped give people "new perspectives" about the use of psychedelic substances.

The Radar also noted that the 2023 GESDA Summit coincided with the 80th anniversary of the first time that a human ever ingested LSD. Swiss chemist Albert Hoffman's first trip in April 1943 launched a decades-long period of widespread experimentation and discovery within academic and countercultural circles that ran into major societal and legal roadblocks in the 1970s when most countries, including Switzerland, classified LSD as a narcotic and banned its sale, purchase and use.

Schenberg – whose work focuses on psychoactive drugs and their effects, both harmful and therapeutic, with a specialty in psychedelic substances – launched the Phaneros Institute in 2011 as a Brazilian nonprofit for pioneering clinical research on psychedelic-assisted psychotherapy and training for health professionals, and it has now grown to include more than 800 students. He said the legal and therapeutic uses of psychedelic medicine may solve "a big problem that's coming from an area that many people don't think any solution could come from, which is illegal drugs."

His interest stems from an unusual experience he said he had about a quarter century ago involving a Brazilian church ritual. "It's not a common church. It was formed out of the colonization of the Amazon. We have this mixture of Indigenous plant rituals with Christianity, with some African spirituality and military social hierarchy. It's a very unique cultural phenomena, and today it's pretty much all around Brazil and also internationally in many, many countries," he said.

Most of the rituals have legal authorization for the religious use of ayahuasca, which signifies "vine of the soul" in the Quechua language. There are hundreds of different ways to prepare ayahuasca, each with chemical differences. It contains a potent substance, N,N-Dimethyltryptamine, or DMT, that has "a very powerful capacity to make humans see things with their eyes closed," Schenberg said. "It has been assessed using neuroimaging by colleagues of mine in Brazil, and they've shown that the activity in

the visual cortex during ayahuasca with eyes closed resembles the brain pattern when we have our eyes open. And people report seeing many, many different things, a variety of things, even perhaps colors that don't exist outside of this, let's say, awakened dream."

Schenberg had a "very meaningful experience in this church," he recounted, "and this triggered my interest in this field at a time when it was not really being so much studied as we're seeing today. Also, important to note, there's another psychedelic compound very, very similar to DMT, which is called psilocybin, and it comes from sacred Indigenous mushrooms used in Mexico and other species of mushrooms as well. One of my favorite pieces of data in the entire psychedelic scientific literature comes from Johns Hopkins University in the U.S. They're running studies for more than 20 years nonstop, and they made hundreds of thousands of sessions with healthy volunteers and patients in the university. And about 70%, or two-thirds of these people, rate their psilocybin experience in the university as one of the five most meaningful experiences of their entire lives."

Schenberg wondered how people could come to view their psilocybin experience on a par with commonly significant life events such as a wedding, the birth of a child or the loss of a parent. The impact of these experiences seems to be reflected in the surge of interest in these fields of research. He published one paper on the neuroimaging of ayahuasca as part of a study in Brazil, and another paper on the neuroimaging of LSD as part of a study by Imperial College London. "Almost 10 years later together they are counting almost 1,000 scientific citations," he said. "This tells us how much interest there is, an increasing interest, inside academic studies and universities on this topic."

Five years ago, he also pioneered a clinical study of psychedelic-assisted psychotherapy for patients with PTSD who have a high risk of suicide. There are now almost 32,000 studies of psychedelic substances, he said, "and this number is likely to keep increasing" particularly due to a rapidly growing interest in the field among public health institutions and regulators in the U.S. and Europe and as many as eight recent scientific journal covers dedicated to psychedelic medicine. In June 2023, the U.S. Food and Drug Administration unveiled draft guidance for psychedelic clinical trials.

During the pandemic, the study of psychedelic medicine "became a biotech industry," Schenberg said, with hundreds of startups and half a dozen public companies running studies and putting money into compounds to develop clinical trials and bring them to market. The global psychedelic market is forecasted to grow to US$8 billion a year in revenue by 2028 and US$12 billion a year by the end of 2035, up from US$3 billion a year in 2022, according to market assessment reports.

The World Health Organization reported in March 2022 that the pandemic had led to a 25% increase in anxiety and depression rates around the world, fueling a surge in demand for psychedelic drugs as people sought ways to cope with their mental health issues. Pandemic lockdowns also prevented people from visiting a therapist or engaging in other traditional forms of therapy for the loss of a loved one, fear, isolation and uncertainty, and the loss of jobs and income.

Over the next five years, he said, the U.S. and European regulatory agencies may approve the therapeutic use of 3,4-Methylenedioxy methamphetamine (MDMA), commonly known as ecstasy, and psilocybin. MDMA is being studied in clinical trials mostly for PTSD, while psilocybin is being looked at for major depression, or treatment-resistant depression. "These will not be just new drugs for the psychiatric mental health sector. These are not drugs the psychiatrist should prescribe and the patient take at home, as they do with current antidepressants or SSRIs, the selective serotonin reuptake inhibitors," said Schenberg. "These drugs change the state of consciousness."

Patients can experience altered states of consciousness that last for six to 10 hours, depending on their personal conditions, thoughts and emotional reactions. Schenberg believes that over the next 10 years, regulators are likely to approve still more psychedelic compounds for therapeutic uses. Those could include mescaline, peyote, LSD and 5-MeO-DMT, a compound found in a poisonous toad. "There's a very huge need for education to train therapists on how to do these procedures and also to train the patient population about what to expect out of these treatments," he said. "There are a series of new compounds coming into the mental health sector that require lots of anticipation and work for us to be prepared to use these treatments wisely, safely and ethically."

Psychedelic substances are not considered highly addictive. Ayahuasca churches in Brazil typically have rituals or sessions every two weeks in part because the substance is not as effective on a weekly basis. Some studies have shown that psychedelic substances are useful in helping people quit addictions to other drugs, alcohol or tobacco. "People can quit 20 years of drug addiction in two or three psychedelic experiences. That's really something that needs to be looked at," he said.

Twenty-five years from now, Schenberg said, it's hard to say where things will stand but there is "a huge potential here to connect this growing biotech

industry" with Indigenous rights as emphasized by the U.N.'s Intergovernmental Panel on Climate Change, or IPCC, with regard to fulfilling the 2015 Paris Agreement's legally binding obligations to curb global warming, and "not only to develop mental health treatments but to prevent mental health problems due to climate change."

International treaties such as the Convention for Biological Diversity, which covers traditional knowledge associated with genetic resources that comes from Indigenous peoples and local communities (IPLCs) and the Nagoya Protocol, a legally binding protocol on access to genetic resources and benefit-sharing, can also help more people enjoy their right to benefit from scientific progress as enshrined in the United Nations' 1948 Universal Declaration of Human Rights (UDHR), another topic featured in the 2023 GESDA Radar, according to Schenberg.

"The IPCC is very clear that to reach the goals of the Paris Agreement and to mitigate climate change, Indigenous territories, Indigenous rights and sovereignty, and the protection of Indigenous cultures is essential," Schenberg said. "And almost all, if not all psychedelic compounds, originate from the knowledge and traditions of Indigenous people."

In 2015, the 196 nations signing onto the legally binding Paris Agreement committed to hold global warming to no more than 2° Celsius above pre-industrial levels, or preferably 1.5°. The Nobel Prize-winning IPCC has detailed how fossil fuel burning is leading to more extreme weather, droughts, flooding, loss of plant and animal species, and sea level rise from the melting of land ice.

Could the advent of psychedelic medicine help ease some of the suffering and anxiety linked to our rapidly warming planet in the coming decades? "Climate change is for sure – I'm very convinced of this – it's for sure the biggest mental health threat we have," he said. "If we run for 2.6° or more of warming, the situation will be very difficult. And perhaps even with the most scalable and best treatments that science can develop, it might not be enough to keep us united and in good international relationships as a human society on this planet. So, think about the possibilities here."

More information

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Key messages

- There's been renewed global interest in psychedelic substances, especially since the COVID-19 pandemic. Despite historical views of these substances as having high abuse potential, there is growing evidence from controlled clinical studies suggesting their potential for treating conditions such as addiction, anxiety, depression, and PTSD.
- Over the next five years, U.S. and European regulatory agencies may approve the therapeutic use of MDMA, commonly known as ecstasy, and psilocybin. In the next 10 years, regulators are likely to approve still more psychedelic compounds for therapeutic uses, and while it's hard to say how things will look 25 years from now, there is a huge potential to connect this growing biotech industry with Indigenous rights as emphasized by the U.N.'s Intergovernmental Panel on Climate Change.
- Despite the promising scientific progress shown by psychedelics, there's a huge need for education to train therapists on how to do deliver psychedelic procedures and to train the patient population about what to expect from such treatments for them to be used in a safe, ethical and effective manner.
- Aside from clinical benefits, psychedelic medicine could even offer a glimmer of hope to the climate crisis that faces us, by keeping humanity united.

Thursday 12 October, 10.00 – 11.00 CET

Interactive Discussion

Defining the Red Line in Research

Andrea Boggio, Francois Rivasseau, Cheryl Moore, Matthias Kaiser, Patrick Aebischer

Defining the Red Line in Research

With new technologies advancing ever more rapidly, there is an urgent need to put more adequate and efficient regulatory mechanisms in place while not hindering the progress and benefits of science. As scientists are in the best position to anticipate where and when their research could cross the line, is self-regulation the answer?

Speakers

Moderated by:

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

With:

Patrick Aebischer, Vice-Chairman, GESDA; President Emeritus, Swiss Federal Institute of Technology Lausanne (EPFL), Switzerland

Matthias Kaiser, Professor Emeritus, Centre for the Study of the Sciences and the Humanities, University of Bergen, Norway

Robin Lovell-Badge, Head of the Laboratory of Stem Cell Biology and Developmental Genetics, Francis Crick Institute, UK (virtual)

Cheryl Moore, Chief Research Programmes Officer, Wellcome, UK; GESDA Board Member

François Rivasseau, Senior Consultant, Science and Diplomacy, World Intellectual Property Organization, Switzerland

Summary

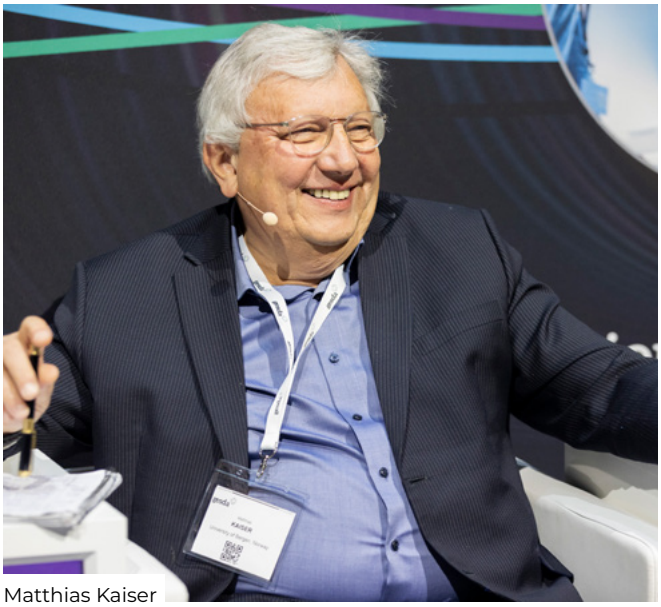
With the advent of transformative technologies such as AI and quantum computing, some scientists wonder if more regulatory mechanisms are needed to ensure more accountability and transparency – but without hindering the progress and benefits of science. For traditional self-regulatory systems to succeed, scientists must observe only voluntary guidelines and rules. The debate raises the "very fundamental question" of where the red lines are in research because scientists have tended to study whatever they find to be most interesting, said GESDA Vice-Chairman Patrick Aebischer, President Emeritus of Swiss Federal Institute of Technology in Lausanne (EPFL). "This is really at the heart of GESDA: We're trying to anticipate to the point that we can give us the time to know if something needs to be done," he said. "Are we ready to put red lines? And if so, how we would do it?"

Aebischer said that when answering that question, it's important to consider "society as a whole" and the difference between research funding agencies and the private sector that has an outsized impact on technology. "When we looked at embryonic research in the United States, there's a very interesting line between where some states said there is no support and the private institutions said, no, we're going to fund it," he said. Scientists "are probably the best positioned" to say where those red lines in research are, he said, but many of them probably "feel rather uncomfortable" doing so.

"If we wait too long and we're going to speak only when we feel comfortable, then it's too late. And I think the problem, too, that I see is we've seen an incredible acceleration in the pace of those discoveries and the breadth," Aebischer said. "It's not only recombinant DNA. We've heard from AI to neurotechnology to organoids and so on. We've never seen as many technologies that could have red lines or at least that would need prudent vigilance. The whole idea of GESDA is really to have this dialogue and have the policy people participating and framing the utilization of that research."

Privatization of governance is featured in the GESDA 2023 Science Breakthrough Radar® which anticipated that concerns for democracy would grow over the next five years as public disquiet forces lawmakers to examine the private sector role in regulating aspects of society. Within a decade, AI systems are expected to become standard tools in the legal system as high-profile legal cases make their advantages clear. Democratic systems are expected to make use of AI in the next quarter-century from now as AI becomes indispensable for local government and civil servants.

Another topic, responsible anticipation, is featured in the Radar as an invited contribution from the panel's moderator, Andrea Boggio, a Professor of Legal Studies at Bryant University. Boggio wrote that we live in times of great acceleration in science and technology, causing him to wonder what the scientific community might be able or have a duty to contribute to the process besides the creativity and intensity needed to achieve breakthroughs. His answer: responsible anticipation.



Matthias Kaiser

Francois Rivasseau

"This form of anticipation is linked to the human rights framework. With freedom comes responsibility, so responsible anticipation is an extension of the recognition of scientific freedom but also the human rights to science," he told the panel. "It's human rights that operate at the level of harnessing the benefits, so it's important, it's a right to share the benefits of scientific progress."

With the debate over AI, a few big industry voices tend to dominate the conversation, because they are very close to it and have been investing in it for a long time, and some governments, such as Canada, the European Union, the United Kingdom, the United States and China are engaged, said GESDA Board Member Cheryl Moore, the Chief Research Programmes Officer at Wellcome Trust. But in all research areas if we want to "push the frontiers of discovery and innovation we have to have the trust of the public because if we don't, we will have significant regulation," she said.

"Scientists are often cited as being those who are best positioned to determine those red lines. I represent a large group of scientists and they are deeply engaged in their work and know the potential for it. That said, there are other perspectives that must also be considered when we think about these things so that we have a well-rounded view," Moore said. "We need the public engaged in these conversations. We need public and private funders. We need publishers. We need a civil society. We need policymakers engaged from the very beginning."

Politics has long been an unavoidable factor for scientists and the direction of their research, which can depend on public and private funding agendas, cultural preferences and national biases. The history of eugenics, for example, shows how nations made a pseudoscience respectable and used it the justify the enforced sterilization of tens of thousands of people and, later, the Nazi genocide. Despite a recent trend in questioning the view that scientific research and knowledge should be free from tough regulation, legal systems often aren't equipped to deal with breakthrough advances.

"One of the problems in drawing red lines is that, of course, different jurisdictions, different countries may want to put those red lines in very different places for a variety of historical, religious or other cultural reasons. And that always poses an issue," said Robin Lovell-Badge, Principal Group Leader and Head of the Laboratory of Stem Cell Biology and Developmental Biology, The Francis Crick Institute, who advocated for more openness in science to encourage more public involvement early on. "I'm generally of the view that science should be open and allowed to explore different avenues. But I agree that in some cases that it can go too far. And things like dual-use research is one area which always provokes concern. But in others it may be too far."

Lovell-Badge said "scientists themselves should be drawing the red lines" but they also must become more proactive, highlighting some of the areas where technologies are raising issues that may be challenging societal views, and where the regulations and governance may be challenged and need to be dealt with or improved. "That's occurred in my involvement with science policy on a number of occasions," he said. "And that would be, for example, nuclear transfer and the prospects of reproductive cloning, which of course was generally agreed not to be allowed. And that's for very good, good reasons. But also, mitochondrial replacement techniques, which now are being used in the U.K. and Australia has approved the use of the technologies. But of course, other countries

don't want to go anywhere near it because they're concerned about it. It's sort of messing around with human life too much. There are issues about making mixtures of human and animal."

Audience member Daniel Bacinello, Director of Research at the Canadian Institute for Advanced Research, said it's challenging to regulate before a technology is developed, "so how do we regulate, for example, fundamental physics? It's easy to regulate once the technology is produced."

François Rivasseau, a Senior Consultant to the World Intellectual Property Organization and former Ambassador of France in Geneva, said the answer for him about where to draw the red lines is obvious. "Yes, we already have a lot of red lines in science, and we should continue to have them. The problem is not to know if we need red lines," he said. "The problem is to know how to build them and for doing what? We have red lines. I spent 15 years in nonproliferation and disarmament. We have red lines on nuclear weapons, on chemical weapons and biological weapons. It's more difficult, obviously, to monitor the red lines in a biological lab than in a nuclear plant. But the experience of this specific field for 30 years now shows us that it is feasible, it is fairly feasible."

With different jurisdictions reaching different conclusions, regulations for modern scientific collaborations "must be worldwide, otherwise it will not work. But the reality of today, we have a decoupling between strategic geopolitical decoupling between the West and China and Russia to caricature a bit of the situation. Makes it particularly difficult to conceive such an effort," said Rivasseau. "It has to start, in my view, from two angles. First, for civil society and the governments ideally building up on the civil society feelings, and of a scientific community on the other hand. Because they are the only ones who really know what we are talking about."

Matthias Kaiser, Emeritus Professor, the Centre for the Study of the Sciences and the Humanities at the University of Bergen in Norway, said he's "not a great fan of more and more red lines for research. That much said, I very much agree with what other people have said about the importance of public engagement. Now, let me explain a little bit, first of all, why I'm skeptical about red lines. First of all, if you look at the history of science, we see that there have been many red lines in history, like not being allowed to cut up dead bodies to learn something about human physiology. But also, there have been new red lines that were not observed earlier, like animal experiments coming up. So, we have a dynamic there. And that dynamic is very much due to the historical, to the cultural development of the surrounding society. It's always embedded in something. Now, I think it is very important to have some red lines, particularly related to human rights and human dignity."


Andrea Boggio


Cheryl Moore

In Kaiser's field of food science, he said, there are enormous dilemmas over the kind of research that is allowed but it is "based on a scientific community with very good intentions" in which researchers are able to work together across disciplines and join with Indigenous communities in seeking to change their food production and to take care of biodiversity. "What my call is basically *not* for work on defining always new red lines but working out these value dilemmas that we face in our research in this anticipatory process and seeking to broaden the dialogue around that research."

An audience member, Karl Thibault, a physicist and Research Coordinator at the Institut Quantique in Sherbrooke, Quebec, Canada, noted that several people on the panel mentioned that scientists should be the ones that define the red lines from an ethical standpoint. "But in my experience," he said, "most scientists have basically no background in this, and they have no training at all, like in the bachelor's degrees and everything. We don't really have courses in ethics. I'm just wondering why you believe that they're the ones that should do this, while they have no training in this?"

The answer came from audience member Pascale Fung, Chair Professor of the Department of Electronic and Computer Engineering and Director

of the Center for Artificial Intelligence Research at the Hong Kong University of Science and Technology. "Just to say in AI, we do have a different levels of ethics committee. Every single conference, every single journal review committee consists of scientists. You're right, we were not trained in ethics, but we learned," she said. "And we work with ethicists, and we work with social scientists and psychologists all the time. It's not perfect, but we mean well, thank you for your comment. We come in peace and we're trying to do the best."

More information

Explore the 2023 GESDA Science Breakthrough Radar®

Session recording on YouTube

Key messages

- There's growing debate on whether more regulatory mechanisms are necessary to ensure accountability and transparency in the development of transformative technologies like AI and quantum computing but the challenge is how to establish red lines in research without impeding progress.
- The GESDA Science Breakthrough Radarâ highlights the importance of responsible anticipation, emphasizing the need or duty of the scientific community to contribute to the ethical aspects of breakthroughs.
- While scientists might be best positioned to determine potential red lines in research, conversations that include perspectives from all groups of society are needed, including the public, public and private funders of research, publishers, civil society and policymakers.
- One of the problems in drawing red lines in research is that different jurisdictions and different countries may want to put those red lines in very different places for a variety of historical, religious or other cultural reasons, so any regulation for modern scientific collaboration must be worldwide otherwise it will not work.

Thursday 12 October, 11.00 – 11.45 CET

Anticipatory Briefing

Embodied Neuromorphic Intelligence

Chiara Bartolozzi

Embodied Neuromorphic Intelligence

Equipping robots with neuromorphic technologies ranging from perception to motor control could allow robots to seamlessly integrate in society, offering endless possibilities for their application. Join this anticipatory briefing to hear about the latest advances in neuromorphic engineering and the opportunities and challenges this presents over the next 5, 10 and 25 years.

Speakers

Moderated by:

Laurent Haug, Founder, 200ideas, Switzerland

With:

Chiara Bartolozzi, Senior Researcher Tenured – Principal Investigator, Italian Institute of Technology, Italy

Summary

Fictional robots have been entertaining, helping and challenging us for centuries now in books and more recently on our screens, but the technology to design and equip real robots with independent perception and motor control remains a major challenge because it requires computing that goes far beyond digital zeros and ones. It needs neuromorphic computers that simulate the way our brains process information. Relying on artificial neurons and synapses, these computers could someday enable robots to solve problems, recognize patterns and make decisions in a way that lets them find their own place in society. But not so fast: first we need to understand why bees, squirrels and other cute animals with small brains are so good at doing certain things, according to Chiara Bartolozzi, a Senior Researcher Tenured - Principal Investigator at the Italian Institute of Technology.

