13th Annual Meeting

STS *forum* 2016

Summary

October 2, 3 and 4, 2016
Kyoto, Japan

Science and Technology in Society *forum*

Summary of STS *forum* 2016

STS *forum* 2016 - 13th Annual Meeting Program

October 1, 2, 3 and 4, 2016

October 1, 2016 (Saturday)	
12:00-18:30	Registration [Grand Prince Hotel Kyoto] (for all STS *forum* participants)
18:00-20:00	Networking Plaza [Grand Prince Hotel Kyoto, Gold Room]

10:30-17:30	Regional Action on Climate Change Conference (RACC8) [Room 510]
14:00-17:30	5th Global Summit of Research Institute Leaders [Room C-2]
14:00-16:40	Kyoto Symposium [Kyoto Chamber of Commerce and Industry]
15:30-17:30	Dialogue between Future Leaders and Nobel Laureates [Room E]

October 2, 2016 (Sunday)				
8:30	Doors open and Registration starts at the Kyoto International Conference Center (ICC Kyoto)			
10:00-11:00	Opening Plenary Session 100: **Science and Technology for the Future of Humankind** [Main Hall]			
11:00-11:10	Break			
11:10-12:20	Plenary Session 101: **Sustainable Development** [Main Hall]			
12:20-13:50	Buffet Lunch [Sakura]			
13:50-15:30 Concurrent Sessions 102	Energy and Environment **Future Prospects of Oil and Gas** [Room K]	Life Sciences **Genome Engineering** [Room B-2]	Engineering and Innovation **Industrial Innovation** [Room C-1]	Earth Science **Earth Observation** [Room J]
15:30-15:40	Break			
15:40-16:40	Plenary Session 103A: **Research and Innovation** [Main Hall]			
16:40-17:10	Coffee Break			
17:10-18:50 Concurrent Sessions 104	Energy and Environment **New and Renewable Energies** [Room K]	Life Sciences **Environment and Health** [Room B-2]	Engineering and Innovation **Future Nanomaterials** [Room C-1]	Earth Science **Ocean** [Room J]
18:50-21:00	105: Official Dinner [Event Hall]			

12:20-13:50	CTO Meeting [Room E]			12:20-15:30
	Cooperation in S&T **Competition and Cooperation among Global Industries** [Room B-1]	Science, Technology and Society **Social Innovation for Sustainability** [Room H]	ICT **Internet of Things (IoT)** [Room C-2]	Cities **Megacities** [Room G]	S&T Ministers' Lunch & Roundtable [Annex Hall]
	Plenary Session 103B: **The Role of Universities** [Room D]			
				16:50-18:50
	Cooperation in S&T **Collaboration among Academia, Industries and Government** [Room B-1]	Science, Technology and Society **Bridging Science and Technology with Society and Politics** [Room H]	ICT **Big Data** [Room C-2]	Cities **Smart Cities** [Room G]	Academy of Science Presidents' Meeting [Room 104]

October 3, 2016 (Monday)								
7:30	Doors open and Registration starts at the Kyoto International Conference Center (ICC Kyoto)							8:00-8:45
9:00-10:10	Plenary Session 200: **Lights and Shadows of ICT** [Main Hall]							General Meeting
10:10-10:40	Coffee Break							10:10-12:30
10:40-12:20 Concurrent Sessions 201	Energy and Environment	Life Sciences	Engineering and Innovation	Earth Science	Cooperation in S&T	Science, Technology and Society	ICT	Funding Agency Presidents' Meeting [Room E]
	Nuclear Technology Prospects [Room K]	**Infectious Diseases** [Room B-2]	**New Manufacturing Technologies** [Room C-1]	**Water** [Room J]	**Science and Technology Diplomacy and International Collaboration** [Room B-1]	**Science and Engineering Education** [Room H]	**Security in ICT** [Room C-2]	
12:20-13:20	Lunch [Sakura]							12:30-14:30
13:20-14:30	Plenary Session 202A: **Population & Resources** [Main Hall]				Plenary Session 202B: **Science and Technology in Business & Finance** [Room A]			University Presidents' Lunch Meeting [Room D]
14:30-14:40	Break							14:40-16:40
14:40-16:20 Concurrent Sessions 203	Energy and Environment	Life Sciences	Engineering and Innovation	Earth Science	Cooperation in S&T	Science, Technology and Society	ICT	Academy of Engineering Presidents' Meeting [Room 103]
	Best Mix of Energy [Room K]	**Healthy Aging** [Room B-2]	**AI and Robotics** [Room C-1]	**Climate Change -Adaptation and Mitigation-** [Room J]	**Science and Technology in Developing Countries** [Room B-1]	**Public Engagement in S&T** [Room H]	**Development of Nano-industry** [Room C-2]	
16:20-16:50	Coffee Break							
16:50-18:00	Plenary Session 204: **Delivering Health Care to the World** [Main Hall]							
18:00-18:30	Move to Kyoto National Museum (shuttle bus provided from ICC Kyoto to the site)							
18:30-20:30	Special Buffet Dinner at Kyoto National Museum							

October 4, 2016 (Tuesday)	
8:00	Doors open and Registration starts at the Kyoto International Conference Center (ICC Kyoto)
9:00-11:00	Plenary Session 300: **Key Messages from Concurrent Sessions** [Main Hall]
11:00-11:40	Coffee Break
11:40-12:30	Closing Plenary Session 301: **Development and Sustainability for the Future of Humankind** [Main Hall]
12:30-13:30	302: Farewell Buffet Lunch [Swan]

Table of Contents

[DAY 3] October 4, 2016 (Tuesday)

Themes of Concurrent Sessions

Energy and Environment

Life Sciences

Engineering and Innovation

Earth Science

Cooperation in S&T

Science, Technology and Society

ICT

Cities

Day 1

Opening Plenary Session 100
Plenary Sessions 101, 103 (A-B)
Concurrent Sessions 102, 104

Opening Plenary Session 100: Science and Technology for the Future of Humankind

[Session Chair]

Omi, Koji, Founder and Chairman, Science and Technology in Society *forum* (STS *forum*), JAPAN

[Speakers]

Abe, Shinzo, Prime Minister, Government of Japan, JAPAN
Cerar, Miro, Prime Minister, Republic of Slovenia, SLOVENIA
Dvorkovich, Arkady, Deputy Prime Minister, Government of the Russian Federation, RUSSIA
Sakakibara, Sadayuki, Chairman, Keidanren (Japan Business Federation); Chief Senior Advisor, Chief Senior Counselor, Toray Industries, Inc., JAPAN

Opening Remarks

Mr. Koji Omi, Founder and Chairman, Science and Technology in Society *forum* (STS *forum*), opened the 13th annual meeting and expressed his appreciation for the attendance of the participants, and his gratitude for the assistance of sponsors and other support organizations.

While science and technology have brought great benefits to humankind, they also pose a variety of challenges. These are the lights and shadows of science and technology, and the fundamental concept of STS *forum* is to gather leaders from around the world from government, academia and industry to address them.

Highlights of the 13th Annual Meeting include the setting of the Sustainable Development Goals by the United Nations last year. Achieving these goals is an urgent task for leaders around the globe. All societies must strive to create a sustainable future for mankind.

In the field of energy and resources, we must recognize the finite nature of resources and ensure their sustainable consumption. Nuclear energy should remain an important pillar of energy, provided that matters of safety are fully addressed. ICT has brought significant changes to society and people's lives. However, ICT also comes with concerns of privacy and security. In addition, medical advances, such as iPS technologies, have also yielded great benefits. It is hoped that the discussions of STS *forum* will contribute to developing breakthrough medical treatments for the improvement of people's lives.

The leaders of the current generation have an important responsibility to foster the leaders of the future. To that end, STS *forum* conducts the Future Leaders' Program, which includes a dialogue with Nobel Laureates. Additionally, STS *forum* encourages the participation of women. This year, the participation of women has risen from 11% to 14%. Furthermore, STS *forum* has held four workshops around the world to increase its visibility around the world.

STS *forum* presents a rare opportunity for leaders from the government, academia and industry, to network and discuss the pressing science and technology issues of our time. It is hoped that participants will engage in frank exchanges of opinions over the course of the annual meeting.