Bartolozzi, an expert in neuroinformatics and engineering, applies what she calls "unconventional computing" to the design of robotic platforms, aiming to create autonomous machines. "The idea in the research that we do, that we call neuromorphic engineering and computation, is to look at animals and try to understand why animals are so good at doing certain things with, you know, such small brains with only very few and small energy consumption. An animal can go around the world, find food, find mates and exhibit very complex behavior and intelligence," she said. "And this is something that robots cannot do. So, the idea is to understand how come the computation that is performed by animals in their brains is so much better than what we have in current technologies."

The research compares digital computation that does things in a sequence with neural computation that can have a high degree of parallelism. Neurons can interact with each other in a recurrent way, so the flow of information moves forward, backwards, and laterally. "There are a lot of connections between neurons so it's performing in a very different way," said Bartolozzi. "The variables that we use in digital are zeros and ones. You have switches that turn on and off, and with that you use these as building blocks to compute a mathematical equation, for example. While in the neural systems, the variables are analog. They are molecules that move from one side to the other of the neuron so that they create changes in how the neurons react to communication that arises from other neurons."

Digital computation relies on transistors that are fast and precise, but if one transistor fails the whole system is down. Neural computation involves neurons and synapses that are slow, imprecise and stochastic. Nevertheless, the computation we do in our brains usually is exacting and trustworthy. "We do what we need to do at the precise time we need to do that most of the time and reliably," she said. "Another big difference is that in traditional computing, you have on one side the CPU that is the central processing unit that does the operations, and on another side, you have a memory. And you have to take data from the memory, bring that data to the central computing unit and do the computation and then bring that data, the result of the computation, back. This is where your energy is wasted. While in the brain, you have neurons and synapses that are connected, and the information is in the connectivity between these neurons and synapses. And so, what we say is that brains do in-memory computing. The memory is co-located with the computing elements. You don't have this back and forth of data that costs a lot. Another very big difference that is really related to tasks that robots have to do, for example, is how

we acquire sensory information. This is kind of the basis of everything. You wouldn't be able to do anything if you don't receive information from the external world, if you don't see something, if you don't touch something."

Unlike humans who can assess the importance of what's being sensed in real time, machines take in information from the outside world through cameras and other sensors and can't necessarily differentiate between what's important and what isn't. "This is kind of one of the main results that we have now in the neuromorphic engineering domain is to have what we call event-driven neuromorphic sensors that work similarly to our sensory systems," Bartolozzi said. "And we have vision sensors that now, for example, are produced also by Sony, so by big companies that are starting to invest in this domain. And we also work on other sensory modalities. I personally work a lot on tactile systems for robots. And, you know, how you acquire the information changes how you have to process the information and how easy it would be to extract what is relevant to guide my behavior or the behavior of an artificial system. Another big difference that we've started looking into now is that artificial intelligence nowadays is mostly disembodied; it's in a computer. It doesn't have a body that interacts with the external world. And this changes a lot. Because if I have a body and I act, I can change how I acquire information. I can pick up an object."

Neuromorphic sensory devices are essential in robotics because they convert external optical or mechanical signals into electrical pulses for neurorobotic brains. The neuromorphic electronics that are needed for intelligent robotics aim to mimic the structure and functionality of the human brain, which relies mostly on visual signals to read the external world. The use of microelectronics plays a key role, requiring interdisciplinary work among biologists, circuit designers, physicists, materials experts and others. Energy conservation in neuromorphic engineering is important, too, because in humans a great number of neural sensors, including visual and tactile receptors, are at work. Ethics experts also are needed to assess the consequences of combining intelligence with artificial systems.

"The technology is mature for the event-driven vision sensors. What you see here is a humanoid robot that is called iCub," Bartolozzi said, motioning toward a picture of a baby-sized robotic figure with a white plastic face and pink lips and eyebrows that the Italian Institute of Technology uses as a platform for researchers to collaborate in developing and testing embodied AI algorithms, and in studying human-robot interactions. "There's still a lot of work to be done, but using a neuromorphic type of encoding, like the same sensory encoding in the tactile sensors, gives a more natural feeling to the prosthetic user when they give tactile feedback. Also, since these systems have low power and you

Chiara Bartolozzi

can design small circuits, we are going towards wearable devices that can monitor what a user is doing and can so inform an artificial system that needs to collaborate with the person."

Their work is starting to involve other technologies, such as photonics, organoids and quantum computing, and the iCub robot is only intended for use as a research platform and isn't considered to be safe to use around people. "The former director of my institute used to say this is the Ferrari of robots; you don't give a Ferrari to a person driving in the street," said Bartolozzi, but ultimately "the idea is to design robots that are useful." To that end, researchers are considering applications like robotic health care companions or environmental and agricultural monitors. "Now we are going towards something that is not completely autonomous but can share and collaborate with humans," she said. "We would have a lot of robots with a lot of specific tasks that you wouldn't even perceive as robots, because they are not humanoids or animals that you can recognize as an artificial agent."

More information

Explore the 2023 GESDA Science Breakthrough Radar®

Session recording on YouTube

Key messages

- Advances in neuromorphic computing and engineering are needed to equip robots with independent perception and motor control, which would allow them to solve problems, recognize patterns and make decisions autonomously.
- Researchers are turning to the natural world for inspiration: understanding how small animals are so good at carrying out complex tasks with such small brains and very little energy consumption is inspiring scientists to study how the computation that is performed in animal brains is so much better than what exists in current technologies. The answer lies in comparing digital computation with neural computation that can have a high degree of parallelism.
- One of the major advances in the field has been the advent of event-driven neuromorphic sensors, which work similarly to the human sensory system, allowing robots to better assess the importance of what's happening in their environment, unlike artificial intelligence systems which are disembodied from the environment.
- Advancing research in this field requires interdisciplinary work among biologists, circuit designers, physicists, materials experts as well as ethicists to assess the consequences of combining intelligence with artificial systems.
- Eventually, the goal of the field is to design robots that are useful and can seamlessly integrate into society as robotic health care companions or environmental and agricultural sensors.

Thursday 12 October, 11.30 – 12.30 CET

Interactive Discussion

Shaping the Future of AI

Alexander Ilic, Alessandro Curioni, Sylvie Delacroix, Pascale Fung, Amandeep Singh Gill

Shaping the Future of AI

Although artificial intelligence has been in existence since the 1950s, the astonishingly rapid acceleration in its recent development means that new tools such as generative AI are already being widely adopted across industries and societies in record time. As the impact of AI transcends national boundaries, what opportunities and challenges remain in achieving international cooperation to ensure that AI is used for the common good and in ways that benefit all of humanity?

Speakers

Moderated by:

Alexander Ilic, Executive Director, ETH AI Center, Swiss Federal Institute of Technology Zürich (ETHZ), Switzerland

With:

Alessandro Curioni, Vice President, IBM Europe and Africa; Director, IBM Research Lab, Switzerland

Sylvie Delacroix, Professor in Law and Ethics, University of Birmingham, UK

Pascale Fung, Director, Center for Artificial Intelligence Research; Chair Professor, Department of Electronic & Computer Engineering and Department of Computer Science & Engineering, Hong Kong University of Science and Technology, Hong Kong SAR

Amandeep Singh Gill, U.N. Secretary-General's Envoy on Technology, USA

Summary

Before last year's phase of rapid acceleration in artificial intelligence, forms of AI had been around for decades including the first program, dating to the 1960s, for the game of Go, which originated in China more than 2,500 years ago. Google DeepMind's AlphaGo, an AI system that combined deep neural networks with advanced search algorithms, also was created to master the game of Go. It defeated a Go world champion in March 2016 and inspired a new era of AI systems. Now, AI is something that "touches all different places in the world, transcends the different national borders, but also cultural borders," said the panel's moderator, Alexander Ilic, a Professor and Co-Founder and Executive Director of ETH AI Center at Swiss Federal Institute of Technology Zürich (ETHZ).

In less than a year, ChatGPT rose to become the most prominent of a new era of generative AI systems that let users enter prompts to receive human-like images, text or videos created by AI. The large language model-based chatbot developed by OpenAI had 1 million users within a week of its launch in November 2022 and 100 million active users by the end of January 2023. GESDA Chairman Peter Brabeck-Letmathe told the 2023 GESDA Summit that the fast pace at which ChatGPT was adopted has provided "a wonderful example" of what GESDA tries to help the world avoid: confronting so many profound questions about a new technology *after* the fact.

In July 2023, United Nations Secretary-General António Guterres highlighted AI's potential to accelerate the U.N.'s 17 Sustainable Development Goals (SDGs) for 2030, but also cautioned against its malicious use. He welcomed calls by some nations to create a new U,N. entity that could "support collective efforts to govern this extraordinary technology," modeled after U.N. agencies like the International Atomic Energy Agency, International Civil Aviation Organization, or the Intergovernmental Panel on Climate Change. Amandeep Singh Gill, a diplomat and technology governance expert named the Secretary-General's Envoy on Technology in June 2022, said the U.N. already has "an existing foundation of work" for creating such an agency, ranging from UNESCO's first-ever global standard on AI ethics adopted by all 193 U.N. member nations in November 2021 to the International Telecommunication Union's AI for Good digital platform and annual summits.

"The Secretary-General has been, since his first mandate, very focused on the two aspects of this. One is the misuse, the risks and the challenges, and now medium-term into the future, but also the missed-use side of it, which is not missing the opportunity that AI offers to accelerate innovation for the SDGs and to bridge the last-mile gap in terms of sustainable development," Gill said, noting there has been a recent "proliferation of initiatives" to deal with AI by the United Kingdom, the Group of Seven leading industrial democracies, the United States, the European Union and Brazil. "The U.N. is ideally placed to go beyond these small groupings to a more universal, authoritative, inclusive setting, and build some connective tissue around these approaches so that the 160-odd countries, which are watching this as if it's a fast train moving in front

Alexander Ilic

Pascale Fung

of them – they can have more agency over this powerful technology. They can own this up for themselves."

With things moving so fast in the AI field, Gill said, the world needs to "accelerate two things: One is the international collaboration – transdisciplinary, transborder – and second, we have to accelerate the governance response. So, we need more innovation in governance. We need more collaboration on governance so that we can stay in step with technology and its outcomes. There will always be this pacing problem, but I think the time has come for governments and the private sector and civil society and independent experts to mobilize themselves more strongly."

An audience member, Denise Garcia, a Professor of Political Science and International Affairs at Northeastern University and author of a new book, *The AI Military Race: Common Good Governance in the Age of Artificial Intelligence*, said she had "grappled with the questions of creating governance on military AI" and wanted to hear the views of Gill and the other panelists. Gill answered that when he hears people talk about how fast AI is moving and that there's too little time to figure how to regulate it, he doesn't like "the pessimism in that" because it implies people lack agency over technology. "We can catch up. We can make sure that we create frameworks that are responsive. For instance, there is a layer of governance that you can put in place at the international level on the military application. This means reaffirming existing principles of international humanitarian law, weapons reviews, practical issues like that," he said. "We have to be proactive, we just can't sit back and let things happen to us. We have to reinforce international collaboration; countries and regions have to come together to treat this as a global problem, a global challenge for humanity, and we have to be optimistic about governance. I think greater investment is needed there, but we need to approach this with a positive frame of mind. We can do this."

Pascale Fung, a computer scientist and Professor at the Hong Kong University of Science and Technology, and also Director of its AI Research Center, said she has been a researcher primarily in conversational AI since 1988, working in the U.S., France and Japan before returning to China. "AI, this term, has been around for decades. But what we have today did not come from the school of AI. It came from information theory, statistical modeling – and actually, a lot of people who were acting here today, we did not consider ourselves AI researchers for decades. We worked on, as I said, modeling, signal processing, pattern recognition, and so on, and what happens is that we use that technology, use those kinds of approaches, to solve AI problems," she explained.

As AI models become more multi-modal, learning from images, video and audio, they become more powerful, because machines, like humans, learn from multiple signals from the physical world. The prospect of combining that growing intelligence with robotics is both exciting and scary to Fung, she said, partly because the machines, again like

humans, learn from all sorts of things that we can't anticipate. The robots could learn from humans, or from the physical world or even each other. One important research trend, she said, seeks to actively align AI models with human values.

"You need to separate science fiction from science, but many of us had never thought we would see this in our lifetime," Fung said. "I'm here to tell you, we are at the beginning of a new era. Some people call this artificial general intelligence. I don't know what to call it, but this is the new frontier model that's able to learn from everything under the sun and do things that we didn't make it to do, and we're not done discovering its capabilities. We actually have no theoretical understanding of the boundaries, capabilities of these models, which is an area that we want to research."

Fung described open science as the fuel behind AI's acceleration, similar to how open cooperation powers the work of international organizations. "Nothing is purely invented by the Americans or by the Europeans or by the Chinese. Everything has been a collaborative effort of the entire scientific community. This trend, we cannot stop it and we should not stop it," she said. "In the scientific community, the AI community, and in different professional organizations, we have our ethics committee, we have our ethics review guidelines. They're not perfect. It's a mess, because it's kind of a democratic process, right? You know, these committees are composed of researchers in these areas from around the world, and we represent different voices. And there's an argument and we try to move forward. So, it's not a clear path that we go from A to B, but we go like a little bit like this, a little bit back. And we listen to each other, we debate, and we go a little bit like this."

Sylvie Delacroix, a Professor for Ethics and Law at the University of Birmingham and also with the Alan Turing Institute, said Article 27 of the U.N.'s 1948 Universal Declaration of Human Rights has been "taken for granted" in recent decades despite its importance around the world as a guarantor of everyone's right to participate in and enjoy the benefits of science and culture. 'It's easy to take for granted. Why? Because you could say, well, it's been doing quite well recently," she said. "Thanks to the Creative Commons and open-source movements, millions of people have put their creative works online, openly accessible. Right. Now, none of the generative AI tools that make the headlines today would have been possible without access to this high-quality open content. And yet very few of those tools respect the reciprocity expectations without which the basically the Creative Commons movements become completely unsustainable."

Delacroix said she sees a parallel between the right to access water and the right to access culture, because of the elemental role of data in today's world. "It basically means that we need to start asking ourselves questions like can today's data needs be met within ecosystem limits? We're not used to thinking like that. But actually, it puts a very interesting light on current top-down regulation. Take the E.U. AI Act. It has recently introduced in its proposed framework very important transparency obligations," she said. "It's absolutely crucial, if we stand a chance of keeping these technologies at our service effectively, rather than the other way around. Transparency, audit possibilities are, I think, a cornerstone of any attempt to regulate AI."

Fung said she also wanted to be "a bit controversial" by acknowledging that a lot of people worry about whether AI poses an existentialist threat to humans. "And my question to all of us is: What if it does? So, it can, it will be able to do everything humans can do and better, in many areas. And this is the first time in human history we contend with another form of intelligence that in many ways surpasses us. It didn't just happen to us – we made it happen. But so, what if it is a threat to us? How can we prepare ourselves for such threats? So how can we?" she asked.

"What I care about is how can we use this kind of intelligence to better humanity, to solve complex


Amandeep Singh Gill


Sylvie Delacroix

problems that we cannot solve alone, such as climate change, such as hunger, such as inequality, such as war and peace," Fung continued. "How can we proactively use this kind of tool to help us solve our most complex problems. And the existentialist threat to humanity has always been humans. Not machines. So, let's think about how to use machines for peace, to better humanity in every way possible."

AI has to be demystified before we can understand what's happening with it and make objective, pragmatic decisions about its future and how to control its risks, said Alessandro Curioni, an IBM Fellow, Vice President of IBM Europe and Africa, and Director of the IBM Research Lab in Zürich. "There is a set of technology developments that made this possible," he said. "All the problems that we have been discussing in the past 10 years about transparencies, about explainability, about data provenance, about bias are amplified with the single big foundation models."

Curioni, an expert in computational materials sciences, asked whether it was wise to allow a handful of companies to retain control over AI but suggested that regulatory controls should be put on the *way* that algorithms are used, based on the level of risk they might pose, and not directly on

Alessandro Curioni

the algorithms. "If we put the right governance, an open approach is the best one because it is the only one that gets transparencies," said Curioni. "The governance has to be done in a way that if you find something that is wrong, you can go back and try to understand why it was wrong."

"I do believe that we do have an opportunity now really to demonstrate that our brain is better than anything else," he added. "It's a very good test to see if we are really better than machines."

More information

Explore the 2023 GESDA Science Breakthrough Radar®

Session recording on YouTube

Key messages

- From its development in the 1950s to the recent surge in generative AI, artificial intelligence has transcended national and cultural boundaries. Taking ChatGPT as an example, its fast adoption exemplifies the need for proactive consideration and discussion of profound questions about emerging technologies before it's too late to act.
- United Nations Secretary-General António Guterres recognizes AI's potential to accelerate the U.N.'s Sustainable Development Goals (SDGs) but emphasizes the importance of governance to prevent malicious use. There are calls for the creation of a U.N. entity to govern AI, modeled after U.N. agencies like the International Atomic Energy Agency, International Civil Aviation Organization, or the Intergovernmental Panel on Climate Change.
- While the speed in scientific advancement is clear, more innovation in governance is needed. Reinforcing international collaboration means that countries and regions must come together to treat this as a global challenge for humanity, while being optimistic about governance.
- As AI models become more multi-modal, learning from images, video and audio, they become more powerful, because machines, like humans, learn from multiple signals from the physical world. Some people refer to this trend as artificial general intelligence and researchers have yet to discover its full capabilities.

Thursday 12 October, 12.00 – 12.45 CET

Anticipatory Briefing

Secrets of the Deep Sea

Lucy Woodall

Secrets of the Deep Sea

The deep sea – which begins around 200 meters down and covers more than 60% of our planet – is the largest habitat on Earth and is largely unexplored, offering untapped potential for scientific discovery. Join this anticipatory briefing to hear about the latest advances in deep sea biology and the opportunities and challenges it presents over the next 5, 10 and 25 years.

Speakers

Moderated by:

Laurent Haug, Founder, 200ideas, Switzerland

With:

Lucy Woodall, Associate Professor, Marine Conservation and Policy, University of Exeter, U.K.

Summary

The ocean is responsible for about half of the oxygen produced on the planet and is believed to hold up to 1 million species of plants and animals – yet two-thirds of those species have not yet been discovered or officially described. It covers about 70% of Earth's surface, however, as of 2023 only a quarter of the global seafloor had been mapped. The part that holds the most mysteries, the deep sea, begins where the light starts to vanish, generally around 200 meters down, and is estimated to cover more than 60% of the planet. Further down, in places that most people never see, the temperatures rapidly plunge, and the water's weight becomes crushing. The only light to be found there is produced by bioluminescent animals and bacteria. "There are few people who ever go down to the deep sea, even though the deep sea is valuable to us," said Lucy Woodall, Associate Professor in Marine Conservation Biology and Policy at the University of Exeter and Principal Scientist at the Nekton Foundation. "The deep sea enables our global processes to happen, it does things like act as a sponge to suck up some of that excess temperature that we're creating through climate change."

Acting as a carbon sink, the ocean absorbs about 31% of the CO_2 emissions released each year into the atmosphere. That helps slow global warming in the atmosphere, the focus of the United Nations' annual climate talks, but the excess of carbon dioxide, methane and other greenhouse gases that are absorbed by the ocean is heating up Arctic and Antarctic waters, changing the water chemistry, and altering the natural processes that allow the water sinking at the polar environments to spread across the planet on the seafloor and to rise and create nutrient-rich waters in some of the most important areas, particularly around the equator. The ocean's carbon absorption leads to deoxygenation and ocean acidification; the dissolving carbon forms carbonic acid, which raises waters' acidity and damages hard-shelled creatures, causing a chain reaction that threatens the food chain supporting marine life. Add to that the impacts of plastic pollution, chemical waste and poorly managed, unregulated or illegal fisheries and you've got a recipe for disaster, according to Woodall.

"The ocean benefits us in multiple different ways. When we think about ecosystem services – and that's sort of the benefits of a system to the planet – we think about it in multiple categories, and one of those is regulatory: that allows us to breathe oxygen, to move through our daily lives and to really think around our climate," she said. "It's like a 3D conveyor belt moving across the planet and making sure that we're getting connected."

One of the primary challenges facing researchers is simply gaining access to the deep sea. It's difficult and it takes considerable resources, namely submergible vehicles that can transport people or are remotely operated. Scientists have traditionally used ships to photograph the depths or to collect samples of marine life, minerals and water. Now, many rely on human-occupied submersibles, remote-controlled deep diving vehicles, programmable robotic vehicles and autonomous underwater vehicles. But in a recent global study of ocean research needs, less than half the respondents reported having access to these types of vehicles, said Sheena Talma, a marine biologist and Science Program Manager for the Nekton Foundation, a U.K.-registered charity for marine research. Some 71% of respondents reported that "an increased access to deep submergence vehicles would significantly impact or transform how they do their work," she said. "It is clear that there are disparities when it comes to who is conducting and leading deep sea research, and this is largely based on what resources are available in different countries as well as institutions."

Over the next decade, there's an opportunity for a more transdisciplinary approach that combines physical, chemical and biological sciences with

social science that extends to “local and traditional knowledge holders,” said Woodall. “Doing that in an equitable way, where everybody understands how we work together, is going to be absolutely transformational in this space. There is also an opportunity for a new funding and accountability model. Traditional funding in North America and Western Europe has very much been, ‘You make me a proposal, I like that, I think you’re a great scientist, you go out and do it.’ Where’s the impact? We don’t know. Maybe it’s a great paper, but are academic papers the best way of communicating all our research? Maybe they’re not the only way for us to share our new findings. But, in fact, that model leaves out many forms of knowledge. It means that we’re not necessarily asking the right questions. So how do we co-create our questions and our solutions to the future to ensure we can have a more equitable planet and society? And in the next 25 years, when we’ve got all of that in the bag and we’re creating science together, I think we can have lots of autonomous robotics out there on the surface and on the seafloor, constantly collecting information. There could be an opportunity of using artificial habitats.”

UNESCO’s latest report on the state of the ocean from 2022 found “indisputable evidence of the continued, widespread and unabated increase of land pollution in the ocean” from nitrogen, phosphorus and plastic. It said their impact on marine life in all its forms is “ubiquitous,” with discernible consequences for human health. “Despite the global significance of ocean pollution, observations remain limited, geographically and thematically, being mainly concentrated at the ocean surface and in coastal areas,” the report said. “Very few observations have been made of floating macro-scale litter. The most poorly described region is the ocean floor, with relatively few observations of either micro- or macro-plastic litter, due to the practical difficulties and costs involved. However, it is considered to be the destination for much of the plastic entering the ocean.”

Ocean stewardship is featured in the GESDA 2023 Science Breakthrough Radar® with insights moderated by Robert Blasiak, a Researcher at the Stockholm Resilience Center. The Radar said new innovations in bioprospecting mean we are gathering unprecedented amounts of ocean data that has wide-ranging uses, such as conservation policy, drug development, bioremediants and enzymes. It also noted that the deep ocean is by far the largest habitat on the planet, in both area and volume, but also the least observed, though the GEBCO Seabed 2030 Project is mapping the sea floor. Within five years, it anticipated, widespread monitoring will be possible, and in a decade’s time robots will begin to gather data. In 25 years, policymakers will have global hydrosphere models.

Lucy Woodall

In 2023, the U.N. clinched a deal for a global treaty to strengthen marine protections on the high seas, which are the international waters beyond the 370-kilometer jurisdiction of coastal nations. The aim is to create a global network of marine protected areas covering 30% of the ocean by 2030 that will conserve the rich diversity of marine species' health and mitigate the rising impacts of climate change. No universal law exists to protect marine species and minerals in high seas that are beyond the coastal waters governed by the U.N. Convention on the Law of the Sea, which came into force in 1994. When the high seas treaty is ratified and takes effect, that will mark an "absolutely momentous time for the deep sea and the high seas," said Woodall, adding there also is an important cultural or spiritual component to the ocean that is worth protecting. "It will be the first time in history that we will have a legal framework to be able to govern and police our high seas."

Meantime, the prospect of mining companies gaining access to some of the deep sea deposits that are beneath international waters has become a major flashpoint between environmentalists and industry. The U.N.'s International Seabed Authority has been debating whether to allow mining companies to scour the ocean floor for polymetallic nodules and sulphides and cobalt-rich ferromanganese crusts. They contain metals and minerals such as cobalt, lithium and nickel that are increasingly used in commercial batteries, wiring and other popular consumer and low-carbon technology. "There's lots of competing interests, there's the opportunity and potential to be getting minerals that are considered important right now from the seabed," Woodall said. "The challenge we have in the deep sea is that often we don't have any baselines. We don't understand what's there. We know it's going to be impactful, and we know it's going to impact on multiple scales."

More information

Explore the 2023 GESDA Science Breakthrough Radar®

Session recording on YouTube

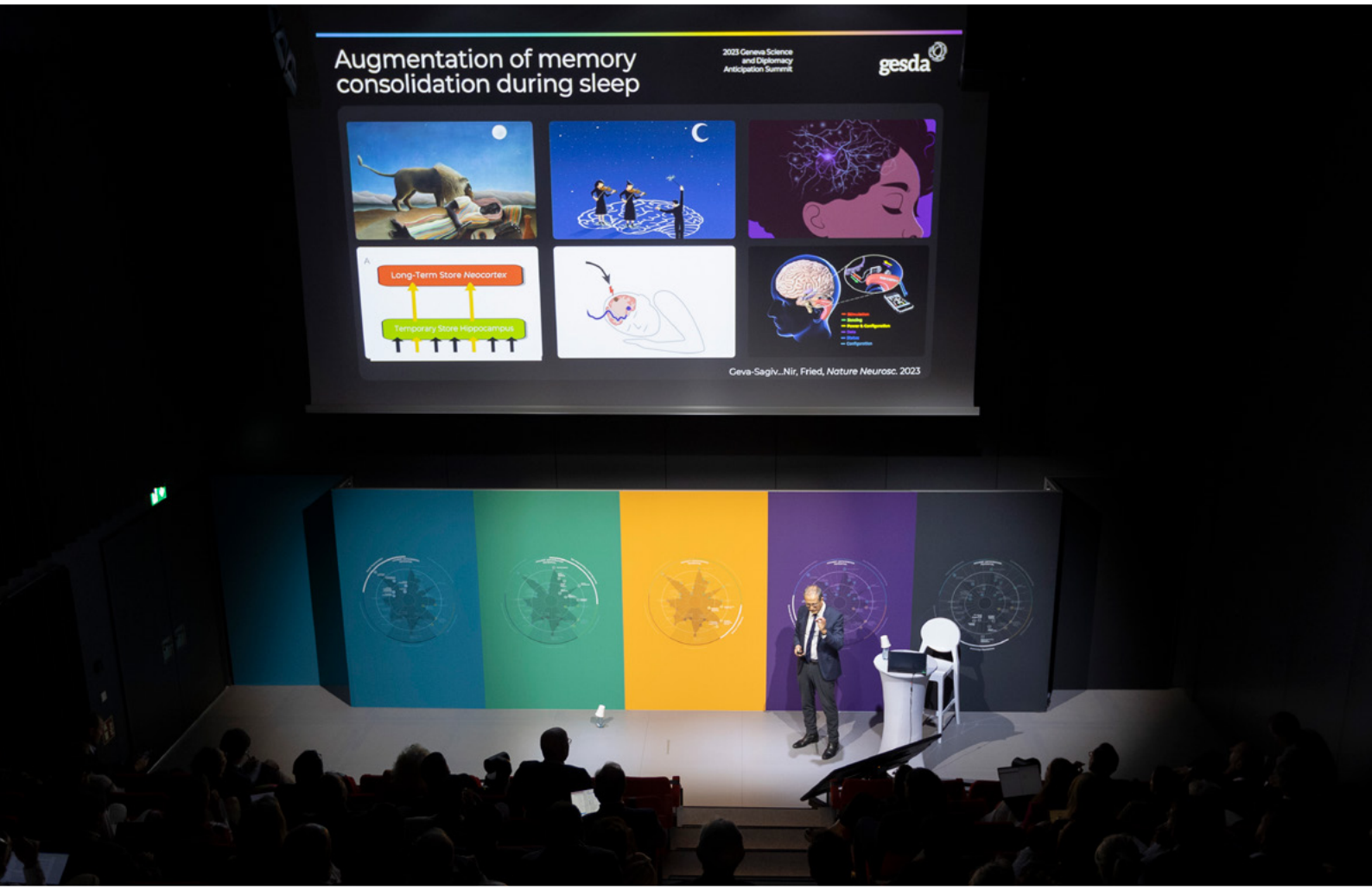
Key messages

- The ocean plays a crucial role in producing oxygen, acting as a carbon sink, and supporting global processes. It covers 70% of Earth's surface and is integral to climate regulation, but its deep sea, which covers over 60% of the planet, remains largely unexplored.
- Human activities, including CO2 emissions and plastic pollution, are negatively affecting the ocean. The ocean's absorption of carbon leads to deoxygenation, acidification, and threats to marine life. Plastic pollution, chemical waste, and poorly managed fisheries exacerbate these issues.
- Gaining access to the deep sea is challenging and resource intensive. Traditional methods involve ships, but newer technologies like submersibles and autonomous vehicles are essential. However, there are disparities in access to these technologies globally, impacting deep sea research.
- The next decade presents an opportunity for a transdisciplinary approach, combining physical, chemical, biological sciences, and social science. Inclusivity, incorporating local and traditional knowledge, and creating equitable partnerships can transform deep sea research.
- The U.N.'s deal for a global treaty aims to strengthen marine protections on the high seas, establishing a network of marine protected areas covering 30% of the ocean by 2030. Environmental concerns arise regarding deep sea mining for minerals, as competing interests and potential impacts lack proper understanding and baselines.

Thursday 12 October, 14.00 – 14.45 CET

Anticipatory Briefing

Augmenting Consciousness



Itzhak Fried

Augmenting Consciousness

From robotics to optogenetics to virtual reality, it's now possible to augment missing or damaged sensory inputs to consciousness – even specific aspects of healthy consciousness that we might want to enhance beyond current limits, such as attention, empathy and memory. Join this anticipatory briefing to hear about the latest advances in neurology and the opportunities and challenges that this presents over the next 5, 10 and 25 years.

Speakers

Moderated by:

Laurent Haug, Founder, 200ideas, Switzerland

With:

Itzhak Fried, Professor of Neurosurgery and Psychiatry and Biobehavioral Sciences, University of California, Los Angeles, USA; Professor of Neurosurgery, Tel-Aviv Medical Center and Tel-Aviv University's Sackler Faculty of Medicine, Israel

Summary

Missing or damaged sensory inputs – and even aspects such as attention, empathy and memory – can now be augmented through robotics, optogenetics and virtual reality. Researchers also are discovering how neurons in the human brain depict space and time, some of the building blocks of consciousness. One of those researchers is Itzhak Fried, a Professor of Neurosurgery and Psychiatry and Biobehavioral Sciences in the David Geffen School of Medicine at UCLA and Professor of Neurosurgery at Tel Aviv Medical Center and Tel Aviv University's Sackler Faculty of Medicine.

Fried, whose specialties range from advanced brain surgeries to deep brain stimulation, said one of the most basic yet difficult questions is how to define consciousness. "There's no single accepted theory of consciousness. The consciousness scientists are bickering," he said. "We are in the dark. We are asking ourselves, 'What about animal consciousness? What about machine consciousness? What about this word, which was never mentioned, artificially intelligent consciousness?' In the clinical world, we cannot wait until we find out what consciousness is, because we have to assess consciousness at every point in time. We have patients who are comatose. So, we've established practical and numerical ways of assessing consciousness that are based on the response of the unconscious or semi-conscious patient through various stimuli such as speech or pain."

The number of people living with dementia is estimated at more than 55 million worldwide, and each year there are nearly 10 million new cases, according to the World Health Organization. Over 60% of the people who have it live in low- and middle-income countries, where care options are more limited. Alzheimer disease is the most common form, causing up to 70% of dementia cases. "The numbers are staggering," said Fried, who is also known for his innovative approaches to studying epilepsy seizures, modern programs for the management of patients with epilepsy, and new methods for recovery speech and memory disorders. "We need to deal with this issue."

Consciousness augmentation is featured in the GESDA 2023 Science Breakthrough Radar® with insights from Fried, who anticipated that no standard, widely agreed definition of consciousness or agreed upon theory would likely emerge for the next quarter-century, meaning that other much-discussed issues like machine consciousness and animal consciousness also will stay unresolved. The Radar, however, found that efforts to augment human consciousness likely will reach maturity over the next 10 to 15 years. As with many medical applications, it said, technologies that spring from a clinical setting will eventually benefit the broader population because the same technologies that diagnose consciousness when there is a deficit or disorder can be used to enhance or augment healthy, functioning consciousness. They will also be helpful in more philosophical areas, it found, and that will improve our understanding of free will, self-autonomy and what it means to be human.

"The language of the brain is electricity," said Fried. "Neurons are really the atoms of cognition. There are billions of neurons and there are obviously more and more connections. And this is really the substrate of your mind. So, the next thing that I want to tell you is that electrical stimulation can modify the content of consciousness." Experiments with electrical stimulation of the brain date to the 1700s. American scientist Benjamin Franklin famously shocked himself in 1750 while trying to electrocute a turkey and came to recognize that passing electricity through the head could affect memory. In 1783, Jan Ingenhousz, a Dutch physician who corresponded with Franklin, confirmed the effect when he

knocked himself out in 1783 and lost his memory in an electrical accident.

To illustrate the modern possibilities, Fried played a video of a patient with electrodes in her brain for epilepsy monitoring who has "an emotional state of laughing" based on electrical stimulation. "This is real laughter. This is not just some artificial thing," he said. "The brain was able to complement the cognitive content, but the emotion was introduced by electrical stimulation and the motor program as well. We are dealing basically with atoms of cognition, specialized neurons. We have what's called the human connectome, which is all the connections between all of this."


Itzhak Fried, Laurent Haug

Fried said it's fashionable to talk about brain circuits identified with cognitive functions in the conscious state; researchers John O'Keefe, May-Britt Moser and Edvard Moser won the 2014 Nobel Prize in Physiology or Medicine for discovering cells that constitute an inner "GPS" or positioning system in the human brain. But this function probably is vanishing, Fried said, because we've been largely delegating it to our GPS-enabled phones and other devices. "So, what is it all about, really? We have a miraculous organ in the brain. It's a memory hub of the brain, and it looks just like a seahorse: hippocampus. This process of information becoming a content which can be consciously retrieved later is a property of this organ." During our deepest sleep, memories are replayed and transferred from the hippocampus to the rest of the brain, through a process called consolidation.

In another video, Fried displayed a patient who is shown images of Martin Luther King, Jr., Madonna, Marilyn Monroe, and the Titanic, and finally responds, repeatedly, to the Simpsons cartoons. "It's not a fluke," he said. "Something happened and the memory came in." The significance is that it may be possible to "predict minds before they are made," he said. "And then you can edit minds. That will be the next step. Maybe you want to take a deep breath?"

The ability to move a prosthetic limb through electrical impulses transmitted by thought illustrates the possibilities because it "goes back to the brain. The brain communicates with the arm. The arm communicates with the brain. Because you can see it's a closed loop," he said. "You can basically restore speech. Meaning, you can go directly from the brain and bypass motor problems en route."

By stimulating the hippocampus "we actually improve your memory for space, you know, finding your way home, or finding your car in the parking lot," he said, which prompted interest from the U.S. Defense Advanced Research Projects Agency, or DARPA, in the potential implications. "By stimulating during that period of consolidation when you are deep asleep, we have a closed loop. We kind of sense or record in the hippocampus, the seahorse. We stimulate the frontal lobe, and we help this interaction. When the patient wakes up, they remember better because of this, and while they are asleep. They don't do anything; they don't feel anything. Their memories improve."

A decade ago, the White House announced a U.S. initiative to accelerate development and application of new technologies that enable researchers to produce dynamic pictures of the brain that show how individual brain cells and complex neural circuits interact at the speed of thought. It also launched a DARPA program to develop a fully implantable, closed-loop neural interface capable of restoring normal memory function to military personnel suffering from brain injury or illness. Five years ago, it successfully implemented in humans a proof-of-concept system for restoring memory function by facilitating memory encoding using the patient's own neural codes.

"We all accept hearing aids, you know, what's wrong with a memory aid?" Fried asked. "If it can be done. But can it be done? That's the question. Can it be done on a practical level? I mean, can it be done non-invasively? What I want to say about the issue of editing memories is that we have four levels. One is decoding, meaning we translate neural activity into a particular memory to a particular movement. We are very good in the computational aspect already. We can really enhance the system, certainly in motor, but we can start maybe to enhance it in memory. Now what about inception and deletion? Inception, meaning introducing a foreign memory. Or deleting a specific memory? You may look at it as some kind of despotic future but, in fact, it can delete a post-traumatic memory. It can have clinical uses."

Elon Musk's Neuralink company is working to connect thought to devices with implantable brain–

computer interfaces, Fried said, and "we are talking here about the speed of thought now, which is even faster than the rate of speech. We are trying to summarize what we are against and then what we are for so that we can maybe edit the content of human consciousness." More externalized brain functions and "something like hybrid consciousness" will soon come, he said, including more "delegation of brain function to external devices and increasing internalization of appendices."

Researchers have discovered even bacteria, a single-celled microbe, may be able to form memories and pass them on. In humans, memory augmentation will probably enter clinical use within a few years, he said, and within a decade, we may be able to augment memory during awake-sleep cycles as part of clinical practices that specialize in memory aids for early dementia. "First, we're trying to get to the speed of motor. Second, to the speed of speech. Third, to the speed of thought," he said.

When considering the relationship between artificial intelligence and human beings from the perspective of consciousness, or whether AI has a moral status, Fried said intelligence must be considered separately from consciousness. "A lot of the computation that you are doing, a lot of cognitive function is happening at an unconscious level really," he said. "Because otherwise, if you need to be conscious to do everything, you wouldn't function, and you will not survive. So, there is really a major difference, I think, between artificial intelligence versus natural intelligence."

More information

Explore the 2023 GESDA Science Breakthrough Radar®

Session recording on YouTube

Key messages

- Defining consciousness remains a complex challenge in neuroscience, with no widely accepted theory. Clinical assessments of consciousness, crucial for comatose patients, currently rely on practical and numerical methods, but defining it more clearly, including animal and machine consciousness, would be a game-changer.
- There's a growing burden of cognitive health issues, with over 55 million people worldwide living with dementia. Over 60% of those affected live in low- and middle-income countries, where care options are limited, so augmenting cognitive function would have societal benefits.
- The GESDA 2023 Science Breakthrough Radar® anticipates that, despite ongoing debates in consciousness science, efforts to augment human consciousness will mature in the next 10 to 15 years. Emerging technologies, initially developed in clinical settings, may eventually benefit broader populations and contribute to philosophical understanding.
- Applications of augmenting consciousness have drawn interest from the commercial sector as well as government agencies in recent years, but ethical considerations remain.
- When considering the relationship between artificial and human intelligence from the perspective of consciousness, one can ascertain a major difference: a lot of cognitive functioning happens on an unconscious level, otherwise humans wouldn't survive.

Thursday 12 October, ??.00 – 14.45 CET

Interactive Discussion

Tackling Tomorrow's Health Challenges Today

Tolullah Oni, Tan Chorh Chuan, Ryan Morhard, Mubeen Goolam, Mariam Ezz El-Arab

Tackling Tomorrow's Health Challenges Today

From designer phages that could allow one to engineer viruses that augment human, animal and plant health to improvements for mental health in the metaverse through shared virtual spaces, science for health is advancing at a rapid speed. How can organizations best be prepared to anticipate tomorrow's trends?

Speakers

Moderated by:

Tolullah Oni, Clinical Professor, University of Cambridge UK

With:

Mariam Ezz El-Arab, iGEM Ambassador for Africa, Egypt (Winner of the 2023 GESDA Youth Anticipation Initiative)

Mubeen Goolam, Stem Cell Researcher, Department of Human Biology and Neuroscience Institute, University of Cape Town, South Africa

Ryan Morhard, Senior Director for Policy and Partnerships, Gingko Bioworks, USA

Tan Chorh Chuan, Chief Health Scientist, Ministry of Health; Executive Director, Ministry of Health Office for Healthcare Transformation, Singapore

Summary

By 2050, the number of people aged 60 years and older is expected to account for 22% of the world population, up from 12% in 2015, and to outnumber children who are younger than 5 years old globally. Four-fifths of these older people are expected to be living in low- and middle-income countries, according to figures from the World Health Organization, and all countries will face major challenges ensuring their health and social systems are ready for this demographic shift.

Fueling the shift is a boom in science for health that is advancing at a rapid speed, helping people to live longer lives. Most people today can expect to live into their 60s and beyond. By mid-century it's expected that the number of people aged 80 years or older will reach 426 million worldwide – triple the number from 2020. One place that has been preparing its health and social systems for this demographic shift is Singapore, where a 76-year-old Singaporean has a similar age-related disease burden as the average 65-year-old globally. That required decades of planning and investment in health care and there are lessons for other organizations in preparing to anticipate tomorrow's health trends today, according to GESDA Board Member Chorh Chuan Tan, Chief Health Scientist and Executive Director of the Office for Healthcare Transformation in Singapore's Ministry of Health.

"We do need interventions with most health care systems moving towards population health and preventative health, towards more value-based outcomes and greater health equity. So those are the goals of most health care systems," he said. "For many countries around the world, healthy longevity is also a key part of what we need for the future; that anticipation part is very important, because it allows us really to look at science and technology around the world and to see where potential solutions might come. But we also do know that there are negative and unintended consequences associated with innovation and our goal as policymakers is to try to maximize the benefits and try to reduce the downsides."

One of the main challenges is that most policymakers are not well attuned to the fast-changing science landscape that requires not only keeping up with the science but understanding its potential implications, he said. During the COVID-19 pandemic, for example, as vaccines became available, many policymakers were unprepared for disinformation, vaccine hesitancy and resistance. "Being able to look at the potential solutions for the future and setting out some of the risks associated with them is an important part of bringing on board policymakers to be better able to shape this," he said. "You have to have a very deliberate and intensive effort to engage the people who are hard to reach if you really want to get good outcomes. Because in most health systems, it's that 20% of harder-to-reach people that drive many of the poor outcomes for the whole health system."

Beyond just better health systems a "whole of government, whole society approach" is needed, he added. "If we really want to drive prevention, it's really about physical activity, eating, mental health and cessation of smoking. Those four things account


Tolullah Oni

for maybe about 40% of premature mortality. And the best way to do that actually is not really to get individuals to change their behavior, but to change their environment. So, you can, if you design your neighborhoods to be more walkable, if you improve the food environment so that there are healthier choices, if you are able to drive smoking down to a particularly low level, it becomes the norm not to smoke. And therefore, these are things which actually can be done outside the health system and probably have a much larger aggregate impact together with what the health system is doing."

Health span therapies and interventions are featured in the GESDA 2023 Science Breakthrough Radar® which forecasts that anti-aging drugs and regimens will begin clinical trials within 5 years, health plans will begin to prescribe validated age-delaying therapies within a decade and medically preventive interventions will be able to stop people from getting ill in the first place within 25 years.