The Prime Minister of Japan, Shinzo Abe, explained the importance of science and technology to him personally and to society. He emphasized that science and technology must make a difference in our societies and that we must not simply wonder how science and technology can make a difference in our societies. The Japanese government is spending over 10 trillion yen tackling medical and healthcare issues, and there are high expectations for the role technology can play in medical science. For example, technologies such as big data, sensors, and robotics hold great potential. However, attention needs to be paid to

balancing scientific advancement on the one hand, and personal privacy on the other.

The Japanese government has initiated the long-term strategy of Society 5.0, which aims to tackle issues such as aging, labor productivity, and human wellness. Sensing, robotics, big data, and cloud computing will play a central role in this strategy.

Additionally, the role of women is essential. Greater efforts need to be made to promote STEM education among women. It is hoped that by bringing women in from the periphery of society and having them play a greater core role, this will give rise to innovations and new perspectives that would otherwise be impossible in male-dominated societies.

The Prime Minister of the Republic of Slovenia, Miro Cerar, believed that the profound transformation of society placed a great responsibility on leaders to produce solutions for the betterment of mankind. There are times when it is unclear if technological advances contribute to the improvement or detriment of society. The resources and capabilities of society have never been higher. However, it seems that society has also become more egocentric, superficial, and neglectful of the environment. The value of science and technology can only be measured by how much they provide to the people and society. Foundations such as legal and ethical values on the one hand, and a sincere attitude towards cooperation on the other, are needed to ensure that science and technology produce more good than harm.

Japan and Slovenia are known for the value they place on sustainability. Both countries also have a long tradition of innovation. Furthermore, there are many examples of successful cooperation between Japan and Slovenia. This would not have been possible without the nurturing of their respective traditions and cultures.

Slovenia plays an important role in research, including areas such as robotics or particle physics. Slovenia has also been recognized for its safe and advanced cloud technologies. Additionally, Slovenian medical institutions confirmed the association between Zika virus and microcephaly. Moreover, Slovenia is cooperating with Japan to advance smart grid technologies. The capital cities of the two countries are also model cases for technology. Tokyo will showcase its smart city technologies to the world at the Tokyo 2020 Olympic and Paralympic Games, while Ljubljana has been recognized as an European Green Capital for its contributions to sustainability.

The Deputy Prime Minister of the Russian Federation, Arkady Dvorkovich, declared that science and technology were key drivers for the future of human society. The Russian government has recognized this and invested in several large-scale science and technology projects, such as nuclear and space technologies nationally, as well as international projects, such as high energy accelerator projects.

Russia has also launched initiatives based around partnerships among government, academic institutions, and businesses. In addition, Russia is advancing research in technologies such as robotics or neuro-technologies for the fourth industrial revolution. The country also recognizes the importance of education and has launched initiatives to that end. While there are potential shadows to science and technology, we have every reason to be positive about their ability to contribute to the betterment of human society.

Dr. Sadayuki Sakakibara, Chairman, Keidanren, believed STS *forum* was an invaluable opportunity for leaders in many different fields to engage in frank and open exchanges of views. Furthermore, he believed that science and technology innovation were the only way to address the pressing challenges faced by humankind, which were unprecedented in their magnitude and complexity. The Japanese business community has dedicated great effort to basic research, as well as the development of innovation and technologies that can contribute to society, such as hydrogen-based vehicles or drugs for treating the Ebola virus.

Japan's vision of Society 5.0 will bring about a super smart society. This will have profound implications for human society but international cooperation is required to make this vision a reality. Furthermore, the key to achieving this vision is to promote open innovation. Another important issue is whether technologies such as robots, artificial intelligence, and so on, will be accepted by society. As such, the engagement of society and the holding of constructive public debate will be important to building a new society, and STS *forum* is growing increasingly significant for fostering such debate. It is hoped that the Tokyo 2020 Olympic and Paralympic Games will showcase Society 5.0 to the rest of the world, and the Japanese business community will do all it can to contribute to that end.

Plenary Session 101: Sustainable Development

[Session Chair]

Holliday, Jr., Charles (Chad) O., Chairman, Royal Dutch Shell plc., NETHERLANDS

[Speakers]

Seko, Hiroshige, Minister, Ministry of Economy, Trade and Industry (METI), JAPAN
Chubays, Anatoly B., Chairman and Chief Executive Officer, RUSNANO, RUSSIA
Uchiyamada, Takeshi, Chairman of the Board, Toyota Motor Corporation, JAPAN
Reinhardt, Jörg, Chairman, Novartis A.G., SWITZERLAND

Chair: Holliday, Jr., Charles (Chad) O.

Opening Remarks

Mr. Charles O. Holliday, Jr. began by stating the original definition of sustainable development, which is "development which meets the needs of the current generation without compromising the ability of future generations to meet their own needs." It is through the eyes of the future generations that we can judge whether we are doing enough for sustainable development.

Shell is undertaking a variety of initiatives. One such initiative is to research whether it is possible to achieve net zero emissions. Shell has found that it is possible but it will take a lot of hard work, that science and technology will be critical, and that we must start immediately.

Another initiative includes the transport of natural gas, which is a cleaner alternative to coal. The most common method is to liquefy it. However, more techniques are needed. One initiative is to develop a floating factory for harvesting offshore natural gas deposits.

In addition, a major issue in developing countries is lack of access to electricity and cooking with unclean stoves, which has many adverse health effects. Shell has launched an initiative to provide clean stoves and reduce such health issues.

Minister Hiroshige Seko explained that when he was appointed, he was asked to be a trailblazer to promote Abenomics and bring Japan back onto the sustainable development track. Although this is a difficult task, the Abe Cabinet believes that its hard work will pay off and will never give up in its efforts to create a better Japan and a better world.

Japan faces many challenges, such as the aging of society. However, these challenges yield many opportunities. For example, the aging of society stimulates demand for technological developments such as robotics, self-driving cars, and medical advances.

Japan stands at the forefront of the coming industrial revolution, in which all things will be connected. Japan's manufacturing prowess will turn intangible knowledge and technologies into tangible products that can be enjoyed by society. To that end, the Japanese government is planning a research center of excellence that will fuse artificial intelligence with Japan's cutting-edge manufacturing technologies. Top businesses from Japan and abroad, as well as leading academic institutions will participate in the center, which will be opened in 2018.

Dr. Anatoly B. Chubays shared his thoughts on sustainable development. Sustainable development cannot be understood without understanding both the digital world and the material world.

The ICT revolution has been extensive. ICT has become highly sophisticated and entrusted with great responsibility, to the point where it is substituting people. Unlike the industrial revolution, where technology substituted human physical capability, this revolution is substituting human intellectual capability. Perhaps the next sector where technology will replace humans is in management.

As for the material world, technology will eventually result in dematerialization. Already, materials are being manipulated at the nano level, with the creation of nano-augmented materials. This in turn has opened up many new fields and is producing new, lighter and stronger materials, which will contribute to sustainable development. RUSNANO is playing a leading role in these efforts.

Mr. Takeshi Uchiyamada reminded the audience that the Kyoto Protocol was adopted at COP3 in Kyoto in 1997. Since then the Paris Agreement was adopted at COP21 in 2015.

Toyota considers the environment to be a top management issue. In 1997, Toyota launched the Prius, the first hybrid car. In 2014, it launched the Mirai, the first hydrogen fuel cell car. More recently, Toyota has announced the Toyota Environmental Challenge 2050, which specifies six challenges.

The first challenge is to cut down emissions from new cars by 90% by 2050 compared to 2010 levels. To that end Toyota now has hybrid vehicles in all its vehicle lineups. It is also about to launch a new-generation hybrid car. In addition, Toyota intends to promote and build on its hydrogen fuel cell technology. Furthermore, Toyota's efforts are not limited to reducing emissions from cars themselves. Rather, it intends to achieve zero emissions in the entire vehicle life cycle as part of its second challenge. The third challenge is to achieve zero emissions across manufacturing plants globally. The fourth challenge is to minimize and optimize water usage at plants. Toyota also aims to establish a recycling-based society and systems as part of its fifth challenge. Finally, the sixth challenge is to establish a future society in harmony with nature.