But in the face of so many breakthrough advances, science and technology anticipation can be difficult. For example, the decade-long span between the biotechnology tools that were available to navigate the H1N1 pandemic response and those that later became available for the COVID-19 pandemic response reveals "an incredible sort of dramatic improvement" in areas such as bio-surveillance, variant tracking and sequencing, said Ryan Morhard, Senior Director for Policy and Partnerships at Ginkgo Bioworks. "Those are the tools of biotechnology that helped us navigate the COVID response," he said. "I share that to just kind of highlight the difficulty around anticipating." Not everything in science has a serious, practical purpose, he added, and that shows the importance of play-driven creativity: "There's a very interesting company out there called Light Bio and they're making these light-up petunias. It's bioluminescent petunias, and these are flowers that light up."

Another type of research that some may not have anticipated earlier is taking place at the first brain organoids laboratory in Africa, where stem cells are cultured to form structures of the human brain that are "incredible for disease modeling and drug development," said Mubeen Goolam, a Stem Cell Researcher in the Department of Human Biology and Neuroscience Institute in the University of Cape Town, South Africa. "We intentionally went to a place that didn't have a technology to try and bring it there, because diversity of opinions and genetic diversity in the models that we generate are the way we make inclusive models, are the way we generate new ideas."

These kinds of new technologies "tend to increase the health care gap between the North and the South. The modern advanced forms of health care are only accessible in specific nations, in specific parts of those nations, particularly in Africa, which tend to get left behind. So, as we talk about development and the way we generate them, we also have to talk about the policies to make sure that they are equitably accessed and equitably spread across the world," said Goolam. And since scientists


Mubeen Goolam


Ryan Morhard

Tan Chorh Chuan

Mariam Ezz El-Arab

also tend to avoid contact with policymakers, he added, there's a need for more forums like the GESDA Summit where "we now have policymakers, decision-makers and scientists together talking about problems and talking about solutions that we can combine together."

Climate change and its impacts on agriculture highlight the drive for equality and more impressive "rising technologies" like those used in synthetic biology to create lab-grown meat that can reduce the carbon impacts and lessen food-borne diseases, according to Mariam Ezz El-Arab, a science writer and teacher who has been the iGEM (international Genetically Engineered Competition) ambassador for Africa and winner of the 2023 GESDA Youth and Anticipation Initiative from Egypt. "I saw this technology as something that can really give us an opportunity to thrive in climate change and in all the environmental changes we are facing and will be facing," she said.

An audience member, Kalonji Abondance Tshisekedi, a Ph.D. student in molecular biology at the University of the Witwatersrand, Johannesburg who is part of the GESDA Youth and Anticipation Initiative, said for those working to improve public health sometimes it "starts with the conversation that we have even with our friends just around the table when you tell them there's this company or this firm that makes meat, for instance, in the lab, and all of a sudden everyone just goes quiet as you are trying to explain to them the benefits they carry. And sometimes also what we don't learn as scientists and young scientists, is how can we make it easier for the community that we're trying to help to break down that information in such a way that they will also get to accept it."

Another audience member, Denis Naughten, an Irish Member of Parliament who has been serving as Chairperson of the Inter-Parliamentary Union Working Group on Science and Technology, said his nation changed its health system after asking the political decision-makers to map out a future decade of health services. "And the point I'm trying to make here is," he said, "we can talk with the policymakers, and the scientists can talk with the policymakers, but if they ignore the decision-makers, we're going to lead to the time lag in terms of the delivery and the implementation of this."

The panel's moderator, Tolullah Oni, a Clinical Professor of Global Public health and Sustainable Urban Development at the University of Cambridge, said the two points in the discussion that jumped out at her had to do with increasing the levels of diversity and deliberation. "If we want to tackle tomorrow's health challenges today, we have to think in diverse ways, whether that is from the sectors that we engage with, the opinions that we engage with," she said. "We have to be deliberate in the efforts and who we reach and who we are engaging with, how we are preparing a pipeline and supporting a pipeline, but really how we are experimenting with different technologies, with different tools, different systems, different processes, different governance mechanisms, different institutions. And I think bringing all of that together, the future is bright."

More information

Explore the 2023 GESDA Science Breakthrough Radar®

Session recording on YouTube

Key messages

- By 2050, individuals aged 60 and older are expected to comprise 22% of the global population, posing challenges for health and social systems worldwide. The majority of elderly individuals will reside in low- and middle-income countries, necessitating comprehensive preparation for the associated demographic shift.
- Policymakers face challenges in keeping pace with evolving scientific landscapes, as highlighted during the COVID-19 pandemic. Anticipating future health trends is crucial for shaping policies that maximize benefits and minimize risks associated with innovation, requiring engagement with hard-to-reach populations.
- A holistic approach is essential for effective health systems. Emphasis should be placed on preventative measures, including physical activity, nutrition, mental health, and smoking cessation. Changing environments to promote healthier choices, beyond individual behavior change, is necessary.

Thursday 12 October, 15.00 - 15.45 CET

Anticipatory Briefing

How to Build a Human

Robin Lovell-Badge

How to Build a Human

From starting life as a single cell to multiplying into the millions of cells that make up the human body as we know it, new technologies are allowing researchers to shed light on cell fate and the potential to modify it. Join this anticipatory briefing to hear about the latest advances in stem cell biology and developmental genetics and the opportunities and challenges this presents over the next 5, 10 and 25 years.

Speakers

Moderated by:

Laurent Haug, Founder, 200ideas, Switzerland

With:

Robin Lovell-Badge, Head of the Laboratory of Stem Cell Biology and Developmental Genetics, Francis Crick Institute, UK (virtual)

Summary

One month before the 2023 GESDA Summit, scientists reported they successfully used embryonic stem cells cultured in the lab to grow a complete "embryo model" of a human embryo, something that closely resembled a 2-week-old human embryo and released hormones that even made a lab pregnancy test turn positive. The breakthrough at the Weizmann Institute of Science's Jacob Hanna Lab in Israel "showed this remarkable ability to self-organize, self-pattern into structures that look remarkably like early human embryos," said Robin Lovell-Badge, the Principal Group Leader and Head of the Laboratory of Stem Cell Biology and Developmental Biology at the Francis Crick Institute. Research into lab-grown human embryo models is valuable due to the abiding mysteries around the origins of the early embryo once it implants in the womb and changes from a few cells into an elongated shape. It has fueled hopes of finding more ethical methods of conducting research into infertility, drug testing and the growth of tissues that can be used in transplants, but it also has revived some of the lingering ethical and legal questions or fears about the possibilities of human cloning or unethical experiments on embryos. It is also worth remembering "there's a lot of stem cell biology that goes on which is not controversial," said Lovell-Badge. "You have other stem cell types which may be a little artificial in some respects, that are able to give many, many more cell types, different types of cells, so they're not confined to single organs. And, indeed, when you're talking about pluripotent stem cells, these are cells that can give rise to any cell type in the body."

Pluripotent stem cells, a particularly potent type of embryonic stem cell because they form all three basic body layers – ectoderm, endoderm and mesoderm – normally exist only in early embryonic development. Scientific breakthroughs using them, including a method of deriving embryonic stem cells from early mouse embryos in 1981 and a method of deriving stem cells from human embryos and growing the cells in the lab in 1998, are clearly valuable in many respects, Lovell-Badge said. Another type, *induced* pluripotent stem cells, are adult cells that have been reprogrammed back into embryonic stem cell-like cells and exhibit "pretty much identical properties," he said. Scientists used them to show they could create something that would give rise to a whole animal, including the first clone of an adult cell, Dolly the sheep, in 2006. "There have been various labs trying to see what happens if you can coax these early embryonic stem cells to develop in a rather disorganized fashion, which is what would normally happen if you just put them in a petri dish and let them grow – if you could make them give rise to structures that more closely resemble an embryo."

One of the ideas behind this work is to be able to use these as models of normal human embryos, since it's difficult to obtain human embryos to work with in a lab; some countries forbid it. "You can use these to study aspects of why a lot of embryos don't make it during in vitro fertilization procedures – why a lot of embryos that begin then fail and you have early miscarriages – and to understand congenital disorders," he said. "And of course, people are very concerned ethically about using the normal human embryos that are left over from IVF programs, even if they are being willingly donated by couples for research. So, using something which is not an embryo might overcome some of those ethical issues. Jacob Hanna also suggests that you might be able to use these structures as sources of cells eventually for transplantation to deal with the lack of organs for transplant. But that's, I think, a long way off. Now, the issue is that, because scientists are trying to develop models of other human embryos and they want them to be as close as possible to human embryos, one of the issues becomes at what point would you say, well, they're too close, they are actually human embryos, and you shouldn't be doing the research on them. Or you should be governed as if you were doing human embryo

research and not stem cell research. And so that's one of the big issues. The other big issue is, well, you've got to know that they're normal. If they really want to use them as a validated model, you have to validate them against normal human embryos."

The longer these embryo models are cultured, the more likely it is they will correspond to normal human embryos, which are prohibited under some laws – and most commonly accepted science policy and regulation – from being kept alive longer than 14 days after fertilization. "Should the 14-day rule be extended? That's a big question in the UK at the moment, but also in several other countries beginning to look at this," said Lovell-Bridge. More questions are being generated by research that involves the use of organoids – tiny, self-organized three-dimensional cell cultures that replicate the complexity of human organs and can be generated from pluripotent stem cells or adult stem cell-containing tissue samples. "It's become very clear that you get good connections made to nerves talking to each other in these structures," he said. "And then if you hook them up to a motor system such as a muscle, if you've got a bit of cortex, you've got motor neurons and another organoid that's giving rise to motor neurons, it will then connect to muscle cells. If you can trigger a response in the first part of a structure and you can do that electrically, or if you modify the cells that you begin with, just by shining a light, appropriate light, onto the structure, you'll get nerve impulses coming from the first bit to the motor neurons, to the muscle, and the muscles would contract. People are starting to get worried a little bit about the complexity of these things."

If they could be derived from induced pluripotent stem cells, that might alleviate some of the worry, according to Lovell-Bridge, and yet "you're getting close to something which is behaving like a functional circuit in a person. And then at some point people are going to start worrying, 'Well, are these structures capable of feeling pain? Are they capable of some form of consciousness?' You can see that that is going to become an ethical challenge at some point." Some experiments have shown that human neurons in vitro can be connected and embedded in a simulated game world, mimicking the arcade game Pawn, where they will self-organize in a goal-directed manner in response to sparse sensory information about the consequences of their actions, termed *synthetic* biological intelligence. "There's no evidence that this is really any form of synthetic biological intelligence or consciousness that we really need to worry about. This is simply showing that you can use these structures in the same way as a neural network in a computer," he said. "But you have to be very careful with the language in this case, particularly as they refer to the structures of these things growing in culture as 'dish brains.' And I think that highlights some of the issues in this whole field – that you have to be very, very, very wary about terminology. They should never be called brain-organized because they're not representing our brain. They should be called cerebral organized."

Synthetic biology is featured in the GESDA 2023 Science Breakthrough Radar® with insights from Bridget Baumgartner, Director of R&D at Revive & Restore, and Andrew Hessel, Chairman and Co-founder of the Genome Project and Advisor and Co-founder of Humane Genomics. They noted that this set of technologies which enable the modification and creation of living cells and organisms, and of their building blocks, could lead to major breakthroughs in fundamental biology and possible applications in fields ranging from nutrition to pharmaceuticals and engineering. "The time may come when we can use these techniques to program functionality into living organisms in the same way that we can program a computer to perform specific tasks," the Radar said. "However, this is profoundly challenging because of the extreme complexity of living organisms."

The ethical dimensions of research into how to build a human can quickly become contentious, ranging from questions about genetically related children who come from different types of parents or from a single donor to the implications of so-called designer babies or heritable genome editing. It's important to reflect on the rationale for the 14-day rule which, at least in the UK, represented "a compromise between those who wanted to do research in early human embryos and those who objected to it on fundamental principles," he said. "Fourteen days was chosen partly because there was a good biological landmark, which is the formation structure called the primitive streak. So visually, you could see that was where an embryo had got to, but also because twinning can occur any time up to 14 days. One argument was that the soul couldn't enter the embryo until after 14 days. Otherwise, identical twins would have the same soul, which evidently is not the case."

Lovell-Bridge said valuable research could be done in the 14- to 28-day stage referred to as "the black box period of development." After 28 days, it's possible to obtain material from terminations. "There's a fairly good morphological marker with a 28-day-old embryo, which is that the closure of the neural tube – so the neural tube is folded like a flat sheet, which then folds up, and it zips all the way along the top – and that's complete in 28 days in humans. And there's lots of structures that begin to develop during that period between 14 and 28 days," he said. "So, I think at the moment that would be a very good compromise, but that's my personal view. Some other people have been

proposing, well, let's make it incremental, let's say 21 days. Others are saying, well, just leave it open-ended, because really it all depends on what could be justified in terms of the importance of the research. If you have a really good research question that required taking it up to 35 days, well, why not? I think that might be okay as long as you have very robust mechanisms of scientific review, ethical review and oversight to make sure that you know what's going on. I think that would be okay. And that is my general view. What you want is a robust regulatory oversight system."

More information

Explore the 2023 GESDA Science Breakthrough Radar®

Session recording on YouTube

Key messages

- Scientists have had recent success in using embryonic stem cells to create a lab-grown "embryo model" resembling a 2-week-old human embryo. The breakthrough offers potential applications in infertility research, drug testing, and tissue growth for transplants but raises ethical questions about human cloning and embryo experimentation.
- Lab-grown embryo models could serve as ethical alternatives for studying normal human embryos or addressing challenges associated with obtaining human embryos for research. However, ethical dilemmas arise concerning the definition of these structures as embryos, embryo viability limits, and the need for validation against normal human embryos.
- Three-dimensional cell cultures known as organoids, replicating human organ complexity, are generated from pluripotent stem cells. Concerns arise as connections between nerve cells within organoids exhibit complexity. Questions about the structures' potential to feel pain or possess consciousness emerge, posing ethical challenges.

Thursday 12 October, 15.30 – 14.45 CET

Interactive Discussion

Science Diplomacy at Scale

Martin Chungong

Science Diplomacy at Scale

Transboundary challenges such as Covid-19 or the climate crises can only be addressed through global collaboration, however, geopolitical tensions point in the opposite direction as nations retreat from multilateralism and erect barriers to international collaboration and challenges to evidence-informed policymaking. Join this session to learn how a globally recognized science diplomacy curriculum and capacity building framework dedicated to effective multilateralism will equip future leaders and their institutions to tackle emerging global challenges.

Speakers

Moderated by:

Annika Brack, CEO, International Center for Future Generations, Belgium

Opening remarks by:

Martin Chungong, Secretary-General, Inter-Parliamentary Union

With:

Stephanie Balme, Research Professor, Sciences Po Paris (CERI/PSIA), France

Jan Marco Müller, Coordinator, Science Diplomacy and Multilateral Relations, European Commission (virtual)

Marcella Ohira, Deputy Executive Director, Inter-American Institute for Global Change Research

Daan du Toit, Deputy Director-General, International Cooperation and Resources, South African Department of Science and Innovation, South Africa

Closing remarks by:

Martin Smith, Head of Policy Lab, Wellcome Trust, UK

Summary

As Russia's war in Ukraine shook Europe and tensions between the United States and China rippled around the world, the first-ever Swiss-led United Nations Security Council "open debate" in May 2023 promoted GESDA's brand of anticipatory science and diplomacy as a 21st century solution. Swiss Foreign Minister Ignazio Cassis, a medical doctor who has been a champion of GESDA and its founding by Swiss and Geneva authorities, presented science diplomacy as a tool to rebuild and future-proof trust through confidence-building approaches and instruments for sustainable peace.

The field of science diplomacy, which includes not only nations but also non-governmental proponents such as citizens and Indigenous communities, shows promise as a modern tool for grappling with transboundary challenges such as pandemics and climate change. Switzerland and other nations such as Japan, the United Kingdom and the United States include the concept in their policymaking. There are signed agreements such as the 2019 Madrid Declaration of Science Diplomacy and 2021 Vienna Statement on Science Diplomacy, and some academic courses that already use the approach, which stems from decades of inter-governmental cooperation practiced in scientific explorations ranging from the great expanse of space to the realm of subatomic particles.

Martin Chungong, Secretary General of the Inter-Parliamentary Union, told the 2023 GESDA Summit that science diplomacy is a vital tool for lawmakers. "For parliaments to be relevant, they need to be kept abreast of developments in the world, and as the primary policymakers in their countries, parliamentarians need to inform their decisions with scientific and technological evidence. They need to help address ethical and moral dilemmas that are emerging because of the development of technology and science. Science and diplomacy for me is a crucial tool for making sure those people who will regulate this world in a good sense are informed by innovation and they are also kept aware of the challenges that come with technology and scientific innovation," said Chungong, also a key member of GESDA's Diplomacy Forum and its task force for creating a Global Curriculum for Science and Diplomacy. "We have been working to forge that alliance between policymakers. We use the word diplomacy for want of a better word, where you would have global leaders, parliaments and all institutions that contribute to decision-making and the world of science and technology. Today we have realized it is important for us to have a common understanding of what we mean by science diplomacy, because it's been out there for as long as I can remember but I don't think there is a common understanding of what we are talking about."

Creating a Global Curriculum for Science and Diplomacy is featured in the GESDA 2023 Science

Breakthrough Radar® which observed that an opportunity exists to establish anticipatory science and diplomacy methodologies among experts and decision-makers, starting with the way we train our current and future leaders across all sectors – including STEM fields, national governments, multilateral institutions and the private sector – to empower the current and next generations with a "multilingual" mindset in science and diplomacy and more boundary-spanning knowledge. For the past several years, GESDA has been working to create an academic curriculum that would provide the training that is needed to promote more global collaboration among scientists and diplomats. Science diplomacy has been an essential part of the cooperation ranging from the International Space Station as a platform for planetary exploration to CERN's research into subatomic particles.

Until now, academic approaches to science diplomacy developed in a patchwork and fragmented fashion, tailored to the needs of specific countries, regions or topics, or serving particular constituencies and values, without a future-oriented approach inclusive of non-governmental proponents and multilateralism, GESDA concluded. As a key hub of multilateralism, Geneva and its cluster of international organizations, including the European headquarters of the United Nations, representatives from governments around the world, multinational corporations, NGOs and others, hold particular promise as a training ground for future international cooperation. "These discussions that we're going to have today will help us move towards validating some of the lessons that we have learned when it comes to what we mean by science diplomacy and how we can actually go ahead and provide training to those who need it, policymakers in particular," said Chungong. "There is a demand for capacity building, for knowledge creation, about what we mean by science diplomacy, and how this can help us make better decisions in the world today."

As he spoke, some of the attendees of the Geneva Science Diplomacy Week series hosted by GESDA – current and next-generation leaders from around the world – were in attendance. GESDA initiated the weeklong learning and networking experience in 2022, and the program is now a partnership extending to 17 Geneva, Swiss and global academic and diplomatic institutions. It offers an intensive week of dialogue and exchange with key international agencies, diplomatic missions, academic institutions, global NGOs and technology leaders in science for multilateralism.

South Africa's top diplomat, Naledi Pandor, the Minister of International Relations and Cooperation of South Africa, also has participated in previous GESDA events. The nation has taken a keen interest in the uses of science diplomacy because it has learned that society progresses through international cooperation and partnerships that are made stronger through more dialogue among scientists and diplomats, said Daan du Toit, Deputy Director-General of the International

Marcella Ohira

Annika Brack

Stéphanie Balme

Daan du Toit

Cooperation and Resources in the South African Department of Science and Innovation. “South Africa would never have defeated apartheid and achieved the democracy we have today if it wasn’t for international solidarity. And we are not going to defeat or respond to the many societal challenges we face today if it’s not through international cooperation. But similarly, if we want to grow our economy, if we want to fight persistent poverty and unemployment, we need investment in science for social advancement, for enhancing the competitiveness of our economy. So, convinced of that crucial contribution of science and diplomacy, what more could not be done if you combine the two of science diplomacy working for the advancement of our society?” he asked.

“If we look at the key challenges faced on the global stage, we all know the examples,” du Toit added. “The COVID-19 pandemic, climate change. More importantly, or more currently, the governance of disruptive technologies such as artificial intelligence; the use of non-tariff trade barriers to prevent exports from the Global South to the Global North. If I could be a bit provocative, those are all science-based issues. So, if South Africa, Africa and the Global South are going to engage in those debates, we need strong science input, and the scientific contribution of the Global South has to be harnessed into those debates.”

The European Union’s evolving framework for science diplomacy reflects an effort to align the cultural, legal and political mindsets of 27 nations, said Jan Marco Müller, Coordinator of Science Diplomacy and Multilateral Relations for the European Commission. “Roughly one-third of the E.U. member states already have a national science diplomacy strategy in place. More and more are investing in scientific capacities in their foreign ministries. When I worked as a science advisor in the External Action Service, I created a network of science advisers in science, diplomacy, people and the foreign ministry. We started with eight member states and now, two years later, we already have 18,” he recounted. “Of course, the countries they come from have very different starting points, they come from very different angles and perspectives on how to use science diplomacy.”

The European Commission funded research projects in the Horizon 2020 program to develop methodologies and advance science diplomacy, he said, but it has yet to adopt a uniform approach to research and innovation to underpin a science diplomacy agenda. “The devil is in the details because what is European?” asked Müller, who called science diplomacy an evolving concept in exercising both power and bridge-building that also reflects “asymmetries” such as the global dominance of the English language. “Europe, in terms of science, is something different than Europe in terms of diplomacy. Europe, in terms of a science-based European research area, goes from Iceland to Israel. Europe, in terms of diplomacy, is the common foreign and security policy.”