Toyota believes that it can overcome these challenges and other challenges facing society through collaboration across industry, government and academia. Toyota intends to be at the forefront of these efforts.

Dr. Jörg Reinhardt believed that the advancement of science and technology had transformed society. Innovation has been a huge driver of growth. However, technological advancements are not reaching all members of society. Furthermore, there are negative aspects to them.

Goal 3 of the Sustainable Development Goals is Good Health & Wellbeing, which is a goal that pharmaceutical companies, such as Novartis, are tackling with a sense of urgency. This has produced many exciting emerging medical advances, such as chimeric antigen receptor T cells for tackling cancer. In addition to cancer, pharmaceutical companies are tackling cardiovascular and other major disease categories. Another challenge is the spread of antibiotic resistance.

Good health is key to long-term human and social development. However, lack of access to healthcare must be urgently addressed. Infectious diseases, such as malaria, can be devastating to developing countries. Novartis and other pharmaceutical companies have carried out a variety of philanthropic activities to fight these diseases.

The issue of lack of healthcare access is not simply the result of the protection of intellectual property rights. The situation is much more complex. In fact, 95% of the World Health Organization's essential medicines are not patent-protected. Nevertheless patients still cannot access the necessary medicine, either because of cost, or perhaps because of infrastructural issues, such as the lack of a nearby medical facility. There is also a lack of qualified medical professionals and capacity-building efforts are needed.

As such, philanthropic efforts alone are not enough. A more effective approach is to work in partnership with governments and NGOs to not only make medical services available to those who need them, but also build up the capacity and infrastructure of a country or community's healthcare system as a whole.

Achieving healthcare access for all will need both technological innovations and also innovative approaches to reform healthcare systems. Government, academics, NGOs, and businesses all have a role to play in making this a reality.

Discussion

Mr. Holliday asked what kinds of innovations the panelists expected.

Minister Seko expected to see innovation in manufacturing technologies combined with artificial intelligence. He also mentioned the development of entirely automated surgical procedures.

Mr. Holliday asked what the advantages of hydrogen vehicles were.

Mr. Uchiyamada believed hydrogen had great potential because there were many ways in which it could be produced, and because of the fact that it could be produced using renewable energy. These efforts are also strongly supported by the vision of the government, which is seeking to create a hydrogen-based society. In addition, hydrogen produces no harmful emissions. Furthermore, hydrogen fuel cell vehicles do not compromise the comfort of owners.

Mr. Holliday wondered who would be incentivized to replace managers with technology.
Dr. Chubays explained that this was simply an extension of the current logic seen in the replacement of workers or cars with technologies.

Dr. Chubays then asked Mr. Uchiyamada what the basic technologies for hydrogen production were.

Mr. Uchiyamada explained that there were no technological barriers for the production of hydrogen. However, the two major issues are the production costs, and the need for infrastructure, such as hydrogen stands. Therefore, collaboration with the energy industry will be very important. There are reasons to be optimistic, as a similar situation occurred with the spread of gasoline stands in our societies.

Mr. Holliday asked Dr. Reinhardt what kinds of medical advances were expected in the long-term.

Dr. Reinhardt expected that a whole range of new technologies would be made available, such as stem cell technologies that could address cancers and other diseases that could not currently be addressed. It is hoped that this will make "old-fashioned" medical practices such as tablets obsolete.

Concurrent Session 102: [Energy and Environment] Future Prospects of Oil and Gas

[Session Chair]

Sieminski, Adam, Administrator, Department of Energy, U.S. Energy Information Administration, U.S.A.

[Speakers]

Al-Sherehy, Fahad, Global Technology Centers General Manager, Saudi Basic Industries Corporation (SABIC), SAUDI ARABIA

Elverhøi, Anders, Director, UiO Energy, University of Oslo, NORWAY

Gunner, Christopher, Shell Country Chairman, President Shell Japan Ltd., JAPAN

Hirai, Hirohide, Director-General for International Energy and Technology Cooperation, Agency for Natural Resources and Energy (ANRE), Ministry of Economy, Trade and Industry (METI), JAPAN

Muraki, Shigeru, Executive Adviser, Tokyo Gas Co., Ltd., JAPAN

Tungsubutra, Teeradetch, Executive Vice President, PTT Research and Technology Institute, PTT Public Company Limited, THAILAND

Chair: Sieminski, Adam

Opening Remarks

The chair welcomed everyone to the Future Prospects of Oil and Gas concurrent session and provided a brief introduction for each of the six speakers.

Staring the session by discussing the role of the energy industry, the first speaker stated that the energy sector was an essential part of meeting global goals for climate change. He commented on the use of carbon capture and storage (CCS) and solar to reduce emissions from other energy sources, such as coal. He touched upon the large amount of land needed to use wind energy and predicted that there wouldn't be a significant decline in fossil fuel demand until 2050.

The second speaker noted that 1.2 billion people don't have access to modern energy sources, and that the demand for energy will grow (possibly by 25% by 2035), with oil and gas continuing to play a core role for decades to come. He considered how countries could transform their economies to create an environment that would help adopt clean energy at a quicker pace, and the need to provide people with more and affordable energy sources while reducing carbon emissions. He also addressed the issue of carbon intensity, describing the advantages of having policy makers place a price on carbon, and noting that gas would have a relatively larger role to play in the future, complementing renewable energy sources. He concluded by stressing the importance of efficiency measures; extending electrification; the increased role of renewables while recognizing the need for grids able to absorb the ups and downs of renewable sources (such as solar and wind); accelerating the switch from coal to gas to reduce power sector emissions; improving building and city infrastructure to run on lower energy demand; and for more government initiatives in cooperation with companies to work on promoting low-carbon, energy-related, and land use technologies.

The third speaker, elaborating on a technology currently being used to combat global climate change, touched upon the use of electric vehicles which would transform the transport sector, and estimated that by 2030 the costs of various renewables could decrease

by around 10-30%. He also emphasized that private companies have reduced investments in upstream development, which may increase oil prices by 2020, a concern for global macro-economic growth. He added that Japan was a large consumer of oil, continuous innovation in shale has reduced prices, and liquid natural gas (LNG) has become a market of focus for Japan.

Gas markets are essential for Asia, as the fourth speaker detailed. He spoke about the natural gas market in the region, noting that current prices of oil were affecting the future development of natural gas. He touched upon Russia's role in supplying LNG to a large portion of Asia, the various supply chains developing in the natural gas market, and stressed that investment and policy frameworks were essential to the energy sector's future development.

The fifth speaker began by commenting on technology and flexibility as key to meet upcoming energy requirements, and expressed that oil prices have most likely already peaked and will only decline in the future. He added that efficiency would be the cornerstone driver for cleaner energy, and that we would only see increases in the use of solar, wind, renewables, natural gas, LNG, and electric vehicles in the future.

The sixth speaker began by addressing a bit of the history between humans and power sources, stating that humans have been on a path of migration towards better energy and are now approaching man-made energy sources such as batteries or nuclear systems. He emphasized that the use of oil would continue in the near future, focusing on its use in the plastics sector, and then touched upon personal views on climate change. He concluded by emphasizing that the driving force for quicker developments in clean energy use would be from mandates produced from regulatory measures.

Discussion

The first discussant talked about the use of electric vehicles and oil and when the two would reach their respective tipping points. He also touched upon appropriate energy mixes, particularly with wind energy.

The second representative was optimistic about the use of renewables and noted challenges in the use of nuclear energy and the limited use of CCS.

The third group's reporter spoke about the growing demand for energy overall and how to meet that demand efficiently. He stressed the need to find breakthroughs for solutions, for mandates and regulations, and for scientists to become more involved in finding said solutions.

The fourth group's discussant highlighted the balance of energy during peak and trough demand times, the capability of networks, as well as policy regulations. He suggested implementing a CO_2 tax and focusing on the developments in India and China.

The fifth representative questioned how to capture CO_2, what to do with it, and who will pay for its handling. He proposed implementing market incentives and examining how the global energy market would evolve, as opposed to discussing how it should evolve. He also questioned the current state of renewables being able to cover energy challenges on a global scale.

One discussant stated that, in 2040, they thought that petroleum use will be bigger in terms of volume, but that value will decrease. Renewables will most likely grow but many markets will still be fairly carbon intensive. However, the role of innovation, science, and technology could easily change that, as well as the role of price. His group's prediction for the price of oil was for it to be in the lower $50s in 2017, growing thereafter, and for natural gas to remain in the $3-4 range. However, he emphasized that predicting the price of oil was unreliable.

Further explaining, he also discussed innovations needed in battery technology in order for larger breakthroughs to occur in the automotive industry, as well as in nuclear technologies, such as in the development of small modular reactors with safer technology to help secure a greater role in the energy mix.

In closing, the chair thanked everyone for their participation and concluded the session.

Concurrent Session 102: [Life Sciences] Genome Engineering

[Session Chair]

Roberts, Richard J., Chief Scientific Officer, New England Biolabs, U.S.A. [Nobel Laureate 1993]

[Speakers]

Chalfie, Martin, University Professor, Department of Biological Sciences, Columbia University, U.S.A. [Nobel Laureate 2008]

James, Anthony A., Distinguished Professor, Microbiology & Molecular Genetics, School of Medicine; Molecular Biology and Biochemistry School of Biological Sciences, University of California, Irvine; Member, National Academy of Sciences, U.S.A.

Kawabata, Shigeki, Vice President, Evolving Medical Solutions, Astellas Pharma Inc., JAPAN

Liu, Edison T., President and CEO, The Jackson Laboratory, U.S.A.

Takahashi, Masayo, Project Leader, Laboratory for Retinal Regeneration, RIKEN Center for Developmental Biology, JAPAN

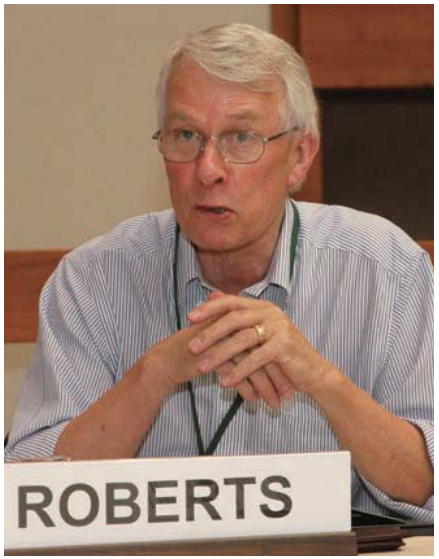
Tragoonrung, Somvong, Executive Director of BIOTEC, National Science and Technology Development Agency (NSTDA), THAILAND

Woltjen, Knut, Associate Professor, Center for iPS Cell Research and Application (CiRA); Associate Professor, Hakubi Center for Advanced Research, Kyoto University, JAPAN

Opening Remarks

The chair opened the session and introduced the speakers.

The first speaker provided an overview of genome engineering. In the past, knowledge about genes was learned from naturally-occurring mutations. Then, researchers started sequencing genes and realized it would be worthwhile trying to create their own mutations, so-called forward genetics. The next step was devising ways to break and manipulate DNA with greater precision. A big breakthrough in this regard was CRISPR technology, which allowed researchers to cut DNA exactly where they wished.



Chair: Roberts, Richard J.

Addressing modern gene-related research, the second speaker spoke about functional genomics, and the application of genome editing techniques in combination with induced pluripotent stem (iPS) cells. These studies enable the study of development, disease development, and so on from a genomic perspective. He also clarified some public perceptions about genome engineering. The current genome editing work is often compared to selective breeding and other work that has long been done, but in fact, the current work is totally novel. There are reasons to proceed with caution, but we can also be optimistic about future advances.

However, some gene editing research produces public controversy. The third speaker elaborated, explaining the difference between somatic gene changes, which are not passed on to children, and germ line gene changes, which are passed onto children. Somatic gene editing is currently occurring in human trials, while research is being done on germline gene editing although it's restricted to animal models. While gene editing might conjure up visions of creating a new human species, it should be understood that the goal is to correct known genetic mutations that cause debilitating diseases - returning a mutation to a known consensus normal sequence. The necessary technological advancements to achieve this are certain to be realized. What will be limiting is the degree of public acceptance and the development of appropriate regulation.

The fourth speaker continued the discussion about gene editing and described the state of regenerative medicine. There is an emerging shift from treatment-based medicine, to regenerative and preventative medicine, which can be both less expensive and more effective. Cell and gene therapy are examples of such medicine, and gene editing plays a very important role in this regard. With regard to public perception, there are often concerns about altering the "normal" genome, but there is no such thing as a normal genome. A more appropriate way to evaluate gene editing is to look at the safety risks and the benefits to society.

Gene editing techniques could have medical applications in other ways as well. The fifth speaker discussed this, detailing mosquito-borne diseases such as malaria and Zika, the need for tools to address them, and sustainable ways to deal with such diseases. Two genetics-based approaches are highly promising. One method is to target and kill mosquitos genetically. However, when mosquito populations are killed, they are never fully eliminated and can reinvade. Therefore, a more effective method may be to confer disease resistance to mosquitos so that they no longer transmit diseases. The CRISPR-CAS system is central to such work. The next question is how to effectively deploy these techniques.

The sixth speaker reiterated that without public acceptance, technical advances could not have an adequate impact on society. For example, public acceptance of genetically modified organisms (GMOs) is low. Society needs to be convinced that GMOs are just a tool that are ultimately for their benefit. Scientists need to communicate better on the subject. One step is to come up with a clear definition of what GMOs are.

The seventh speaker provided a history of the development of GMOs and the spread of fear about them. Concerns over GMOs were spread by various green parties in Europe as a backlash against Monsanto. This was very effective. Although GMOs are not essential for Europe, they are for developing countries, but the European Green Parties have spread their concerns to these countries as well. Once people are frightened, it is very difficult to reassure them. Science has shown that GMOs are completely safe, and an initiative led by Nobel laureates has been started to raise awareness of that fact, with the goal of reaching out to top political and religious leaders around the world to seek their endorsement.

Public backlash is not the only thing limiting research. The eighth speaker elaborated on this topic, discussing the development of regulations related to genome editing, which have fallen behind the pace of technological advancements. Regulations should be considered

from two perspectives, the protection of biodiversity and the impact on the environment, and the protection of the safety of humans. With regard to the former, one challenge is the fact that genome editing can produce GMOs far more rapidly than previous genome modification techniques. Another challenge is ensuring a unified international approach, but this can come into conflict with countries' national interests or the regulations of international organizations. When holding discussions on regulations for genome editing, it is important to avoid getting caught up in technical arguments. Rather, it is necessary to hold comprehensive discussions that evaluate the risks and benefits from multiple angles, involving multiple stakeholders who all recognize that genome editing represents one solution for addressing society's problems.

Discussion

The first group's representative discussed promising advances in genome editing techniques and the need for scientists to work with regulatory authorities to oversee the development of appropriate regulations, given the newness of the field.

The second reporter highlighted the importance of presenting genome editing as a need and not a luxury. There is also reason to believe that if one nation takes the lead in terms of accepting genome editing, other nations will follow that example. In addition, public acceptance should begin at the grass roots level. Once grassroots support is achieved, it will be easier to obtain political acceptance. Another point to consider is that despite advances in science and technology, confidence in science and technology seems to have receded. Therefore, it is important to ensure that trust in science and technology is carried over from generation to generation.

The third discussant talked about research on editing somatic and germinal genes and the need to find ways to introduce these technologies into society.

The fourth group's reporter mentioned the large amount of misinformation that existed on genome editing. Initiatives to educate the public are necessary. Humanization, democratization and globalization of the science are needed, and as part of that, scientists also need to be educated on how to communicate and engage with the public.

The fifth representative discussed the importance of primary education for fostering long-term public acceptance. Another useful approach is to distinguish between the technology

or the tools for deploying technologies, and the actual product that the public receives. Another important point is that those who oppose GMOs tend to have a better media platform than scientists, and scientists need to develop this platform and the related skills.