For over three decades, nations in the Americas have joined together to foster scientific knowledge on global environmental change research, said Marcella Ohira, Deputy Executive Director and Director for Capacity Building at the Inter-American Institute for Global Change Research. The third decennial U.N. “Earth Summit,” hosted by Brazil at Rio de Janeiro in 1992, for example, was a pivotal event in modern environmentalism. It launched the Convention on Biological Diversity and gave rise to the U.N. Framework Convention on Climate Change (UNFCCC), which in turn led to the 1997 Kyoto Protocol and 2015 Paris Agreement and now

serves as the platform for the world's climate talks. "So basically, we have been doing science diplomacy since the beginning, from birth, because we were established by nations with a very specific science agenda. And we have been sitting on the interface of science and policy. Nevertheless, over the last 30 years – we celebrated our 30th anniversary last year – we looked at the accomplishments of the IAI over three decades and it has been mainly contributing to science. We were able to develop the leading scientific research networks, especially in Latin America, the Caribbean, who are working on global change research of priority for governments and for the scientific community, such as climate change, oceans, biodiversity and ecosystem service, to mention a few. But one of the challenges that we have also identified is not only IAI's challenge, but also other institutions, other countries and regions, is the uptake of science. How can we really foster and have the science support processes of design and decision-making for both public and private sectors? That has been really something challenging that we have not been able to do in the past 30 years."

Ohira said her organization recently has reflected on what kind of programs are needed, and decided it should focus more on transdisciplinary science that accounts for varying knowledge and disciplines and principles of equity, diversity and inclusion. "For example, how can we bring Indigenous communities' knowledge, not only scientific knowledge and disciplines? That has to be taken into account," she said. "Also, how can we bring policy decision-makers, end users in the co-design of the framing of the research questions, so that it will be useful for an end user and would help address solutions to current problems that we have? Institutions like GESDA and IAI could be conveners, facilitators, bringing those different stakeholders, help them establish this dialogue."

Stéphanie Balme, a Research Professor at Sciences Po Paris who specializes in science diplomacy and Chinese relations, said her university trains the vast majority of future diplomats in France and many international students who become the next generation of diplomats around the world. "We believe that social science is part of science diplomacy, that social science is very important to address the issue of the link between expertise, knowledge and international relations," she said. "We have worked a lot on interdisciplinary projects. We recruit a growing number of students who come from experimental sciences, from STEM, and who are interested in international relations. We build groups of people who come from both sides, and we try to challenge them by saying you have to understand from within certain sciences to find some expertise on which you're going to be quite good at and to really improve your knowledge on science diplomacy."

Out of those efforts, she said, the university has observed more students from the Global South being drawn to science diplomacy as a tool for gaining a bigger voice on the global political stage. It also has found that science diplomacy is good tool to understand the issues of "decoupling" and of "the fragmentation of the world" with regard to China. "We can address the issue of the fragmentation of the world and maybe it could be a solution for bringing E.U.-China together on an apolitical, a less political issue." But science has been a global activity for a long time, she noted, marked by international scientific collaborations that have won Nobel Prizes. "Science diplomacy is our common foreign policy somehow," she added. "GESDA really is a great tool to be able to work on the international governance of science. … We should take seriously science diplomacy, putting it on the top of the agenda and showing how much it's de-politicizing international relations today."

Science diplomacy is "key in this polarized world" and rooted in an obligation that nations share to promote peaceful, friendly relations, said David Fernández Puyana, Ambassador and Permanent Observer of the 43-nation U.N. University for Peace, which was established in 1980 by a U.N. General Assembly resolution promoted by the government of Costa Rica. "The first and most important text is the United Nations Charter, which was the most relevant peace treaty in the 20th century. Also, we have obligations under international law. We have the Universal Declaration of Human Rights and also the International Covenant on Economic, Social and Cultural Rights, which recognize the right of everyone to get access to scientific research," he said. "We have a need for this kind of diplomacy. We have global challenges. And the only solution to have some kind of way out is through global solutions from the international community, in particular the scientific community. Global challenges like climate change, biodiversity, artificial intelligence."

Martin Smith

Jan Marco Müller

Among the audience members, Brazilian neuroscientist Eduardo Schenberg asked whether science diplomacy might be a useful tool for strengthening international accords that could prevent the "biopiracy" of genetic resources or Indigenous knowledge found in Latin American countries. Austrian marine scientist Sabine Gollner asked whether it will be possible to ensure that science diplomacy encompasses all disciplines, or if some might be left out. Russian physicist Alexander Nezvanov wanted to know if panelists believe science diplomacy should be seen as a profession.

Du Toit answered that science diplomacy is a useful tool at the World Intellectual Property Organization in Geneva, where IP-based aspects of genetic resources are debated. "It's not only our South African government lawyers but also our scientists and specifically our experts in Indigenous knowledge who will participate. That's science diplomacy in action, where it matters very much. Yes, science diplomacy should cover all areas of science. I would see it really through a lens of open science. We like to say science knows no borders, not between countries but also between disciplines," he said. "If we need a specific career of people who are just science diplomats, I'm not necessarily convinced of that. What you want is for the diplomats to be empowered and to understand the role of science diplomacy. And you want the scientists to understand diplomacy."

Balme said the goal is to have all the sciences represented in science diplomacy, which should aim to provide its practitioners with "a kaleidoscopic perspective" on any given issue. "There's a need of increasing ethics standards, but also at a level which does not prevent scientists from doing research, because innovation and ethics should work together, and it should not be seen as a barrier for practicing research," she said. "We need to have science diplomats. We will see in 20 years' time whether we don't need it anymore, but currently speaking we do need them." There's a need to train diplomats who specialize in science, Puyana added, the same way that some diplomats specialize in human rights or internal dialogue. The United Nations was established in 1945 with the aspiration of saving future generations from the scourge of war, he noted, and "it's an aspiration to have this global curriculum in that sense. It's fundamental to include the ethical values."

One of the world's biggest independent charities, the U.K.-based Wellcome Trust, is keenly interested in GESDA's approach to science diplomacy because it can help tackle global health challenges, according to Martin Smith, the Head of Policy Lab at Wellcome Trust. "Wellcome has just agreed a new grant to GESDA to support the development of the Global Curriculum for Science Diplomacy. The grant is worth just over 8 million Swiss francs over the next five years. It's a substantial investment. And I want to

say a little bit about why Wellcome is so interested and excited by this opportunity, the solution that GESDA has come up with," he said. "Wellcome is a global charitable foundation. We plan to spend £16 billion over the next ten years. And at the heart of what we do is funding scientific research. And many of the things that we fund are the things that you see on GESDA's Radar. At our heart is funding discovery research in particular. But we want to be more than just a funder. We're interested in trying to tackle global health challenges, and we picked out three of those for our new strategy. And they are climate and health, mental health, and infectious disease. Truly global challenges that require global solutions. But Wellcome's very clear that investment in science alone isn't enough. Science alone won't solve global health challenges. It's the most important thing that we think we can contribute to this picture, but science isn't enough. Evidence isn't enough. Truth isn't enough."

"All of these things will be mediated through politics, through diplomacy, through international relations," he continued. "And that's why investing in building the cadre of people who can interact at that interface between science and diplomacy, as we've just been hearing, is so important to us. I want to share with you a couple of the features that really stood out to us as part of GESDA's proposal. The first word is the word global, and we've heard a lot about that today. It's not an easy task to do, and we're excited by the ambition that GESDA has in trying to do this. Global is exciting, because we are talking about global challenges and building that capacity around the world for science diplomacy is really important. But of course, it has to be based on understanding of local contexts. It has to be able to be adapted to all sorts of contexts around the world. That's a very, very important feature of this. The other feature is, we're not just talking about trying to equip scientists with a little bit of extra knowledge and understanding in order to go out and talk to politicians. We're talking about the other direction, as well. We're talking about building diplomats' understanding of science, building this understanding, and being able to interact between those two worlds, which I think is really important."

More information

Explore the 2023 GESDA Science Breakthrough Radar®

Session recording on YouTube

Key messages

- Science diplomacy, involving nations, NGOs, citizens, and Indigenous communities, is considered a modern tool for addressing transboundary challenges such as pandemics and climate change. Switzerland, Japan, the U.K., and the U.S., among others, include science diplomacy in their policymaking, supported by agreements like the 2019 Madrid Declaration and 2021 Vienna Statement.
- GESDA is working on creating a Global Curriculum for Science and Diplomacy, aiming to provide anticipatory science and diplomacy training to current and future leaders across sectors. The curriculum aims to foster a "multilingual" mindset, encouraging collaboration across STEM fields, governments, multilateral institutions, and the private sector.
- Science diplomacy faces challenges in fragmented academic approaches and the need for a future-oriented, inclusive, and multidisciplinary approach. Geneva, with its international organizations and diplomatic presence, is seen as a promising hub for training in science diplomacy and promoting global collaboration.
- As well as anticipating scientific breakthroughs, it's important to invest in building up the cadre of people who can interact at the interface between science and diplomacy to address global challenges.

Thursday 12 October, 16.00 - 16.45 CET

Anticipatory Briefing

Fungal Pandemics

Anuradha Chowdhary

Fungal Pandemics

As antibiotic producers and deadly pathogens, and both necessary members of ecosystems and invasive species, the complexity of the fungal kingdom is vast. Join this anticipatory briefing to hear about the latest advances in mycology and the opportunities and challenges that this presents over the next 5, 10 and 25 years.

Speakers

Moderated by:

Laurent Haug, Founder, 200ideas, Switzerland

With:

Anuradha Chowdhary, Professor of Medical Mycology, Vallabhbhai Patel Chest Institute, University of Delhi, India

Summary

The complexity of the fungal kingdom – essential to health, agriculture, biodiversity, ecology, manufacturing and biomedicine – isn't fully understood. Fungi degrade organic matter and produce chemicals needed in antibiotics and immunosuppressants, and they also cause rapid species extinctions and the loss of biodiversity. More than 200 of the 148,000 known species of fungi are closely associated with humans, bringing infectious diseases that kill about 2 million people a year.

The prospect of fungal pandemics is featured in the GESDA 2023 Science Breakthrough Radar® which noted there are novel infectious diseases caused by fungi that are on the increase worldwide and are more difficult to treat than bacteria or viruses. It forecast that tackling the challenge over the next decade could save 1.6 million lives a year and salvage enough crops to feed 8% of the world.

Better understanding of the fungal kingdom also could contribute to addressing some of the biggest challenges facing the planet and humanity, the Radar anticipated. Fungi, which are highly efficient microbial degraders of plastics, might provide an important solution to the world's plastic pollution crisis through targeted degradation in the environment and at recycling and plastic treatment plants. Improved control of fungal pathogens that affect trees also would boost carbon-absorbing biomass.

Yet fungal infections are widely unrecognized and there's little surveillance data. "People die more with fungal infections than malaria and it is same with tuberculosis," said Anuradha Chowdhary, a Professor in the Department of Medical Mycology at Vallabhbhai Patel Chest Institute, University of Delhi, India. "The most important cause of death of fungal infection is under-diagnosis."

A new HBO show, *The Last of Us*, featured a climate-linked pathogen infecting people worldwide and turning them into zombie-like creatures. When a TV journalist asked a scientist if the cause was bacterial or viral, the scientist said it was a fungal infection. The audience laughed, since people mostly think of fungi as yeast, mold or mushrooms. "That's the usual response," the scientist said.

Despite the fictionalized zombie fungus, Chowdhary described the sci-fi drama as "a reminder to all of us that if we do not take action at a global level, fungi are there for us. They are our friends, but they're going to kill us. We have to live in harmony. We have to have a planet where our fungi live with us, helpfully," she said. "We love our wine, we love our beer, we love our cheese."

Fungi pose more of a threat to human health, wildlife and crop production than is widely known. Billions of people on the planet suffer from skin infections, dental cavities and headaches caused by fungi, according to Chowdhary, while tens of millions of infants and hundreds of millions of women are affected by other types of common fungal infections. "Not only dry skin and mucosal infections, but we have a lot of allergies. We have chronic fungal infections when we have a change of weather because fungi are present and the spores are present in the environment," she said.

The number of people who die of fungal infections is greater even than the death toll from malaria or tuberculosis, and recent studies show there has been a rise in the number of antifungal drug-resistant infections and multidrug-resistant fungal pathogens. The most common types of invasive fungal diseases, *Candida*, *Aspergillus* and *Cryptococcus*, are opportunistic pathogens that can cause severe morbidity and mortality in immuno-compromised people. Another one, *Pneumocystis*, most often occurs in people with a medical condition like HIV/AIDs that weakens their immune system.

"It's under-recognized and we do not have enough surveillance data," said Chowdhary. "The most important cause of death of fungal infection is under-diagnosis."

In the United States alone, direct medical costs from fungal diseases are estimated at US$6.7 billion to US$7.5 billion a year, and indirect costs from premature deaths and missed work or school are estimated at US$4 billion a year, according to the U.S. Centers for Disease Control and Prevention. Many fungal diseases go undiagnosed, the CDC says, and no national public health surveillance exists for common fungal infections such as ringworm and vaginal candidiasis, or for certain serious fungal infections like *Aspergillosis* and *Cryptococcosis*. And the rest of the world?

"We do not have data from other parts of the world," Chowdhary said.

Fungal pandemics haven't happened in people yet, but there have been outbreaks in wildlife. The chytrid fungus has killed frogs and salamanders around the world and led to declines of more than 500 amphibian species by eating their skins alive. The white nose syndrome, a deadly fungus first found in the U.S. in a New York cave in 2006, has killed millions of bats across North America. The fungus is thought to have originated in Europe, where bats already may have adapted to it.

The CDC warned in 2023 that a drug-resistant and potentially deadly fungus was spreading quickly among people in U.S. health care facilities. In 2009, Japan had labeled that fungus – a type of yeast called *Candida auris*, or *C. auris*, which can cause serious bloodstream, wound and ear infections – as a harmless pathogen. Then more cases started appearing in South Korea, and there was a huge outbreak at two hospitals in India. "It has become a global pathogen in less than 10 years," Chowdhary said. "It has gone to more than 60 countries. And why is it important? Because we have only three or four classes of antifungal drugs, not like bacteria, where there are hundreds of antibiotics."

Echinocandins, a class of antifungal drugs, are usually used to treat the pathogen, but it is becoming drug resistant in people. "Climate change has a huge impact on fungal infections," she said. "This pathogen probably has emerged because of the high heat, because this can thrive at 40° Celsius." Another class of antifungal drugs, Azoles, are used to treat *Aspergillosis*, but it, too, is growing drug resistant in people amid its widespread use as a fungicide to protect plants. A ringworm caused by a highly contagious fungus, *Trichophyton indotineae*, that was found in patients in Asia has since spread to Europe and the U.S., and it is growing resistant to Terbinafine, an antifungal medication.

In 2022, the World Health Organization released its first-ever list of fungal "priority pathogens." It identified 19 fungi as significant public health threats that can cause severe infections and show a growing resistance to antifungal drugs. During the COVID-19 pandemic, hospitalized patients were hard hit by invasive fungal infections. "In the next 10 years we will be working on these important priority pathogens," Chowdhary said of the list. "Policymakers will take into view that these fungi are the ones which we need to work on, because these are the ones which affect us globally."

With limited access to essential diagnostic tools to identify these fungal infections, public health officials in Latin America, Asia and several other parts of the world first must become better equipped, she said, and even the well-equipped laboratories in North America must become better prepared to conduct susceptibility testing. "To address this threat of antifungal drug-resistant infections we need to have the surveillance data from different parts of the world," said Chowdhary, and to "advance our laboratory capacity, make them capable of diagnosing fungal infections."

More information

Explore the 2023 GESDA Science Breakthrough Radar®

Session recording on YouTube

Key messages

- As antibiotic producers and deadly pathogens, and both necessary members of ecosystems and invasive species, the complexity of the fungal kingdom – essential to health, agriculture, biodiversity, ecology, manufacturing and biomedicine – is vast and isn't fully understood.
- Over 200 out of 148,000 known fungal species are closely associated with humans, causing infectious diseases that result in approximately 2 million deaths annually. Fungal infections are often under-diagnosed, surpassing the death toll of malaria and tuberculosis.
- Addressing the increasing threat of novel infectious diseases caused by fungi could potentially save 1.6 million lives annually and preserve enough crops to feed 8% of the global population over the next decade.

Thursday 12 October, 17.00 - 18.00 CET

Plenary Session

From the Atomic Bomb to AI: Lessons from Oppenheimer

From the Atomic Bomb to AI: Lessons from Oppenheimer

Whether it be artificial intelligence or the climate crisis, all global challenges require international cooperation in science and engagement with society. In the face of rapid scientific and technological development, what lessons can be learned from the past and ensure that we responsibly anticipate the next breakthrough and its impact at large?

Speakers

Moderated by:

Adrian Monck, Editor-in-Chief, Seven Things, Switzerland

With:

Patrick Aebischer, Vice-Chairman, GESDA; President Emeritus, Swiss Federal Institute of Technology Lausanne, Switzerland

Paolo Benanti, Theologian and Academic, Third Order Regular of St. Francis; Professor, Pontifical Gregorian University; Advisor to Pope Francis on A.I. and Technology Ethics, Italy

Doreen Bogdan-Martin, Secretary-General, International Telecommunications Union

Charles Oppenheimer, Founding Member, The Oppenheimer Project, USA

Kate Oppenheimer, Founding Member, The Oppenheimer Project, USA

Summary

Three months after the popular *Oppenheimer* film hit movie theaters worldwide, two relatives of the late theoretical physicist J. Robert Oppenheimer described the man known as "the father of the atomic bomb" as a model of leadership for dealing with major scientific and technological crises. Other experts and leaders agreed his life story holds lessons for modern ethics and governance.

The renowned American physicist's assignment at the Manhattan Project's laboratory in Los Alamos, New Mexico was to win a world war by prevailing in the race to produce the first fast-neutron chain reaction in a usable device that could harness the destructive power of nuclear fission. As head of a top secret and remote U.S. Army lab, he led a group of Nobel Prize-winning scientists in overcoming a series of scientific and technical challenges to produce a world-altering weapon. GESDA panel members drew parallels to today's acceleration in the uses of artificial intelligence.

"I always point to the period of August 17th, 1945, which is right at the end of World War II, where Robert Oppenheimer and his contemporaries laid out a four- or five-point plan that said we would never be able to make ourselves safer from atomic weapons. They'd get larger. You couldn't have a monopoly on them. And the only path in dealing with them was cooperation," said the scientist's grandson Charles Oppenheimer, who founded the Oppenheimer Project in 2019 to honor his grandfather's legacy and work to advance a safer future in the face of technological change.

"He was able to take that message directly to the government and advise them in a true scientific anticipatory display. And it didn't work at that time. It got overruled by government. He famously got prosecuted for not being enthusiastic enough about making atomic bombs. And I think that's the reason that we're talking about them today and making movies about them. And it's so aligned with the values in this conference," Charles Oppenheimer said of the GESDA Summit. "This to me represents the opposite of that – when there's groups of government, scientists, business people coming together and saying that we can make technology, but we can also manage it in an effective way. I've been called to represent my grandfather's values, not just the historical view, not just the Hollywood view, but his values that can still impact the world. And that's what we're trying to do."

The late scientist's grandniece, Kate Oppenheimer, who also serves on the Oppenheimer Project, said Robert Oppenheimer's love of science and his overriding belief that science must be explored cooperatively to benefit all humanity are values that resonate strongly today. "There is this love of the perfect balance of our surrounding world, and that is something that's so core to our family and I think also to probably most people who explore science. There's just this amazement," she said. "I think we have to keep that in mind as we do this work and keep reminding ourselves of that."

Doreen Bogdan-Martin, the Secretary-General of the International Telecommunication Union, recalled Robert Oppenheimer's famous response to Eleanor Roosevelt during her radio program in February 1950, less than two weeks after U.S. President Harry Truman overruled members of the Atomic Energy Commission's General Advisory Committee and directed the U.S. to develop a hydrogen bomb. Oppenheimer argued the decisions to develop powerful atomic and hydrogen bombs touched "the very basis of our morality" and held "a grave danger for us in that these decisions have been taken on the basis of facts held secret. This is not because the men who must contribute to the decisions, or must make them, are lacking in wisdom; it is because wisdom itself cannot flourish, nor even truth be determined, without the give and take of debate or criticism. The relevant facts could be of little help to an enemy; yet they are indispensable for an understanding of questions of policy. If we are wholly guided by fear, we shall fail in this time of crisis. The answer to fear cannot always lie in the dissipation of the causes of fear; sometimes it lies in courage."

That quote by Oppenheimer "actually captures well this current moment," said Bogdan-Martin, whose U.N. agency dates to 1865, when the telegraph was still in use, and has recently been focused on "all of the excitements and some of the risks that surround" the swirl of A.I. uses that are being developed and adopted at a breakneck pace. "I think this is the moment where we have to be courageous. It's also the time that we have to be hopeful," she said. "We have to be courageous in tackling things like the digital divide and the fact that you can't be part of the A.I. revolution if you're not part of the digital revolution. And today we still have a third of humanity that's never, ever connected to the Internet. It's too costly. They don't have the skills and lots of other barriers."

She said the lessons apply to balancing risk without stifling innovation "and letting the benefits of A.I. flourish for the greater good of humanity," which is the purpose of ITU's A..I for Good global platform and summits seeking to leverage international cooperation through the United Nations and other institutions like GESDA that promote a post-war multilateral architecture of global governance. "We're looking very concretely at the benefits of artificial intelligence for each and every Sustainable Development Goal," she said of the U.N.'s 17 beleaguered goals for universally spreading peace and prosperity by 2030. "There's many governance discussions happening."

Four years after U.S. President Dwight Eisenhower's "Atoms for Peace" address to the United Nations General Assembly in December 1953, the

Adrian Monck, Kate Oppenheimer, Charles Oppenheimer

Paolo Benanti

Doreen Bogdan-Martin

International Atomic Energy Agency was created to respond to society's deepest fears and expectations around the use of nuclear technology. Also in 1957, Bogdan-Martin noted, the first satellite went into orbit, and it took a number of years before international cooperation was established in the field of space. "Now, the ITU has been regulating communications frequency spectrum for more than 60 years. But it happened. The satellite went into space. Others followed. And then eventually the governance piece caught up." Bogdan-Martin said she believes the world is in a similar "A.I. moment" marked by worry and reckoning, and "we need to not have fragmented approaches. We really need to find a way forward for global governance. I think it needs to be with multiple stakeholders. We need the scientific community engaged. I think we need the developers engaged. We need the user perspective. And we need to take kind of all the views and look at the best framework for governance."