The sixth discussant mentioned approaches to gain public acceptance. One important point is to show concrete benefits. With regulations it is important to avoid technology exceptionalism, to focus on a product or traits rather than methods, and to emphasize the underlying science.

Concurrent Session 102: [Engineering and Innovation] Industrial Innovation

[Session Chair]

Kleiner, Matthias, President, Leibniz Association, GERMANY

[Speakers]

Colombani, Pascal, Director and Honorary Chairman, VALEO, FRANCE

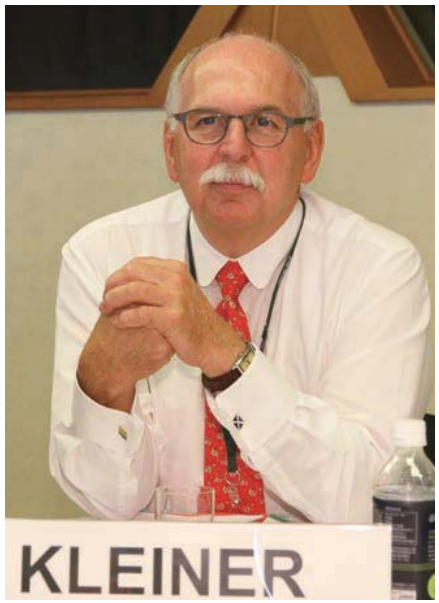
Cudré-Mauroux, Nicolas, Chief Innovation & Technology Officer, Research & Innovation, Solvay SA, BELGIUM

Grubbs, Robert Howard, Victor and Elizabeth Atkins Professor of Chemistry, Division of Chemistry and Chemical Engineering, California Institute of Technology (CALTECH), U.S.A. [Nobel Laureate 2005]

Murata, Daisuke, President & C.E.O., Murata Machinery, Ltd., JAPAN

Yeh, Nai-Chang, Professor of Physics and Fletcher Jones Foundation Co-Director of the Kavli Nanoscience Institute, Department of Physics, California Institute of Technology (CALTECH), U.S.A.

Zulkarnain, Iskandar, Chairman, Indonesian Institute of Sciences (LIPI), INDONESIA



Chair: Kleiner, Matthias

Opening Remarks

The chair stated that the session would focus on long-term relationships between industry and academia, crossing the valley of death, supporting the development of people and brains, and international policy support to promote international networks and new technologies.

The first speaker began by stating that industry research tends to be solution focused, while academic research is mostly curiosity driven and that this kind of approach can often lead to breakthrough technologies. While there is great potential for partnership, the question is often how to develop truly strong partnerships. She stated that a recent breakthrough

at CALTECH was the development of a new room temperature, high quality graphene growth technology, which had generated lots of interest from all over the world. One example was a medium-sized European company whose interest was in line with the scientific research interests at CALTECH and wished to provide funding for research and personnel in return for access to the CALTECH IP, which is the basis for a good relationship. However, in another case with a very large company looking to solve a technological challenge, the researchers on both sides had strong interest in working together, but the lawyers involved on the company side had little respect for the culture of academia and no understanding that sharing ideas and funding research would benefit their research and the company. Another case is with a small company where the discussions were interesting, but because of lack of funds, it may have been difficult to collaborate, and this is a case where there might have been a good opportunity for government funding. Another approach is a company that wishes to create a consortium of companies and universities. Export controls and national security have also become major issues for international collaboration, requiring governments to come together to agree on important technologies that should be promoted, reducing barriers to collaboration. Finally, the partnership among industry, academia, and government is needed to prepare workers so that they can adapt to rapid advances of modern technology. Failure to address this issue could lead to serious social instabilities.

Detailing the complexity of manufacturing, the second speaker explained the driving forces for smart manufacturing, including optimizing the use of minimal natural resources and minimal space, developing security and safety factors such as the resilience to quickly recover from natural disasters, and providing answers to other issues facing society such as the aging society. He discussed the increasing difficulties in finding skilled staff that goes hand-in-hand with the increase in use of automation. It used to be said that automation should replace tiresome jobs, while humans do work that automation cannot do, but still there are many tiresome jobs that machines cannot do, and this is an area where there is still room for improvements to be made.

The third speaker stated that despite a long history of collaboration between industry and academia, intensity does not increase very quickly. He stated that it is important to push incremental innovation, as has been implemented in Japan since the 1970s. Academia tends to push a formal approach to research, while industry has both formal and informal approaches. Academia can therefore improve its flexibility and broaden its strategy through effective partnership with industry. The valley of death is often due to lack of cash-flow in the early stages, and therefore funding is an essential element of overcoming the valley of death.

One solution to the funding issue can be found in innovative market-based approaches such as crowdfunding, but there is also a role for government to play in providing grants or loans. In terms of preparing people for broader innovations, he stated that providing better access to education is one key issue. Scientific diaspora can be one approach to developing domestic innovation, as well as ensuring free flow of resources between industry and academia, as well as between countries. ASEAN countries have a platform to facilitate the mobility of scientists and researchers among the member countries. The speaker also noted that to promote international networks, the paradigm must shift from competition to cooperation and collaboration. Intellectual property (IP) rights have several forms, but there must be a balance between protection and public access.

Further describing the relationship of academia and industry, the fourth speaker stated that the simple mission of academia is enabling innovation while that of industry is delivering value. There are cases when there is an overlap between these but also cases where there is a gap between the two. One issue is that there is often a difference in timescales between companies and academia. Academia is also about developing options, while industry is always focused on the end goal. The bridge between these that provides comfort with innovation at the same time as short-term goals and targets is often a startup, where the environment is often close to academia but with a focus on an end goal of creating value. When working with startups, it is important to think about the interdependence between partners and to try to understand if the startup is really the right partner.

Detailing a part of his background, the fifth speaker explained that, in his experience at his university, approaches from companies interested in his technology had initially created lots of problems, but these problems were solved by creating a startup. There have also been changes in industry, where often large companies had central research laboratories with lots of opportunities. These opportunities have mostly disappeared, and so this is another area that is replaced by startups. Chemistry is an area that can require long timescales, and VCs often lose patience and remove funding. In order to reduce barriers, it should be possible to continue research further within universities. There are also many issues to be solved with the patent system in the US, while the European system seems to be somewhat better.

The sixth speaker stated that we are going through rapidly changing times due to advances born out of basic research, but the impact on everyone's lives was barely imagined only a few years ago, due to the rapid transition to digital technologies together with the increased focus on green materials and renewable energies. Transformational changes of society occur due to ecological considerations and the availability of immense amount of data and computing power. He gave examples related to spatial, automobile, energy, and cybersecurity applications. Innovation policy requires a number of elements to be successful: access to first class basic research, aiming at breakthroughs, partnerships with shared objectives, rapid prototyping, and understanding of manufacturing and operating challenges. He stated

that national policy should encourage risky fundamental research, whether publically or privately funded, and create conditions for its successful applications to new products and services. Open innovation is more and more used to create an ecosystem that provides all of the required elements, which are: an environment that facilitates the transformation of basic research results in technologies, downstream industrial capabilities ready to capture innovative products, and access to capital. Such an environment has been successfully created in Silicon Valley. Finally, innovation will often require a shift in competencies, for example, a large increase in software engineering and bioengineering needs, and this must be reflected in education systems.

Discussion

The first group's discussant stated that there was active discussion on the difficulties of collaboration, and in particular, on the difficulty of lawyers controlling the discussions of valuation of IP, which is often a recipe for disaster. There was also discussion on the difficulties of cultural issues in different countries with regard to tolerance for failure, which can dissuade people from entrepreneurial activities.

The second reporter stated that discussion had focused on different education systems in different countries (in some countries there are more applied sciences) and the importance of proximity to innovation parks to encourage collaboration. It was also noted that work with industry should be counted toward tenure track. There was an example raised of some industries where ownership is less important than benefit through licensing, which is very refreshing as fighting over IP can often account for 50% of the workload of a researcher, and therefore avoiding this is a great benefit. For mobility of researchers, there should be bridge between academia and research, allowing tenure tracks to be maintained while going back and forth. He also stated that the difficulty of defining innovation is something that needs further discussion.

The third group's representative noted that industry and academia are different in nature, but there are some examples of models for how to bridge the gaps, such as how to share costs between government and industry. Another issue was about optimizing angel investor support and the gap in funding for global startups. There are concerns about brain drain and how the international community can help to solve this issue. He also noted that academics need to allocate more time to lecturing, despite their primary interest being in research and working with industry.

The fourth reporter stated that the issue of startups had been discussed, noting that there is a fine balance between research and innovation aspects. Solutions include investing in talent that is well versed in business models as well as technology. Incentives were discussed, including individual incentives for engaging in innovation. It was noted that it is a very complex interplay of dynamics that is also dependent on local cultures.

The fifth discussant stated that to reduce the valley of death, building the right ecosystem (such as the right systems to provide long-term funding through public-private partnerships) is a very important issue. He also stated that bringing the right brains together is key, combining scientific brains with business brains, which is extremely challenging.

The sixth group's representative stated that some countries' industry still has large research centers where fundamental research is done, while in others this model has been abandoned, and therefore more work needs to be done on cooperation. It was noted that respecting the cultural differences between countries, but also between industry and academia, is essential for success.

The chair summarized the session, stating that it is necessary to know the interests of every partner in collaborations and to know that if you ask disruptive questions you must expect disruptive answers. He also noted that science had become more entrepreneurial in the past decades, and he wished sometimes that industry could also be more entrepreneurial.

Concurrent Session 102: [Earth Science] Earth Observation

[Session Chair]

Le Gall, Jean-Yves, President, Centre national d'études spatiales (CNES), FRANCE

[Speakers]

Blackerby, Christopher, NASA Asia Representative, National Aeronautics and Space Administration (NASA), JAPAN

Murthy, Y.V.N. Krishna, Director, National Remote Sensing Centre (NRSC), Space Research Organization (ISRO), Department of Space, INDIA

Nittler, Larry R., Staff Scientist, Department of Terrestrial Magnetism, Carnegie Institution for Science, U.S.A.

Okada, Nobu, CEO, ASTROSCALE PTE. LTD., SINGAPORE

Yamamoto, Shizuo, Vice President, Japan Aerospace Exploration Agency (JAXA), JAPAN

Chair: Le Gall, Jean-Yves

Opening Remarks

The chair started the session by greeting the attendants and introducing the speakers. Earth observation and climate change will be the main topics of discussion.

The Paris Agreement was reached in December 2015. This was one of the most momentous events of the entire decade. The information gathered that led to the Paris Agreement was due to the efforts of the Earth sciences community to collect a variety of data. Among the 50 climate variables that are being measured today, 26 are measured from space via satellite. Earth observation from space was integral in reaching greater international cooperation.

Satellites play a fundamental role in gathering climate data and tracking long term climate trends. Of measurable climate aspects, rising sea levels are the most visible result of climate change. There is room to develop technological innovations to further track these trends.

There are several projects already underway to manufacture satellites that can measure carbon counts.

Data alone is not sufficient in tackling climate issues. Global cooperation is also essential. Numerous satellites already circling the Earth are the direct result of international cooperation. Additionally, the Paris Agreement is a big step toward curbing global warming. Space agencies, on an international level, are already looking forward into the future to ensure compliance with gas emission protocols that stemmed from this agreement.

It is difficult, however, to ensure that all of the signing parties are meeting their obligations. Satellites are already playing a major role in this type of monitoring, but a larger number of more sophisticated satellites are required to create a full and robust analysis.

To further other objectives, space agencies are set to meet again in Marrakesh. They will meet to discuss sustainability issues around Africa, including access to water, and the role that Earth observation will play in preventing future crisis. It is hoped that by building on past success, the new meeting will develop potential resolutions.

Bringing a political perspective to the discussion, the first speaker stated that Earth observation is vital to meeting the Indian government's goals. To that end, India has invested in a natural resources management system that operates with around 15 global satellites that provide numerous climate data.

Space technology is encouraged to be integrated across every discipline in India. Surprising innovations have been cropping up as a result of these syntheses, such as the union between navigation and communication.

Social and economic security has been transformed by this technology. The Urban Management Plan, a plan to create sustainable government, would make independent bodies able to evaluate fragile ecosystems, resource conservation, and the impacts of climate change in India by making essential climate variables more accessible. This information is already being used to affect and inform disaster preparedness. To further the quality and accessibility of more government programs, India has plans to continue expanding their satellite program into the future.

The benefits of space programs stretch to the general public as well. Science and technology should be commercially viable, and there are services that can be done using the data taken from satellites. Investment in satellite programs results in new innovations in both business and science. An ideal space program is an act of public-private cooperation that benefits everyone. This idea also extends to international cooperation, because satellite programs lead to mutual benefits for all parties.

Emphasizing the importance of the science, the second speaker stated Earth observations are the key way to measure the state of the environment. There are more than 130 Earth observation satellites constantly flying around the Earth. This means that a massive amount of data is constantly being collected on variables such as land cover, sea surface temperature, precipitation, and greenhouse gases. With such data, we can better understand and predict global warming, climate change, and its potential impact.

In order to sustain integrated ground and space-based observations, we need to verify that new technologies are able to provide for new possibilities. We must also establish an international political framework to ensure that these observations are broadly accepted to help us respond to climate change. Such linkages between technology and policy are very important.

The Japanese government is working with IPCC to modify guidelines so that GOSAT's, Japan's greenhouse gas observing satellite, data can be used to evaluate emission reductions of greenhouse gas. If the use of satellite data is authorized by the international authority, the Earth observation system to measure CO_2 from space can be accepted and sustained as an essential infrastructure.

Speaking from an industry perspective, the third speaker stated that the primary focus of his company, and indeed his connection to the field of Earth observation, is both protecting Earth observation satellites from space debris and focusing on space flight safety.

Earth sustainability and satellite sustainability are related to each other. The key role of Earth observation is to find and collect data about Earth from space. Much like the compromised environment of Earth, the space environment is in a critical situation. More than 23,000 large debris and an immeasurable amount of small debris are orbiting Earth. Even small particles have enough power to damage satellites, leading to the necessity for space debris removal services. Small debris is undetectable from Earth's surface, so there are plans to launch a satellite to detect small debris density and to provide End-of-Life management solution for satellites to make sure no defunct satellites remain in space any longer.

The dangers of orbital space debris should also be a crucial education topic. Space debris exists because people litter in space, similar to how they litter on Earth. People must learn to love space to solve the situation.

By protecting satellites and educating the public we can ensure a safe environment for our satellites and continued data collection. If we fail to cope with this issue, it could result in a catastrophic situation. These problems can be solved with the cooperation of both business and space agencies.

The fourth speaker began by stating that Earth is one of an untold number of the planets in the universe. Understanding the observations of Earth requires understanding Earth as a planet in the context of other planets.

Planetary science and other branches of space science have a key role to play in advancing our Earth observation technology and understanding. From robotic exploration, we know that Mars was once a wet world. This evidence allows us to see that Mars has experienced extreme climate change. Venus, too, was likely a habitable planet at one point. By understanding these kinds of planets, we can understand the potential consequences of climate changes in the Earth's future.

From a technology point of view, planetary science has long played a key role at NASA, the National Aeronautics and Space Administration. The remote sensing techniques used in Earth observation were originally used to observe other planets. Many techniques are

developed synergistically between the collaboration of both planetary and Earth science professionals. Future scientific research will involve this type of interdisciplinary cooperation.

Further describing NASA's role, the fifth speaker stated that Earth observation is a crucial field at NASA, with 19 NASA-controlled satellites currently orbiting the Earth, many of which are international partnerships. NASA recognizes the importance of Earth science from space, and there are four issues to address in order to maintain robust programs.

First, governments have many priorities, so Earth science is sometimes overlooked. One way to secure appropriate budgets is to examine the many uses of data across multiple disciplines. Scientists can use data for scientific purposes as well as for societal applications.

Second, ensuring free and open access to data is vital as it allows for use by all policymakers and the user community. This is a long-standing policy in the U.S. and some other countries, but not every government has embraced the concept. The science community must push governments for increased access to data.