Audience member Alice Pannier, a Research Fellow and Head of the French Institute of International Relations' Geopolitics of Technology Program who took part in GESDA's Geneva Science Diplomacy Week 2023, questioned whether A.I. was the right technology to be compared to the atomic bomb. She suggested that emerging technologies like quantum computing "would be a better fit in terms of their effect, because in the end also there is no A.I.. power without computing power. A lot of the A.I. power relies on just how powerful the computers are." Another audience member, Anousheh Ansari, CEO of XPRIZE Foundation and member of GESDA's

Diplomacy Forum, also questioned the comparison because "in case of the atomic bomb, there is a human in the loop that makes a decision to use it or not to use it. In the case of A.I., and generative A.I. specifically and the direction it's going, we're taking the human out of the loop in many cases, and that's where the real danger lies. And the other big difference is you had governments involved in that decision-making. So, it was in the hands of an individual. And A.I. technology and how it can cause damage could be a decision made by a person or a company."

In June 2023, Pope Francis and the Vatican released a handbook to guide technology companies in the ethical development of A.I. and other "disruptive technologies." The Vatican, which published the handbook in collaboration with Santa Clara University's Markkula Center for Applied Ethics, said a number of Silicon Valley companies had approached the Vatican for ethical guidance. The Pope also partnered with the center to form the Institute for Technology, Ethics, and Culture, which said its aim will be to bring together leaders from businesses, civil society, academia, governments and all faith and belief traditions to promote deeper thought on technology's impact on humanity. "The ethical approach to innovation is simply to question innovation – to allow the different stakeholders to be aware of which kind of displacement of power and form of order the new technology is bringing inside society," said Father Paolo Benanti, a Franciscan monk, engineer and ethicist who serves as an advisor to Pope Francis on the ethics of A.I. and other technology, and is a Professor of Ethics and Moral Theology at the Pontifical Gregorian University in the Vatican.

"It's not a matter that A.I. is more important over another technology, but it's important to recognize which kind of technology is A.I. Because if we look at the history of technology, we have to recognize that usually we develop a special-purpose technology, because we have some needs. For example, we are hungry, and we would like to cultivate every day better and we develop technologies," said Benanti. "But there are moments in the history of human beings in which we develop technology that is not special-purpose, but that we can define as special-purpose technology. Historians are debating if the wheel was the first general-purpose technology,

but for sure electrical power, chemical power are general-purpose technology. They are not used to doing one thing, but everything in the process will be used with that kind of technology after it is invented. In that sense, A.I. is the next big candidate to be a general-purpose technology. That means that could be infused in every kind of technology that we can use."

With nuclear technology, it's also important to remember there are beneficial uses such as in medicine, agriculture and low carbon energy production, said GESDA Vice Chairman Patrick Aebischer, who is President Emeritus of Swiss Federal Institute of Technology Lausanne (EPFL). "The raison d'être of GESDA is really this need to anticipate what is going to happen in science so as to give it sufficient time for society to know how to handle those discoveries," Aebischer said.

"It's also the realization that scientists cannot do that by themselves," he said. "We see many more technologies that have great potential applications, but that also need to be controlled and mastered

Patrick Aebischer

if we don't want to hurt our species and the planet we're working on. I think there's this urgency, and if GESDA can bring something to the table, by telling and trying to inform people of what is coming so that they are given a sufficient amount of time from our doing it to frame the application, I think we will have done what we want to do."

More information

Explore the 2023 GESDA Science Breakthrough Radar®

Session recording on YouTube

Key messages

- J. Robert Oppenheimer, known as "the father of the atomic bomb," is viewed as a model of leadership for handling major scientific and technological crises. His role in the Manhattan Project, leading a team of Nobel Prize-winning scientists, is seen as particularly relevant to today's challenges in artificial intelligence.
- Developments in artificial intelligence are prompting fear because unlike the atomic bomb, there is not necessarily any human in the loop to make a decision.
- Anticipating the latest developments in science and technology – as GESDA does – so that society has sufficient time to assess their impact and act could help to prevent mistakes of the past.

Friday 13 October, 09.00 - 10.15 CET

Plenary Session

Quantum Solutions for All: The Incubation of the Open Quantum Insitute

Ignazio Cassis

Quantum Solutions for All: The Incubation of the Open Quantum Institute

From drug discovery to global agriculture, quantum computing has the potential to transform industries and societies with recognition that has seen the awarding of Nobel Prizes and billions of dollars of investment over recent years. Join this session to learn how the Open Quantum Institute will ensure that quantum solutions are accessible and available to all for the benefit of humanity.

Speakers

Opening remarks by:

Peter Brabeck-Letmathe, Chairman, Board of Directors, GESDA, Switzerland

Ignazio Cassis, Minister of Foreign Affairs, Switzerland

Moderated by:

Barry Sanders, Scientific Director, Quantum City, Canada

With:

Matthias Christandl, Professor, Department of Mathematical Sciences, University of Copenhagen, Denmark

Sana Odeh, Clinical Professor of Computer Science, New York University, USA

Prince Osei, Director, Quantum Leap Africa, Ghana

Laura Piddock, Scientific Director, Global Antibiotic R&D Partnership (GARDP), Switzerland

Matthias Troyer, Technical Fellow and CVP, Microsoft Quantum, USA

Team Smart Current (Allen Baranov of Massachusetts Institute of Technology and Yafa Hassan Jaradat of Palestine Polytechnic University), First Prize Winners of the 2023 NYUAD Hackathon for Social Good in the Arab World

Closing remarks by:

Urbasi Sinha, Professor, Quantum Information and Quantum Computing Lab, Raman Research Institute, India

Summary

The official launch of the Open Quantum Institute (OQI) at the 2023 GESDA Summit capped a two-year journey from the design phase to the incubation phase, ushering in the next phase – a three-year pilot program hosted by the European Organization for Nuclear Research (CERN) – starting in the first quarter of 2024. As an emerging technology with a massively transformative potential, quantum computing quickly rose to the top of GESDA's priorities in 2021 when experts saw that a science and diplomacy approach was needed to ensure universal access to its benefits.

Quantum computing is expected to be as disruptive someday as artificial intelligence has been in 2023, Swiss Foreign Minister and Federal Councilor Ignazio Cassis said during a four-part session devoted to the OQI on the third and final day of the Summit. Designed and incubated by GESDA with 130 partners worldwide, the OQI was slated to open its doors at CERN on March 1, 2024.

"With the power to radically change the way we communicate and process information, it opens up new ways of solving currently unsolvable problems. It also puts the encryption we rely on today at risk," he said. "It is, therefore, not surprising that the GESDA Science Breakthrough Radar has identified quantum computing as a key technology with strong potential for the future."

The first part of the session featured remarks by Cassis and GESDA Chairman Peter Brabeck-Letmathe. The second part was a panel discussion on the OQI's goal of accelerating use cases quantum computing. The third part was a high-level political panel hosted by Cassis and the fourth part was the official launch of the OQI with the assistance of the Swiss Federal Department of Foreign Affairs (FDFA), CERN, UBS and other supporting partners.

The topic, Quantum Revolution and Advanced AI, is featured in the GESDA 2023 Science Breakthrough Radar® which also includes the OQI Incubation Report

Sandro Giuliani

Peter Brabeck-Letmathe

2023 that delves into how GESDA and its partners, with the support of the Swiss government, CERN and UBS, created a new institute to try to ensure that quantum computing will be used for the common good.

The Radar anticipates that quantum computing will be used in real-world applications within 10 years, and that within 25 years it will be able to perform simulations in chemistry and material sciences that are simply not possible today with conventional technologies. Decades of academic research into quantum computing has led to significant investment from technology companies and government initiatives, with that investment in quantum technologies reaching US$35 billion in 2022 including almost 6% of that going toward startups, according to the World Economic Forum.

Switzerland has been a quantum leader. One Swiss company, ID Quantique, which was spun off from the Group of Applied Physics at the University of Geneva more than 20 years ago, has been working on network security solutions for the financial industry, defense, government organizations and other enterprises. The two Swiss federal institutes of technology, ETHZ and EPFL, were among the first universities to introduce master's programs in quantum science and engineering.

Cassis, a medical doctor who has been championing science and diplomacy in Switzerland and abroad, noted that it was during a lecture at MIT Computer Science and Artificial Intelligence Laboratory in 1982 that physicist Richard Feynman proposed using quantum mechanics to make calculations that were impossible with classical computers. That idea led to quantum computing.

Today, scientists and engineers are working on quantum devices for a range of uses such as secure communications, precisely measuring magnetic fields, development of new drugs, energy-efficient ways of producing fertilizers, and creating materials for batteries that have a higher energy density.

"Quantum technologies will have a direct impact on society as a whole in health, in energy, food and many other areas but we have to be honest and say that today we don't know exactly what the impact will be," said Cassis. "In line with the GESDA Science Breakthrough Radar, we are confident that we will see impacts on people, society and the planet in the coming years and decades. It's time to prepare ourselves for a human-centric use of quantum computing."

GESDA initiated the creation of the OQI to ensure that quantum computing is primarily used to advance the United Nations' 17 Sustainable Development Goals for 2030. "It goes hand-in-hand with a strong belief that science and diplomacy must work together to ensure that scientific and technological breakthroughs benefit all of humanity, not just a select few," Cassis said. "The core mission of this multilateral, cross-sector science diplomacy initiative is to create a market of quantum-use cases for the SDGs by 2026. A special prize will encourage the articulation of such use cases, focusing on three topics: zero hunger, good health and climate action."

The OQI will work according to three priorities: Ensuring access to a pool of private and public quantum computers; promoting education and training in quantum computing; and activating diplomacy to shape multilateral governance rules for the use of quantum computing.

Brabeck-Letmathe recalled how one of the chapters of the 2021 Radar had also focused on the topic, Quantum Revolution and Advanced AI, and recognized that quantum technology not only was an emerging scientific field but possibly one of the most disruptive technologies of our time. From that flowed the past two years of efforts to prevent quantum technology from causing an even bigger future digital divide and to ensure that potential use cases will remain focused on the SDGs.

The work involved a multi-stakeholder task force with leaders of academia, diplomacy, industry and philanthropy co-led by Anousheh Ansari, the Founder and CEO of the X-PRIZE Foundation, and Matthias Troyer, a Technical Fellow and Corporate Vice President at Microsoft Quantum. Diplomats from more than 20 countries who represent their missions to the U.N.'s European headquarters in Geneva also participated as members of the GESDA Diplomatic Forum. The project "came to life based on the regular diplomatic working dinners held here in Geneva by the permanent representatives of Switzerland, Morocco, France and Mexico," Brabeck-Letmathe said.

After GESDA's Board of Directors decided to fund the OQI's incubation phase, CERN agreed to host OQI during the start-up phase and UBS agreed to provide funding to help get it off the ground. Under the leadership of Switzerland's FDFA State Secretary Alexandre Fasel, the Diplomatic Forum detailed OQI's genesis in a new "Intelligence Report on the multilateral governance of quantum computing for the SDGs" published to coincide with the official launch of the institute.

"GESDA is an instrument of anticipation and of action. GESDA is not only a think tank. And today we are delighted to share our first major step as a do tank, which is the inauguration of the Open Quantum Institute. It is a tribute to the dedication and collaboration of all the GESDA community," Brabeck-Letmathe said. "So let us carry this spirit of action and unity forward. Let us continue to innovate, to bridge gaps, to create a world where the promise of science benefits all of humanity."

The panel discussion on accelerating quantum use cases began with the moderator, Barry Sanders, a Professor and Director of the Institute for Quantum Science and Technology at the University of Calgary, explaining that quantum computing "is not about speeding up computers to do things – it's about changing the very notion of what is hard or easy for a quantum computer to be able to do." As nations and companies vie to build quantum machines, he said, the OQI will work to "establish a quantum computing ecosystem that is beneficial to the Sustainable Development Goals."

Matthias Christandl, a Professor in the Department of Mathematical Sciences at the University of Copenhagen, said the potential for new drug discovery, particularly research that could impact the growing problem of antimicrobial resistance around the world, is a promising use case because a drug's molecules are made of atoms that behave quantum mechanically. "This really raises the bar, sort of raises the goal of what you can do and how you can impact your research," he said.

He has been working with Laura Piddock, the Scientific Director of the Global Antibiotic Research and Development Partnership (GARDP), on trying to expand antibiotic development and access so these infections are treatable for everyone. Most of GARDP's work involves time-consuming clinical development, so the OQI could help greatly speed up that process. "At the moment, even using the best computing power we've got, we're still not radically reducing the time it takes to discover something and turn that into a new treatment," Piddock said. "We're still talking about at least a

Barry Sanders, Matthias Christandl, Laura Piddock

decade, and this really offers the opportunity of a breakthrough to start reducing that time."

Troyer, of Microsoft Quantum, said the good news is that the promise of quantum is real. "The applications we heard about will be possible. And that will let mankind get to the challenges of climate change, food security, human health," he said. "And while we still have to do lots of progress in science engineering to get there, we need to look beyond the technology. We need to look at the people. Because we need the best minds. We need the most diverse perspectives. We need the most dedicated people to make it real."

As Microsoft builds quantum computers, it wants to work more with academia, industry, and governments and "that's where the initiative at GESDA and now the OQI are essential," he said. "We want to find a responsible way of making the future access to quantum inclusive but equitable and working with the best minds around the world to make it real. That's a deep question. I've worked on quantum now for more than two decades. We're at the point now where we have the clarity of what we can do with quantum, and the clarity of what's needed to get there."

The African Institute for Mathematical Science (AIMS), a pan-African network of centers of excellence for postgraduate training, contributes to quantum information and computing through its Quantum Leap Africa Initiative for generating high-impact research in data science and smart systems engineering. Prince Koree Osei, a mathematician who is Centre President of AIMS Ghana and Lead Scientist and Director for Quantum Leap Africa, said "talent abounds in Africa, but these talents need

Sana Odeh

access to the science and technologies in these fields to actually unlock their potential."

"What the Open Quantum Institute will do for us is to allow a lot of our students who are interested in and specializing in quantum and quantum technology to have access to quantum computers and the infrastructure that they need to develop in these fields," he said. "We need to ensure that people from different backgrounds and culture are actually at the leading edge of creating this technology and deploying this technology. The model that we have shown at AIMS demonstrates this fact."

The panel discussion also featured the First Prize Winners of the 2023 New York University Abu Dhabi (NYUAD) Hackathon for Social Good in the Arab World, a GESDA partner. Two of the winning team's seven

Barry Sanders, Prince Osei, Matthias Troyer

Allen Baranov

Urbasi Sinha

members, Allen Baranov of MIT and Yafa Hassan Jaradat of Palestine Polytechnic University, took to the stage alongside the founder and organizer of the annual hackathon, Sana Odeh, a Clinical Professor of Computer Science and Faculty Liaison for Global Programs of Computer Science at NYU, as their other team members joined the audience.

"Being here, especially at the core of science and diplomacy, is really important to everybody today, especially bringing AI and quantum computing to a talented world," Odeh told the Summit. "It's really our responsibility to allow access and opportunities to everyone around the world to benefit from opportunities in science and technology, especially what it's going to offer. Millions of jobs in the future will be dependent on the knowledge from AI and quantum computing."

Yaffa Hassan Jaradat

Partnering with GESDA "transformed the hackathon" by opening up connections to the SDGs, the United Nations and other multilateral organizations that helped "to guide and prepare our students to build these sustainable applications that will have impact locally and globally," she added. "It's really a glimpse of hope into the future of how GESDA and the international community, when they come together, they can really do great things and allow us to innovate in a big way."

The "Smart Current" team won the top prize at the international hackathon – which encourages the use of quantum computing to solve SDGS-related challenges – for a solution that uses affordable, clean energy to avoid and mitigate blackouts in power grids. It found that by managing power more efficiently, it could reduce by 60% the risk of future blackouts. Jaradat, who managed to join the Summit just days after war erupted in Gaza, recounted how a blackout had plunged Palestine into darkness and caused the death of a newborn, Ahmed, when his oxygen machine ran out of power.

"This doesn't need to happen. Ahmed is one of hundreds of cases like this in the world. The transformation of our energy grids holds the promise of preventing such heart-wrenching losses," she said. "With Smart Current, we can make life safer and easier for families like Ahmed's. Even in the USA, the usual damage from blackouts exceeds US$100 billion. Can you imagine what's the impact in North Africa, where blackouts are over 30 times more frequent and longer in duration?"

Baranov said the team's tool made it possible to predict where blackouts might occur by using a special technique called quantum topological data analysis, which analyzes how businesses, homes and power stations are all connected in the grid. "With this tool, we can pinpoint where we think the blackouts will occur and, using the tool, we could reroute electricity so that there's no widespread blackouts," he said. "The classical algorithm runs far less efficiently than the quantum version."

"The Open Quantum Institute is more than just a project, it's a compelling call to action," he added. "It's a heartfelt plea for a world where every brilliant mind from every corner of the planet can contribute and harness the potential of quantum computing. And with multilateral cooperation, we can help set up the guardrails that are necessary with this new technology. Then when we bring everyone to the table from scientists to diplomats, technologists and politicians, we can make sure that we maximize the growth of the field."

Closing out the panel session, physicist Urbasi Sinha recounted her involvement in developing the OQI since 2020, first as a task force member, then as an advisory board member. "Bringing together science and multilateral diplomacy in quantum is a unique task," said Sinha, a Professor at the Raman Research Institute in Bangalore, India, where she heads its Quantum Information and Computing (QuIC) laboratory. "The quest to harness the power of quantum technology inclusively is simply beginning. The OQI is spearheading this effort. It is a collective global endeavor, and it will be successful. You know, we are all convinced that it will be successful. It's getting launched today, but it will be successful because of how diverse the community is."

Activating multilateral governance also is an essential pillar of the OQI, said Sinha, who helped shape India's national quantum mission. "Many of us now, as countries, we have national quantum strategies, but it won't make a lot of sense if we don't get together under an umbrella, which is what OQI is providing us," she said. "We hope what we are doing with quantum will pave the way for like-minded approaches in some of the technologies the GESDA Radar is anticipating. Together we can make the quantum leap towards a world of innovation, diplomacy and boundless possibilities."

More information

Explore the 2023 GESDA Science Breakthrough Radar®

Session recording on YouTube

Key messages

- The official launch of the Open Quantum Institute (OQI) at the 2023 GESDA Summit capped a two-year journey from design phase to incubation phase, ushering in the next start-up phase: a three-year pilot program hosted by the European Organization for Nuclear Research (CERN). Designed and incubated by GESDA with 130 partners worldwide, the OQI was slated to open its doors at CERN on March 1, 2024.
- Scientists and engineers are working on quantum devices for a range of uses such as secure communications, precisely measuring magnetic fields, energy-efficient ways of producing fertilizers and creating materials for batteries with higher energy density.
- The potential for new drug discovery, particularly research that could impact the growing problem of antimicrobial resistance around the world, is a promising use case because a drug's molecules are made of atoms that behave quantum mechanically.
- GESDA initiated the creation of the OQI to ensure that quantum computing is primarily used to advance the U.N.'s 17 Sustainable Development Goals for 2030. It will work according to three priorities: Ensuring access to a pool of private and public quantum computers; promoting education and training in quantum computing; and activating diplomacy to shape multilateral governance rules for quantum computing.

Friday 13 October, 10.45 - 11.45 CET

Plenary Session

Quantum Solutions for All: High-Level Political Segment

Alexandre Fasel, Ignazio Cassis, Sarah Bint Youssef Al Amiri, Peter Sztaray, Viscount Camrose, Tatiana Valovaya, Yoichiro Matsumoto, Patricia Gruber

Quantum Solutions for All: High-Level Political Segment

Ministers and decision-makers discuss the opportunities and challenges offered by quantum technology.

Speakers

Moderated by:

Alexandre Fasel, State Secretary for Foreign Affairs, Switzerland

With:

Sarah Bint Yousef Al Amiri, Minister of State for Public Education and Advanced Technology, United Arab Emirates

Viscount Camrose, Minister for AI and Intellectual Property, UK

Ignazio Cassis, Federal Councillor and Minister of Foreign Affairs, Switzerland

Patricia Gruber, Science and Technology Advisor to the Secretary of State, USA

Joel Hernández, Sub-Secretary of Foreign Affairs, Mexico (video message)

Yoichiro Matsumoto, Science and Technology Advisor to the Minister of Foreign Affairs, Japan

Emilija Stojmenova Duh, Minister of Digital Transformation, Slovenia (video message)

Péter Sztáray, State Secretary for Security Policy and Energy Security, Hungary

Tatiana Valovaya, Director-General, United Nations Office at Geneva

Summary

At a political roundtable organized by the Swiss Federal Department of Foreign Affairs (FDFA) and GESDA, high-ranking government officials from countries in Asia, Europe, the Middle East and North America strongly endorsed an initiative to scale up the fledgling Open Quantum Institute (OQI) in Geneva and establish it as a global hub of quantum computing resources and technical expertise for projects that support the U.N.'s 17 Sustainable Development Goals for 2030.

Moderated by Swiss State Secretary and Ambassador Alexandre Fasel, the political discussions about the OQI, proposals for the global governance of quantum computing, and other aspects of science and diplomacy brought together ministers and top-level advisers from Hungary, Japan, Mexico, Slovenia, Switzerland, the United Arab Emirates, the United Kingdom, and the United States, along with Tatiana Valovaya, the Director-General of the United Nations Office at Geneva.