Third, there should be a concentrated diplomatic effort promoting the importance of Earth science from space. Although there are many international, multilateral groups highlighting Earth science, direct engagement from senior government officials is not always maximized. Having high-ranking officials communicate the importance of science is integral for the continuation of these programs.

Finally, it is imperative to stress the importance of Earth science to the public. There are many competing options for public attention, and this can lead to a lack of awareness of climate issues. We should be thinking of creative methods for raising public attention, such as utilizing social networks or celebrity partnerships.

Earth observation satellites have come a long way, but there is more to be done, and the challenges can only be addressed through international cooperation.

Discussion

The first group's discussant stated that funding patterns need more international collaboration between organizations. There are different approaches in different parts of the world concerning whether space observation should be funded publically or privately. There

needs to be a commercial component to funding to make up for sinking private investment. Despite Earth observation being quite cost effective, as few as a couple of cents per hectare, funding can be hard to find.

The second reporter stated that there is a challenge in determining whether data should be shareable or not. The US has a committee to discuss the situational appropriateness of opening data. Needs for improvement of time resolution were discussed, and it was agreed that various means, including use of drones, should be considered. Issues of science-oriented approaches and industry-oriented approaches were discussed. The latter tends to be given higher priority, because of cost and return on investment. But, this does not apply to security missions. Finally, it is important to increase the number of people who understand science.

The third group's representative stated that there is a need for a clear route to disseminate data in a format that people can understand. The sharing of ideas and global coordination could help. The missions should be designed collaboratively across international borders to avoid competition and repetition.

The fourth discussant stated that despite the availability of data, cross-disciplinary expertise is needed to analyze this data, and there is now more data than experts. The range of environmental issues can differ depending on locale, but some areas don't have access to suitable experts to analyze collected data.

The fifth reporter stated that it is a challenge to inform and educate both the general population and policymakers. One issue, often ignored by both the science community and the general public, is whether we can fix the changes that have already happened. We should continue monitoring data while preparing for the worst.

The chair then called on the attendants to provide their recommendations for solutions to the addressed issues. Attendants suggested public education, international cooperation, and continuation of observation.

The chair further asked about how to manage international cooperation, considering that the formation of agencies can create new, unintentional layers of bureaucracy. Attendants suggested that the creation of a digital platform would encourage cooperation between scientists and encourage laypersons to engage with science by collecting data.

Then, the chair questioned the attendants about education and the media. Attendants suggested that information is disseminated via the media, meaning that scientists use it as a channel to reach broad audiences. Scientists and media personalities should work together to create a common language to mutually understand each other. It was also suggested that young people have changed their information sources, so traditional methods of education have to be revamped.

The fourth speaker then emphasized the potential power of citizen-scientist projects. These projects are good for the distribution of data analysis while engaging large numbers of non-scientists.

The chair asked about the prioritization of education and the media vs. international cooperation. The attendants then determined that education and the media should be prioritized above international cooperation in initial stages to help garner local support (and eventual funding) for Earth observation programs.

Concurrent Session 102: [Cooperation in Science & Technology] Competition and Cooperation among Global Industries

[Session Chair]

Maex, Karen, Rector Magnificus, University of Amsterdam, NETHERLANDS

[Speakers]

Harel, Elchanan S., President and Founder, Harel-Hertz Investment House Ltd., ISRAEL

Hashimoto, Kazuhito, President, National Institute for Materials Science (NIMS); Professor, Policy Alternatives Research Institute, The University of Tokyo, JAPAN

Remy, Sébastien, SVP, Head of Airbus Group Innovations, Corporate Technology Office, Airbus Group, GERMANY

Rübig, Paul, Chairman, Science and Technology Options Assessment (STOA); Member, European Parliament, BELGIUM

Saovapruk, Yongvut, President, National Food Institute, Ministry of Industry, THAILAND

Tanaka, Ken-ichi, Executive Fellow, Corporate Research & Development Group, Mitsubishi Electric Corporation, JAPAN

Chair: Maex, Karen

Opening Remarks

The chair opened the session by outlining the theme of Cooperation in Science & Technology. It is important to consider how collaboration between global companies can be undertaken so it leads to innovation. In the knowledge triangle of industry-academia-government there are cultural difference to overcome in order to have true collaboration. These "cultural" differences can differ from country to country. In some sectors public-private partnerships have been very successful for precompetitive research. Additionally, going forward, the role of startup and large companies will be key in driving innovation. Considering their role, and how to support them, will be key. Collaboration between global companies will be essential to address the issues facing the world, including social and environmental ones.

Considering these issues, the first speaker spoke from a private company's point of view on the issue of IoT, and its great potential to make connections on both a people-people and government-government level. To realize this, collaboration and information-sharing is key to make the system more sustainable and efficient. Of course, many in industry talk with customers every day, but through finding partners in different fields, one can make more innovative products. Additionally, the method of collaboration is important, as is finding the best partners, including partners from diverse industries and fields, through making personal connections. Moving beyond the competition-cooperation dichotomy is key, as the technologies and systems that can be realized working with partners will be bigger and better than those developed independently.

The second speaker introduced the initiatives of the Japanese government in promoting innovation, including at the National Institute for Material Sciences (NIMS). In Japan, a new government-wide initiative was launched under the name Society 5.0, combining IT technology, and Japan's excellent machinery expertise, including robotics. To realize Society 5.0, open innovation must be realized, because it is becoming very difficult for single organizations to handle the scale of infrastructure required. Therefore, collaborative development and research is important. A new research platform at NIMS will be launched to create a venue for this. This system will start at the national level and potentially grow to the international level; will contribute to the realization of Society 5.0; and will also help companies collaboratively solve pre-competitive issues. However, some challenges have emerged, including the "cultural" problem of companies traditionally taking a self-sufficient approach.

Elaborating on company culture, the third speaker noted that competition can contribute to positive social and environmental change. For instance, the airline industry competes to realize better fuel efficiency. The goal is partly business-related – to reduce costs – but this leads to reduced CO_2 emissions, leading to environmental benefits. Identifying common motivations in pre-competitive issues is important in this. An efficient collaboration scheme, such as the European Clean Sky Joint Undertaking, can help to bring competitors together because open innovation is the key to realizing the further evolution of industry. Establishing and maintaining platforms that are global in scope, and creating standards for technology, is instrumental in ultimately realizing commercialization.

The fourth speaker began by explaining startups and their role in global competition. The new industrial revolution requires creativity, swift decision-making, active learning, and

complex problem solving. When comparing today's Fortune 500 list to that from 50 years ago, one notices that there is major difference. Startups have been driving large, established companies out of the top echelon. Corporations have two options when purchasing a startup – absorb and capitalize on this innovation, or absorb and eliminate it because it does not match the corporation's business model. Accordingly, there are four dilemmas facing startups. First is the dilemma of choosing an R&D direction; second is the startup dilemma – building a long-standing business or aiming for purchase by a big company; third is the dilemma of transferring or not transferring IP; and fourth is the dilemma of the global movement of talent.

Furthering the discussion of economic interactions, the fifth speaker described the dual importance of competition and collaboration in the food industry. For example, a smart food city integrates public and private sector organizations and makes the supply chain more efficient. With this integration, identifying the uses of raw food materials and food products, and making adjustments for better allocation, will be possible. Creating a research platform for this has led to positive changes, and enabled the creation of startups which further drive innovation and create jobs and opportunities, leading to further economic growth.

Belonging to an organization that concerned with innovation and opportunities, the sixth speaker shared the initiatives of the Science and Technology Options Assessment (STOA) committee of the European Parliament. It examines the potential impacts of new technologies on diverse fields through digital modelling, etc. Competition and collaboration play important roles in driving innovation, creating connections between technologies, organizations, and so on. Instrumental in supporting this are big data and analytics, which can identify risks and opportunities in new technologies and linkages. In effect, this creates a digital world which is a reflection of the real, physical world, where data can encourage both competition and collaboration. Additionally, this model can help to address broader issues. For example: Is the production of sufficient food for everyone in competition with renewable energy? Impact assessment and other digital modelling initiatives can play a key role in realizing collaboration for innovative solutions to the problems facing the world.