Countries, notably those from the Global South, not only want access to quantum computing resources but also the opportunity to co-develop them, which is what the OQI is being set up to do, according to Fasel, who also serves as the Swiss Special Representative for Science Diplomacy and is a former Chairman of the GESDA Diplomatic Forum. "We need to bring the global quantum computing system to fruition, and so this combination of existing scientific excellence and bringing in global talent from all over the world is what we are trying to do," he said. "We need excellent science so that we can use it for the advancement of a good and just and equitable global order."

Sarah Bint Yousef Al Amiri, the UAE Minister of State for Public Education and Advanced Technology, called the OQI "a milestone effort that drives several factors forward" in the public policy domain of technology development, ensuring it is aligned with societal and economic needs. It's important to multilaterally establish regulations, she said, but not too early because that could stifle innovation and not too late because that could weaken their effect. "That's, of course, a very easy statement to make, but a very hard balance to ensure," she said. "Governance globally through multilateral efforts needs to ensure that we don't increase the technology gap between nations, and we don't increase the technology gap in terms of access to technology. The more complex technology gets, if we don't design into the process a mechanism to share the utilization of that technology, especially with quantum computing, it will be very difficult to reap the benefits."

Given the importance of future quantum computing, Péter Sztáray, Hungary's State Secretary for Security Policy and Energy Security, questioned "how the security and the safety of this project can

Sarah Bint Youssef Al-Amiri

Peter Sztaray

be assured" at the OQI. "It's a very noble approach to assure openness to all the scientists to such a quantum institute. It's very important because that could help our goal to elevate those regions and those countries who are a little bit lagging behind and, on the other hand, have all the knowledge from all the different parts of the world brought together and accumulated knowledge together to reach scientific goals. But at the same time, there's also a risk with that, that this kind of state-of-the-art technology can fall into the hands of the bad guys also. And the question is how we can tackle the dichotomy of openness, on the one hand, and of security and safety, on the other hand."

Openness in quantum is of absolute importance, said Jonathan William Berry, the U.K. Minister for Artificial Intelligence and Intellectual Property. "In answer to the question, 'How open should quantum be?' As open as possible, as secure as necessary." In 2014, when the U.K. became the first country to adopt a national quantum strategy, there was a strong sense that creating a proper regulatory landscape would "enable quantum success at a national level," according to Berry, who is known in Westminster by his hereditary title, the fifth Viscount Camrose. An openness toward the emerging technology is needed, he said, because "the scale of quantum means that it will never kind of sit within one country or even a group of countries." The U.K. strategy also focused on teaching quantum skills and "importing smart people from elsewhere to acquire those skills," said Berry. "What that then enables is, first of all, private investment, business investment coming in."

Emilija Stojmenova Duh, Slovenia's Minister of Digital Transformation, said in a video message that governments and industries view quantum computing as a way to gain a competitive edge. "Quantum computing holds the potential to exponentially enhance AI capabilities. Enhanced collaboration between quantum physicists, AI experts and computer scientists is vital for realizing the full potential of quantum-AI convergence," she said. "As quantum computing progresses, ensuring the security of AI systems and data becomes increasingly challenging and demands new methods and strategies. Therefore, effective governance mechanisms at the international level by the European Union, United Nations, OECD, the Council of Europe, and other international organizations are needed to address these global AI challenges and opportunities together."

As head of the U.N.'s European headquarters, Tatiana Valovaya has a prominent role in supporting efforts to achieve the SDGs, but she said their success or failure also greatly depends on emerging science and technologies. The latest U.N. assessment of the SDGs, a roadmap to shared peace and prosperity that was endorsed by the 193-nation U.N. General Assembly in 2015, shows that 85% of the associated 168 targets are off-track and unlikely to be accomplished. Valovaya, an economist and former Russian diplomat who is the first woman to serve as the Director-General of the United Nations Office at Geneva, said all great transformations are accompanied by great challenges.

"Revolutions, social unrest, global conflicts, revolts, growing inequalities between the regions, rise and

Tatiana Valovaya, Yoichiro Matsumoto

Emilija Stojmenova Duh

fall of the empires of nations. We now understand this. Can we mitigate the negative sides of this development? And can we do better than our predecessors? I'm sure we can," she said. "For the first time in history, humanity does have a roadmap to the next social and economic paradigm. And we also understand what we need now to implement this, but also understand how we can have more global governance and multilateral cooperation to really harness the use of the technologies."

Japan has been working to make its national science and technology plan, which is updated every five years, more "human-centric" and focused on societal values, according to Yoichiro Matsumoto, the Science and Technology Adviser to Japan's Minister of Foreign Affairs. "Now it must be a human-centric society, and maybe we're thinking economic development and the solution to societal issues is by highly integrating cyberspace and physical space and incorporating advanced technology into all industries and social life," he said. "And maybe quantum computing is mostly an important thing for a digital twin. And so, AI, quantum and biotechnology – cutting edge fundamental technology – that will affect all scientific and technological innovation."

In a video message, Joel Hernández, a lawyer and veteran diplomat who serves as Undersecretary for Multilateral Affairs and Human Rights in Mexico's Ministry of Foreign Affairs, said GESDA's pioneering, multi-disciplinary approach toward quantum computing, AI and eco-regeneration "seamlessly aligns with Mexico's overarching foreign policy vision" including the convergence of science and diplomacy, which holds the key to a brighter future for humanity. "Hand-in-hand with our esteemed partners at GESDA, we will continue to harness the formidable synergy of science and diplomacy, anticipate, address and overcome the most significant global challenges."

When she oversaw the international science program for the U.S. Navy, Patricia Gruber recalled, the goal was to seek out and fund brilliant researchers around the world who were doing promising work, then connect them back to the U.S. research enterprise. Gruber, who now serves as the Science and Technology Adviser to the U.S. Secretary of State, said it was really about "building that international collaboration and an ecosystem where the free flow of ideas can really help accelerate the S&T community. So, the role of government, however, goes well beyond just funding research, right? It really is about trying to create the rules of the road, if you will, and the principles; thinking about how we make sure that as technology evolves, that it is going to be available, is going to be inclusive, it's going to be safe for users, it considers human rights, and so on."


Patricia Gruber

Viscount Camrose

Alexandre Fasel

The U.S. adopted a national quantum strategy in 2018 that recognizes the transformational qualities of quantum-based technologies such as GPS for navigation, MRIs for medical imaging and semiconductors for computer chips. “I really have to give a shout out to GESDA for this sort of forum. It is wonderful to see the science and technology community recognizing that they need to be engaged more with diplomats and diplomacy and governance,” Gruber said. “I personally look forward to 10 years from now looking back and saying, you know what? The governments and the ministries around the world got it right on quantum and we’re in a good place.”

In response to the quantum revolution, Switzerland wants the OQI to serve as “the umbrella of the quantum national strategies,” said Swiss Foreign Minister and Federal Councilor Ignazio Cassis, a diplomat and medical doctor who has championed science and diplomacy as a 21st century theme for sustaining Geneva’s relevance as a global hub of multilateralism. The OQI will explore use cases for quantum technologies to “maximize the chances while minimizing the risks,” he summed up. “It is working in Geneva, in the ecosystem of the multilateral organizations, the NGOs, the industrial and private sector organizations who are based here. And this is the reason we’re here.”

More information

Explore the 2023 GESDA Science Breakthrough Radar®

Session recording on YouTube

Key messages

- High-ranking government officials from countries in Asia, Europe, the Middle East and North America strongly endorsed an initiative to scale up the Open Quantum Institute (OQI) in Geneva as a hub for ensuring the technology is accessible and is used in service of the U.N.’s 17 Sustainable Development Goals for 2030.
- Ministers and top-level advisers participated from Hungary, Japan, Mexico, Slovenia, Switzerland, the United Arab Emirates, the United Kingdom, and the United States, along with Tatiana Valovaya, Director-General of the U.N. Office at Geneva.
- Countries, notably those from the Global South, not only want access to quantum computing resources but also the opportunity to co-develop them.
- The latest U.N. assessment of the SDGs, a roadmap to shared peace and prosperity endorsed by the 193-nation U.N. General Assembly in 2015, shows 85% of the associated 168 targets are off-track and unlikely to be accomplished.
- Switzerland wants the OQI to serve as an umbrella for quantum national strategies by exploring use cases for quantum technologies to maximize the chances while minimizing the risks.

Friday 13 October, 11.45 - 12.15 CET

Plenary Session

Special Announcement: Launch of the Open Quantum Institute

Sandro Giuliani, Ignazio Cassis, Nathalie Fontanet, Fabiola Gianotti, Christian Bluhm, Peter Brabeck-Letmathe

Special Announcement: Launch of the Open Quantum Institute

Speakers

Ignazio Cassis, Minister of Foreign Affairs, Switzerland

Peter Brabeck-Letmathe, Chairman, Board of Directors, GESDA, Switzerland

Christian Bluhm, Group Chief Risk Officer, UBS, Switzerland

Fabiola Gianotti, Director-General, CERN, Switzerland

Nathalie Fontanet, Geneva Cantonal State Councillor, Switzerland

Summary

Backed by the Swiss government, the European Organization for Nuclear Research (CERN) and Switzerland's largest bank UBS, GESDA formally launched a new global institute in Geneva that will work to ensure that future quantum computing is accessible and used for the common good.

The Open Quantum Institute, after two years of incubation and design by GESDA in collaboration with some 130 experts, will be hosted by CERN as a new three-year pilot program that will be fully embedded into CERN's wider Quantum Technology Initiative. UBS agreed to be the lead financier and impact partner, providing strategic expertise and funding of up to 2 million Swiss francs a year.

Swiss and Geneva authorities whose governments created the Geneva Science and Diplomacy Anticipator Foundation in 2019 joined with leaders and representatives of GESDA, CERN and UBS in marking the transition to the next scale-up phase. The OQI, announced as a new initiative a year ago, was expected to open at CERN on March 1, 2024.

"Today we are launching the Open Quantum Institute, and we are handing it over to its new host CERN," GESDA's CEO Sandro Giuliani said in kicking off the special announcement. The OQI's new website also launched at https://oqi.gesda.global/. Giuliani said the journey toward the creation of the OQI in Geneva began with Swiss Foreign Minister and Federal Councilor Ignazio Cassis and his "vision to put science at the core of the 21st century diplomacy."

Peter Brabeck-Letmathe, Ignazio Cassis, Nathalie Fontanet, Fabiola Gianotti, Christian Bluhm

Cassis thanked GESDA's Board of Directors and its staff, CERN, UBS, and the many scientists around the world who contributed to the OQI's creation. "As a politician but also as a medical doctor, I firmly believe that everyone should have access to scientific progress. That progress should be harnessed for the advancement of humanity and cooperation between nations, and that technology should be used for the common good, not just for economic or military gain," he said.

"The field of science diplomacy, born here in Geneva almost 70 years ago with the creation of CERN, is experiencing a second spring and is likely to shape this international Geneva of the 21st century," said Cassis. "What we are doing here is new and, therefore, difficult. The combination of anticipation, which looks far ahead, and action, which must be immediate, is a challenge in itself. And the method by which we want to build this bridge is new and still untested."

Nathalie Fontanet, State Councilor of the Republic and Canton of Geneva, said there was no better place to announce the launch of the OQI than at CERN's new Science Gateway center. "We live, I believe, at quite an important moment in international Geneva's history. We are trying to create new bridges between science and diplomacy. We also strive to build gateways between present and future," she said. "International Geneva is a unique center for global cooperation."

In October 2021, hundreds of scientists from around the world participated in GESDA's efforts to identify the future importance of quantum computing in the first edition of the GESDA Science Breakthrough Radar®. Within two years, the GESDA Foundation

Peter Brabeck-Letmathe, Fabiola Gianotti

designed and incubated the nascent steps for the creation of the OQI then found the two major partners that were needed to run and fund it for the next few years: CERN and UBS.

The burgeoning collaboration between the private and public sectors, academia, scientists, and the international community in Geneva and abroad was described in a new paper on the OQI's genesis: "The Intelligence Report on the multilateral governance of quantum computing for the SDGs."

CERN's Director-General Fabiola Gianotti, who is a GESDA Board member, said her organization is proud to host the three-year pilot phase of the OQI, which will benefit from CERN's experience in uniting thousands of scientists from around the world. The OQI will develop best use cases that advance efforts to achieve the United Nations' 17 Sustainable Development Goals (SDGs) for 2030. It also could serve as a "template" for future science diplomacy initiatives, according to Gianotti.

Sandro Giuliani, Ignazio Cassis, Nathalie Fontanet, Fabiola Gianotti, Christian Bluhm, Peter Brabeck-Letmathe

Christian Bluhm

"We are so proud and pleased because the objectives of the OQI and the mission and values of CERN are perfectly aligned," she said. "And making sure that society at large and not just a few benefit from quantum computing is the main goal of the OQI."

UBS Group Chief Risk Officer Christian Bluhm, representing the bank, said that when he first heard about the OQI project, he was immediately struck by the caliber of people involved. "It took me about 10 or 15 minutes to figure out we are talking about a network of the best of the best," he said. "I was very early on convinced, since I also have a personal interest in quantum computing."

Bluhm, a mathematician who specialized in probability, said he then spoke with UBS Group CEO Sergio Ermotti and they decided "to finance this for the prolonged time into the future" because the bank believes that quantum computing is "probably the most disruptive technology of the decade."

"We are proud to be part of the journey," said Bluhm, who will keep tabs on the OQI and contribute to its progress by joining GESDA's Advisory Board. "Before quantum computing will be in a state where it will be broadly commercially deployed, that will take a few more years. But what we believe as a firm is, if we don't go on that train ride now – be at the forefront of research with strong partners – we might see that the train leaves without us."

"But there's another reason. We're also committed to society, we are committed to sustainability and, in particular, we are committed to Switzerland," he said, adding that CERN's unique status as a world-leading research institute is another draw.

GESDA Board Chairman Peter Brabeck-Letmathe said the launch of the OQI is "a real milestone in the young history of GESDA," helped by the Swiss Federal Department of Foreign Affairs (FDFA), CERN and UBS. He thanked the foundation's founders, Cassis and Fontanet, for their "unwavering support and trust" in GESDA, along with Gianotti and all of CERN's member nations for agreeing to host the fledgling OQI. The CERN Council, with delegates from all 23 member nations, approved the OQI project in October 2023, the same month as the GESDA Summit.

"Our partnership is invaluable to our shared mission of making technology inclusive and open for everybody. And I'm sure that the Open Quantum Institute can continue to count on the strong support of all the CERN community," said Brabeck-Letmathe. "I would also like to acknowledge and thank the incredible individuals and organizations within the quantum community and beyond who believed from the beginning in this endeavor, and which were so important for the success."

"The Open Quantum Institute stands as an emblem for GESDA's unique approach," he added. "CERN is taking the lead in scaling up the Open Quantum Institute; GESDA will remain involved in the project. GESDA will co-chair the Open Quantum Industry Advisory Committee, maintaining continuity with the project design and the community that is supporting this. GESDA will also facilitate the diplomatic collaboration at the Open Quantum Institute."

In a symbolic gesture, the panel session for the special announcement ended with Brabeck-Letmathe handing Gianotti a copy of the intelligence report describing how the OQI project grew to fruition over the past two years. "We don't have a building, we don't have a garden where we can plant a tree, and we don't have a door which we can open, so we have no key," he told her as he handed her the document. "And with this, I wish you a lot of success and thank you very much."

After that exchange, Brabeck-Letmathe brought the 2023 GESDA Summit to a close by pointing to some other interesting exchanges such as a discussion among American and Chinese representatives on the delicate issue of neuroscience. "As this remarkable summit is coming to an end, so I stand before you with a heart full of gratitude and optimism for the future, for science, for humanity."

"And I think the Open Quantum Institute is the first, hopefully, of many GESDA-born initiatives. Because it's our ambition to replicate this success in other areas highlighted in the Science Breakthrough Radar. We already have a pipeline of solutions which we have discussed with you, and there we have received your feedback," he said. "Together we have been setting in motion a future which is based on solid science and filled with limitless possibilities."

More information

Explore the 2023 GESDA Science Breakthrough Radar®

Session recording on YouTube

Key messages

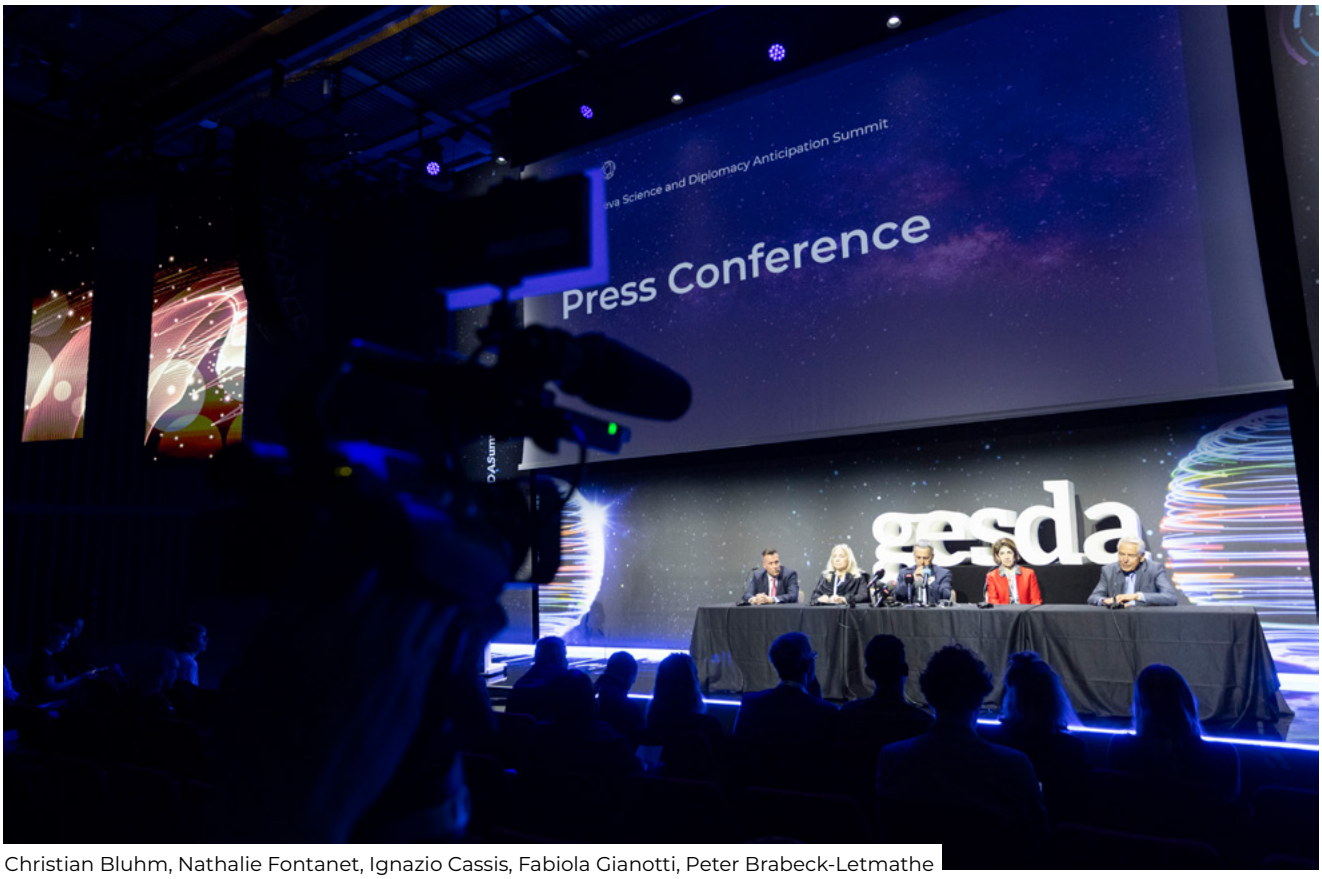
- The Open Quantum Institute (OQI) in Geneva, backed by the Swiss government, the European Organization for Nuclear Research (CERN) and Switzerland's largest bank UBS, seeks to ensure quantum computing is accessible and used for the common good.
- After two years of incubation and design by GESDA with some 130 experts, the OQI will be hosted by CERN as a new three-year pilot program and fully embedded into CERN's wider Quantum Technology Initiative. It is expected to open on March 1, 2024. UBS agreed to be the lead financier and impact partner.
- The OQI is part of the Swiss government's vision of putting science at the core of 21st century diplomacy in Geneva. It will develop best use cases that advance efforts to achieve the United Nations' 17 Sustainable Development Goals (SDGs) for 2030 and could serve as a template for future science diplomacy initiatives.
- GESDA will remain involved by co-chairing the Open Quantum Industry Advisory Committee and facilitating diplomatic collaborations; UBS will keep tabs on the OQI and contribute to its progress by having a seat on GESDA's Advisory Board.

Press Conference and Press Review

Press Conference

The official launch of one of GESDA's leading initiatives, the Open Quantum Institute (OQI) in Geneva, which marked its passage from incubation to a 3-year pilot phase, was the main focus of questions at a press conference that, for the first time, was held at the closing rather than prior to the opening of the annual summit. After two years of efforts to design, run and fund the OQI led by GESDA and some 130 partners and representatives in Geneva from about 20 countries, journalists were curious about some of the far-reaching impacts that quantum computing is anticipated to have on major technology companies, international peace and security, and Swiss and global banking. Some of the questions at the press conference, which was moderated by Daria Robinson, an astrophysicist who is Deputy CEO of GESDA and Executive Director of its Solution Accelerator, also reflected on the past year's astonishingly rapid deployment of generative artificial intelligence tools throughout organizations and industries, and how the world's geopolitical tensions – notably the outbreak of war between Israel and Hamas during the previous week and Russia's full-scale war on Ukraine since 2022 – affected international scientific collaborations at multilateral institutions.

"We know what is at stake with quantum computing in geopolitical terms, but also in commercial terms, how do you think that the big tech companies are going to follow your advice and are going to share what they are working on?" asked Stéphane Bussard, a longtime journalist with the Swiss daily newspaper Le Temps in Geneva, who is in charge of its International Geneva section. He also wanted to know more specifics about the funding that Switzerland's largest bank, UBS, announced it would provide for the OQI's pilot phase. Laurent Sierro, a Geneva-based international journalist and editor for Swiss News Agency Keystone-SDA-ATS, followed up by pointedly asking Swiss Foreign Minister and Federal Councilor Ignazio Cassis whether Switzerland might use its two-year elected seat on the United Nations Security Council, the most powerful arm of the world body, as a means of addressing some of the worries voiced at GESDA's high-level political panel with ministers and government officials that was held earlier in the day to solicit their assessment and support. "We can feel already that there is also concern from some ministers, we could hear that this morning, and that there are concerns in terms of peace and security. And some say that quantum might be as important in the 21st century as nuclear weapons in the 20th century," said Sierro. "Switzerland will have



Christian Bluhm, Nathalie Fontanet, Ignazio Cassis, Fabiola Gianotti, Peter Brabeck-Letmathe

another presidency of the Security Council next year in October. In the past, the Council addressed some technological questions. Is it something you're going to raise during the presidency next October? Are you going to try to get the general commitment already from the Council and from its members to precisely get something in the early parts of the discussion?"

Cassis, a diplomat and medical doctor who received and answered questions in German, French, Italian and English, said the answer was yes. "This is a crucial question and it will be discussed, I am convinced," he replied. Switzerland hosted an "open debate" during its first-ever presidency of the Council in May 2023 at UN headquarters in New York, where Cassis showcased GESDA's brand of anticipatory science and diplomacy as a 21st century solution. Switzerland is due to hold the Council's monthly revolving presidency again in October 2024. The role lets countries take turns shaping the global agenda and hosting open debates on topics that affect international peace and security, which is the Council's mandate. The first Swiss-led session, Cassis noted, featured "technological questions, and, in particular, the question of cooperation, science and diplomacy."

In answer to the question about technology companies, GESDA Chairman Peter Brabeck-Letmathe said the OQI's proponents were surprised at how things turned out, because they initially thought it would be difficult to persuade businesses that had collectively invested tens of billions of dollars into developing quantum computing to share their work. "All of them were very open and all of them have been forming part of this open quantum community which we have created," he said, noting that one of the co-leaders of GESDA's OQI initiative has been none other than Matthias Troyer, a Technical Fellow and Corporate Vice President at Microsoft Quantum. "We were able to convince a company that it is also for their good to be in the beginning part of necessary regulations," said Brabeck-Letmathe. "This is a unique opportunity that we can start to discuss about the needs and the impact that the new technological breakthrough is going to have and discuss it before it's a reality so we can shape the best thing. That's a reason why they participate."

Brabeck-Letmathe emphasized that the OQI's fundamental role does not involve the creation of future quantum technology. "This will always be done either by private companies or, of course, universities, public institutions and things like this," he said. "But what we are doing and what we are trying to offer is to have an institute where people from all over the world, independently from where they are coming, whether they are from Africa, Asia, Europe, or the United States, they have the possibility to start to think about how this new technology can be best applied for the big part of humankind." He also said that OQI's proponents had "negotiated with big private companies to get access to their quantum computers, and they will be able to start to work now so that when the technology is ripe and when the really first quantum computers are there, we don't have to start to think what are the issues, what are the possibilities, but what are also the dangers that come? And that we have already thought in advance what are the regulatory frameworks necessary, so that this technology is not falling at the end of the fuse, but it's for the use for the big part of the population."

As of March 2024, the OQI is to be fully embedded within the Quantum Technology Initiative run by the European Organization for Nuclear Research, known by its French acronym CERN, which was founded in 1954 and operates the world's largest particle physics laboratory. CERN's member nations agreed to host OQI's pilot phase so it can scale up from 2024 to 2027. "My ambition is for the OQI to become a kind of reference template for future initiatives in the field of science diplomacy," said CERN Director-General Fabiola Gianotti, who received and answered questions in English and Italian. "If the OQI is successful, it will attract many, many companies. We start already with a large number of partners from the private sector, and I'm sure that if we manage to show the impact that the OQI can have on society at large, and that the OQI or similar initiatives can be absolutely crucial to avoiding the digital gap in quantum – we discussed this already several times – more and more companies will join. So, for me, being an experimental physicist and being able and used to work by successive prototypes, I think this is the right way to go, step by step."

Gianotti also noted that the 2023 GESDA Summit was the first event to be hosted in CERN's new Science Gateway facility, which was inaugurated just days earlier. "We hope with the Science Gateway to really expand the opportunities that we offer to people from all over the world and all ages to come and visit and see the importance of science and of science for society," she said. "CERN has been a partner of GESDA from the beginning, and we share common values and common objectives, like the importance of science and technology for a sustainable future of humanity and of the planet, the importance of sharing science and technology with everybody, and the importance of having all people on board, also people from underprivileged countries."

UBS announced it will provide funding of up to 2 million Swiss francs annually plus some strategic expertise "over the next several years" for the institute. In answer to questions about UBS financing for the OQI, Christian Bluhm, Group Chief Risk Officer for UBS, told journalists that "the

amount which we agreed with GESDA is exactly what they asked us for" but acknowledged his answers to reporters' questions were intentionally "a bit vague, based on internal policy, but what I can say is that the financial support is strong enough and long enough so that we could kick this off today." In a press statement, the bank said that its funding will cover OQI's designated pilot phase lasting three years. Bluhm, who will also take a seat on GESDA's Advisory Board, said the bank wanted to be part of the quantum journey, otherwise "we might see that the train leaves the station without us."

Nathalie Fontanet, State Councilor of the Republic and Canton of Geneva, which co-founded GESDA along with the Swiss Confederation in 2019, reminded the press conference that the chief purpose of the OQI will be to focus global talent and resources on developing potential use cases for quantum computing that help achieve the UN's 17 Sustainable Development Goals (SDGs) for 2030. "In politics and in conflicts, we see that it is difficult to go together as multilateralists," she said. "And we believe that this initiative will be a way to build together with science and diplomacy of the future and to find new solutions, in particular concerning the SDGs and other solutions."

Natascha Schwyn, a correspondent for Swiss public radio and television broadcaster SRF, asked Cassis, in German, whether the OQI might present Switzerland with "a possible way out" of a difficult political situation in the wake of Switzerland's exclusion from Horizon Europe and other European Union initiatives in 2021, after the Swiss government declared that negotiations on its relationship with the EU had failed. Horizon Europe is the EU's largest-ever research and innovation program with more than 90 billion euros of funding available between 2021 and 2027. It is open to participants from all over the world, but Switzerland is excluded from competing for some of the key grants that provide fund cutting-edge research or support early-career researchers. But the OQI "is not an alternative solution to Horizon Europe. It's on another level. It is a complementary solution. Horizon Europe is a research funding program. We don't do research here. Here we are making a – how should I say – a higher-level dimension. This means classifying, managing and shaping what happens to the research," Cassis answered. "We're trying to think a little faster so that we can perhaps anticipate, classify something, establish certain principles." He reflected that the Swiss and Geneva governments are in the business of promoting multilateralism. "If the 19th century was determined by international humanitarian law, the 20th century was determined by human rights and human rights, then at the beginning of this new 21st century, it would be cooperation between science and diplomacy, the core business of the international Swiss."

Philippe Mottaz, a Swiss journalist and founder of the Geneva Observer, said it's widely expected that one of the first concrete applications of quantum computing will break the crypto system as we know it today, which begs the question of how much trust and security the world's financial systems might have in the future. "This is of strategic importance for Switzerland as a financial center and I wonder if you'd like to share your thoughts?" he asked, inviting Bluhm and others to comment. "Clearly, there is a huge awareness in the risk community," Bluhm answered, "among financial institutions across the globe, that quantum computing is really disruptive and a real threat if you don't become quantum ready in the way you and your cloud, in the way you protect your data, and all of that. And everyone in the risk community in banking is aware of that, is working on it, and will also be ready in time before it really becomes a threat in order to protect our data." Gianotti added that "as it was mentioned before by Federal Councilor Cassis, the OQI is not a technical institute. The OQI does not develop quantum technologies. At CERN, we have a quantum technology initiative and there we develop our quantum activities, and many national laboratories and institutions across the world, and public and private sector institutions develop technology. The Open Quantum Institute is to apply what we know in quantum computing to societal challenges."

Mottaz then posed a question about artificial intelligence, asking if GESDA might announce a major initiative on AI governance next year. Brabeck-Letmathe said GESDA's work is anticipation, not catching up with a fast-moving technology. "We are trying to anticipate. Quantum computing is not existent today. It might exist in five years; most probably will exist in 10 years," he said. "We are specializing in looking forward, getting the feedback from the scientists' community, what they are thinking that their breakthrough will bring in five years, 10 years, 25 years."

Julien de la Fontaine, a journalist with RTS, the French-speaking companion to SRF, posed a question to Cassis, in French: "It is very simple. Why did you consider it important to come here today?" Cassis replied that the Swiss and Geneva governments have been "working together on the question of how to guarantee a future for international Geneva. Beyond the issues specific to Switzerland – international humanitarian law, human rights – we are no longer competitive, if that word still applies, in this process. There are other cities, other continents, which attract more international business, and, therefore, which take customers from us. If we can put it that way, without trying to go to where the costs can be lower, or they can be lower. But what we have here is a fair, wonderful ecosystem that provides added value. And if we don't have added value, we will lose

attractiveness." He said that as a medical doctor, he witnessed the introduction of new technologies, like CT scans and MRIs, that opened up new possibilities. "This is, therefore, where the GESDA Foundation comes in, in the field of anticipated cooperation in scientific diplomacy. Today, there are other forms of cooperation in the fields of science and diplomacy. Here, it is about anticipation, as the president of the foundation explained well. We're trying to do something completely new and create a method that, if it works, can be prototyped for other problems"

Riccardo Bagnato Bulgarelli, a correspondent in Geneva for RSI, the Italian-speaking companion to SRF and RTS, asked Cassis, in Italian, how the wars in Gaza and Ukraine might affect international scientific collaborations. He noted that he had spoken with the "brilliant" and "successful" Yafa Hassan Jaradat of Palestine Polytechnic University, who had joined the stage on the last day of the GESDA Summit as one of the first-place winners in the 2023 New York University Abu Dhabi (NYUAD) Hackathon for Social Good in the Arab World, a GESDA partner. "I wonder what the futuristic scope of this multilateral project is," Bagnato Bulgarelli said. "The problem arises that general instability and multilateralism are greatly threatened and can threaten these projects." Cassis answered that CERN has been successfully carrying out international scientific collaborations for nearly 70 years but deferred to Gianotti for more comment. "Initiatives like OQI, like CERN, are simply more than necessary in today's world, precisely at a time when the world is characterized by great conflicts and great enmities," Gianotti said. "Places like CERN are islands of hope. Trust. *D'espoir*. This is why we must continue to support initiatives as they mostly work in this direction here, precisely because we are living in such a difficult and troubled world. It is important to have initiatives that may give faith to humanity and give hope. I think CERN is one of these institutions."

Maurizio Arseni, a journalist based at the FacLab of the University of Geneva, asked Gianotti and Cassis, on behalf of Geneva Solutions, if they envisioned the OQI becoming "kind of a quantum oversight authority in a few years, not now." In answer to the question, Gianotti said it was important to "be a little bit careful in, first of all, in distinguishing between quantum developments and quantum applications. As I said before, the OQI is not developing quantum technology. The OQI is trying to apply the quantum technologies to society, in particular to the challenges that the world is confronted today. I think we need a governance in the development of quantum technologies and in their applications. Whether the OQI one day can play that role, it's a bit premature to establish today. It's clear that one of the goals of the OQI, in particular with the pilot project, is to open the discussion – *continue*, rather – the discussion, because the incubation phase in GESDA has already done a lot on that, on how it helps the governance for the application of quantum technology should be. So, it can help in continuing the dialogue and in opening the road to the future governance for the application of quantum technologies. It's premature to say today if this will be successful or not. Of course, we are working for success. As I said before, we are pioneers now. We are kind of pioneers of prototyping and we have to progress step by step."

Cassis added that teenagers quickly learn that posing the correct question is "already half of the answer," and it's the same with the OQI. "Facing such a disruptive technology means not knowing what is going to happen. And if the Open Quantum Institute could help us in identifying the corporations and the responsible institutions to answer the current questions and bring the correct questions to the right places, then we will be successful. The OQI will not replace the United Nations. It will not replace the science. It will be a bridge between science and diplomacy at large."

Press Review

The third Geneva Science and Diplomacy Anticipation Summit drew significant media attention across multiple platforms and featured the highest proportion of original articles compared with the two previous summits. The most comprehensive coverage in terms of original content revolved around the launch of the Open Quantum Institute (OQI) and the announcement of GESDA's Global Curriculum for Science and Diplomacy, two of GESDA's most advanced initiatives.

The third summit and GESDA Science Breakthrough Radar® in October 2023 marked the end of the first year since GESDA shifted from a startup to an active launching pad for global initiatives and solutions like the OQI and Global Curriculum for Science and Diplomacy. GESDA Chairman Peter Brabeck-Letmathe announced on the first day that the Wellcome Trust will support GESDA and its partners with 8 million Swiss francs to create the Global Curriculum for Science and Diplomacy.

Media attention to the third summit, which in the previous two versions had included a press conference on the first day focused on the Radar's latest findings, drew particularly extensive coverage on the third and final day – and accounted for 45% of its total news coverage – when the press conference was held to announce that the OQI will be launched as part of the Quantum Technology Initiative run by the European Organization for Nuclear Research, known by its French acronym CERN, and financed during its start-up phase by Switzerland's biggest bank, UBS.

Europe stood out as the most prominent region in terms of coverage, largely due to extensive reporting by Swiss media outlets. The amount of original content generated about GESDA has unquestionably been most prominent in Switzerland, where the multilingual media landscape plays a pivotal role in shaping the narrative and discourse. Among the most prolific sources of multimedia content about GESDA and its activities have been the French, German and Italian arms of the Swiss Broadcasting Corporation SRG SSR, and its 10-language international service, SWI swissinfo.ch.

Other leading producers of news focused on GESDA included Swiss News Agency Keystone-SDA-ATS and the French-language outlets Le Temps and Heidi. news in Geneva. Coverage of GESDA tended to have a positive tone, as it delved into topics with a focus on presenting facts, figures and potential outcomes. As much as 29% of the overall coverage of the third summit could be attributed to the presence of Sarah Bint Yousef Al Amiri, the United Arab Emirates' Minister of State for Public Education and Advanced Technology, who called the OQI "a milestone effort that drives several factors forward" in the public policy domain of technology development.

Most of the stories about Al Amiri, however, were reprints or adaptations of a text published by Asian News International (ANI), an Indian news agency, in the UAE and India. One notable exception was an article published by Handelszeitung. The peak coverage of her was on October 18th. Al Amiri, a computer scientist with a deep interest in aerospace engineering, gained fame as the first chairwoman of the UAE Space Agency and science lead for the Mars Hope mission to the red planet that had the cooperation of three American universities in developing the Hope orbiter.

Some 13% of the third summit's total coverage was made up of articles discussing the expectations and agenda. These pieces highlighted the gathering of 800 scientists, diplomats and business leaders in Geneva for discussions on scientific diplomacy. The peak was reached on October 11th.

Stories on climate change and the GESDA Radar drew media attention, too, but at a lower rate than the other subjects. Scientific media outlets, which focused on quantum computing, climate change and the GESDA Radar, accounted for a mere 1.5% of GESDA's entire media coverage landscape.

Online media platforms maintained their dominant position, boasting a significant 95.5% share in the media landscape with an overall reach amounting to 145 million. By region, Europe accounted for 59% of the coverage. Asia and the Middle East were next, with 16% and 13%, respectively. North America had 7%, Africa 3%, and Oceania and Latin America made up the remaining 2%.

By country, Switzerland and India led with 44% and 15% of the coverage, respectively. The next most were the UAE, 9%; United States, 7%; France, 5%; Italy, 4%; the United Kingdom, Jordan and Belgium, each with 2%; and China, Egypt, Germany and New Zealand, each with 1%. An assortment of coverage from other countries and regions accounted for the remaining 6%. As in years past, much of the summit's international news coverage originated with newswire content that was being fed to syndicated newspapers and was largely generated by a small cadre of international journalists based at the Palais des Nations in Geneva, home to the UN's European headquarters.

International journalists based at the UN in Geneva, however, were drawn away from covering the third summit due to the outbreak of a new war in the Middle East four days earlier. The new war had huge implications for humanitarian aid, refugees, public health and other purposes of Swiss-based international organizations. The geopolitical ramifications were as far-reaching as the impacts of Russia's all-out war on Ukraine starting seven months before the second summit. Still, the number of original articles generated about the third summit came to 114, compared with 97 from the second summit and 106 from the first summit. But the news coverage from the first summit was dominated by an Associated Press article, "Swiss-Backed Project Aims to Avert New 'Cold War' in Science," that was picked by hundreds of US syndicated newspapers. The AP story plus others by Newsweek and Bloomberg reached a collective audience that numbered in the billions.

International coverage of the third summit also may have suffered from media fatigue due to other events in Geneva. For the second year in a row, the GESDA Summit was held just a week after the Building Bridges summit, which advances sustainable finance. The Swiss Media Database, which measured coverage of both events, found 58 mentions of GESDA (43 in French, 13 in German and two in Italian) and 56 mentions of Building Bridges, including 20 alone published by L'Agefi. However, this was the first time that GESDA surpassed Building Bridges in terms of coverage, likely due to the OQI announcement. In 2022, there were 47 mentions of GESDA compared with 64 about Building Bridges. And in 2021, there were 29 about GESDA and 50 about Building Bridges.

The two wars made GESDA's discussions on the future of peace and war at the third summit timely. In their questions, journalists reflected widespread concerns about the bloodiest conflict in Europe to break out since the Second World War and the

dangerously polarizing and deadly Israel-Hamas war in the Middle East. News coverage ahead of the third summit highlighted a partnership between GESDA, the Geneva Centre for Security Policy (GCSP) and Columbia University's School of International and Political Affairs (SIPA) to identify new approaches toward anticipating the future of peace and war, particularly longstanding armed conflicts with multiple outside powers.

Print coverage represented around 3% of the total coverage. A noteworthy example was Le Temps, which wrote several articles covering topics like multilateralism, climate change, and human rights. It also reported on the launches of the OQI and the Global Curriculum for Science and Diplomacy. Two press releases at the opening and closing and daily accounts of the highlights in stories posted on LinkedIn during the summit also helped to boost its general publicity and public engagement.

For the third summit, GESDA released its first digital communication campaign with branded content spread over the main digital platforms: GESDA's website, LinkedIn, X (formerly Twitter) and YouTube. GESDA's one-month campaign strategically placed pieces of content that were developed around storytelling associated with anticipation, along with science and diplomacy. The campaign's digital toolkit included more than 120 visual assets, including different types of visual content to showcase complex information in an easier way, such as explainers that presented the summit, OQI and Radar in a branded and simple infographic. During the summit, GESDA had 170 posts using a multi-channels strategy to diversify its digital coverage based on the targeted audience and expected results. In 2023, GESDA reached more than 5,000 followers on X and more than 6,000 on LinkedIn. It also began a monthly newsletter, GESDA News, that goes out to about 4,500 regular subscribers and is most widely read in the United States, Switzerland and United Kingdom. Notably, tweets during the third summit that featured or were sent by GESDA Board Member Mamokgethi Phakeng, who has nearly 350,000 X followers, drew as much as 610,000 impressions.

GESDA's media presence extended well beyond the written word, encompassing radio and television broadcasts. GESDA's representatives participated in interviews, discussions and panel discussions on both national and international platforms. Broadcast media also captured Swiss Foreign Minister and Federal Councilor Ignazio Cassis' statements during the third summit. Reporting peaked on October 13th when Cassis revealed the official launch of the OQI, emphasizing its mission to leverage quantum technologies that can accelerate progress towards the SDGs.

Top articles were produced by Swiss News Agency Keystone-SDA-ATS; Emirates News Agency, also known as WAM, the official news agency of the United Arab Emirates; SWI swissinfo.ch; and Corriere del Ticino, a regional daily newspaper. Headlines such as "Quantum technology should serve the common good," "GESDA launches a science diplomacy course and expands," and "Swiss Foreign Minister Ignazio Cassis speaks at the GESDA Summit" featured in articles by Swiss News Agency Keystone-SDA-ATS. "Sarah Al Amiri leads UAE delegation to Switzerland" headlined an Emirates News Agency story. "Technology governance: can GESDA put Geneva on the map?" led a SWI swissinfo.ch article. And the headline, "Peter Brabeck-Letmathe: Scientific diplomacy at the service of peace," topped an exclusive interview with him published by the Corriere del Ticino.

"The announcement of the creation of the institute takes place at the end of the third edition of the Geneva Science and Diplomacy Anticipator (GESDA). The high technology it will deal with is, among other things, linked to the so-called anticipatory scientific diplomacy, i.e., the possibility of predicting technological advances and their repercussions on society, as well as identifying solutions to best manage such changes," the Corriere del Ticino reported.

"The Open Quantum Institute, officially born today in the presence of Federal Councilor Ignazio Cassis, lays the foundations of multilateral governance for quantum computing, something strongly desired by the Confederation," it said. "In addition to science diplomacy, the institute will also focus on leveraging quantum technologies to accelerate the achievement of the UN Sustainable Development Goals and facilitate access to these cutting-edge technologies on a global scale."

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