Discussion

The first representative shared their group's discussion on the tensions between collaboration and competition. From the business side, there is increasingly a realization that collaboration is necessary, not just competition, because of the increased pace of technological

evolution and communication driven by the internet. Also, the importance of face-to-face meetings are important.

The second reporter described their group's discussion on funding mechanisms and why certain ones lead to success. One factor that contributed to its success was the fact that it was started with public funding. Also, leadership and management ability with original vision and mission are keys in driving open innovation and setting the correct tone. And finally, collaborating with all points of the knowledge triangle is also very important.

The third representative detailed their group's discussion on the barriers preventing competition becoming collaboration, and what industry can do to ease this transition. One key is finding the right partner and the right human resources to enable this, through networking broadly and diversely, and expanding the hiring "net" to a global level. Also, ensuring the accessibility of information is important, such as furthering the posting of information online. An "umbrella" framework for partnerships could also be beneficial. Finally, finding common ground between academia, industry and government will be very important, but it proves a challenge because many come to the table with different goals and requirements.

The fourth group's discussant explained their group's discussion about how to make successful startups. To create a successful startup, a high degree of genius is required. Fortunately, there are many geniuses, from a great many backgrounds. However, the academic approach of starting with a solution and then finding the problem to solve

afterwards is not effective, because it would not necessarily solve the problems faced by society, or address industry needs. Recently in Japan and other countries, the trend of larger companies funding startups which co-exist in their industries can ensure that innovation is not disruptive to pre-existing economic structures.

The fifth reporter illustrated their group's discussion about what the best space for collaboration could be. One option that emerged was space because there is little preexisting infrastructure or potential competitor presence. When one gets closer to the ground, there tends to be more competition – and more regulation and restriction about talking to competitors.

Summing up the session, the chair closed by saying that policy-making and the presence of strong leaders are key in helping collaboration be achieved. Entrepreneurship and innovation through people-people connections will also be a key driver. The human factor cannot be overlooked, from realizing innovation though collaboration, to considering the problems human society faces and which must be solved.

The chair thanked all members for their active participation and brought the session to a close.

Concurrent Session 102: [Science, Technology and Society] Social Innovation for Sustainability

[Session Chair]

Lee, Yuan Tseh, President Emeritus, Academia Sinica, CHINESE TAIPEI [Nobel Laureate 1986]

[Speakers]

Al-Abdulqader, Abdullah Bin Hasan, Chairman, Saudi Telecom Company (STC), SAUDI ARABIA

Chubachi, Ryoji, President, National Institute of Advanced Industrial Science and Technology (AIST), JAPAN

Galli, Fiorenzo Marco, Director General, National Museum of Science and Technology Leonardo da Vinci, ITALY

Marshall, Larry, Chief Executive, Commonwealth Scientific and Industrial Research Organization (CSIRO), AUSTRALIA

Olds, James L., Assistant Director, Directorate for Biological Sciences (BIO), National Science Foundation (NSF), U.S.A.

Wilhelmsson, Thomas, Chancellor, Chancellor's Office, University of Helsinki, FINLAND

Chair: Lee, Yuan Tseh

Opening Remarks

The chair opened the session by welcoming the participants and expressed his confidence that it would be an open and fruitful discussion. The recent COP 21 conference in Paris laid out a target that the world must limit the rise in the global temperature to no larger than 1.5 degrees from the pre-industrial era and create a carbon-neutral society by 2050. As the global temperature has already risen 1 degree, we are already sliding toward the edge of this limit. While society has made certain strides, there remains much work to be done, especially in the technology field, which cannot always keep up with the rising challenges. Thus, social innovation is needed to supplement the technological advances. He then asked the speakers to make their presentations.

The first speaker began by stating that the main focus of his presentation would cover the environmental challenges which are created by human behavior. Even when society has made technological progress, if human behavior is not changed, it will not be enough. The scientific community has had good cooperation in this matter so far, but social science has not been sufficiently active in addressing these issues. Incentives in research should reward social innovation as much as it does technological innovation. What is needed in social science is improvements in the law, economic incentives, and carbon innovation schemes.

The speaker then noted that at his university, a research group is developing a trading scheme for biodiversity in cooperation with the ministry of environmental affairs. Data acquirement of carbon footprints, etc. needs to be further improved. It is also necessary to use behavior science to gently push people in the right direction. An example of this is changing the default settings on computers to save power and paper use. There also should be a more comprehensive research on human behavior and the results of this research must be more actively communicated with policy makers and a continuous dialogue established.

While social innovation is an important aspect of sustainable development, there are a number of definitions and angles that can make implanting it challenging, the second speaker noted. One definition that the speaker found compelling, however, was "managed development along with good coupling between business and industry." The speaker then said that his company, Saudi Telecom Company, has created a corporate culture that promotes further environmental protection and sustainability, and possesses good collaboration with the Government of Saudi Arabia.

The speaker then noted that it is difficult to convince business communities about long-term environmental outlooks, but it is a challenge that all must take on. Furthermore, ICT by itself cannot sustain development, but it is a major factor. Saudi Telecom Company has a number of initiatives in this direction, such as efforts to support startups and small entrepreneurs by providing them with advisory assistance and technological support. The company also has a fund for venture capital, hosts a number of technology competitions, and deploys initiatives to further the use solar power and reduce carbon footprints.

The third speaker first relayed CSIRO's experience working philanthropically with Africa and other countries, while dealing with the increasing challenge of reduced government funding. Therefore, CSIRO is now seeking other sources of funding to supplement this loss through commercialization of science. He then moved to climate change, and asked the other participants if they considered climate change a scientific or social problem. Either way they are viewed, the solutions to climate change require deep scientific and social innovations.

CSIRO plays its part in addressing environmental issues, and not only pursues innovative breakthrough ideas, but teaches scientists how to present their ideas and findings to the customers and the public at large. It is important to understand the audience and the client. For example, CSIRO developed a new cattle feed from seaweed to reduce cattle methane emissions, which took social innovation to tailor the solution for the customer. Rather than fixing blame, CSIRO is seeking to provide solutions. The speaker noted that when industries and the scientific community collaborate, it sends a powerful message to customers, and the customers in turn vote for their government, creating policy change.

Noting one of the problems of technological development in society, the fourth speaker stated that failures in social innovation primarily stem from a problem of culture. His museum, the National Museum of Science and Technology Leonardo da Vinci, has a saying that "science is culture," highlighting how science is influenced by cultural behavior. The future is presenting new challenges not foreseen in the past. He highlighted the recent exponential growth of the population in the recent years, where only 20% of the population currently uses 80% of the resources available. Finally, the speaker pointed out that the problems in environmental sustainability are largely cultural and tied to education. The most important investment is to invest in the developing countries, which will bring more and diverse ideas for the future of scientific progress.

From an economic perspective, the fifth speaker first raised the point that while smartphones have provided great social change, they originally came about from basic science investments. It is important to understand the role of funders, which have the potential to socially innovate through their investments in basic science. A simple example to improve sustainability is to look at plants. Even on its best day, a plant's photosynthetic efficiency is only at 2%. There are a lot of upsides to this from a business perspective. For example, doubling the efficiency to 4% is a way to feed the world and curb carbon.

Moving on, the speaker discussed global collaboration and investment and raised fertilizer as an example. Fertilizer for cereal crops costs money and pollutes water. If industries can find a way to take nitrogen fixation and make it work in cereal crops, it would be beneficial. We know social innovation can happen based on many examples. When thinking about climate change and feeding the world, such innovation is more important than ever. It is imperative to sample climate space not only in one's own home country but across the globe.

The sixth speaker explained how his organization, the National Institute of Advanced Industrial Science and Technology, is conducting R&D to create a low-carbon society. One of the main challenges is finding a source of reliable and sustainable energy, as the energy generated by solar and wind power depends on weather conditions and are highly localized, making them unreliable on a mass scale. Therefore, his institute is turning to hydrogen as a clean energy resource. Hydrogen is flexible and can be stored on a long-term scale. As a part of this effort, the institute is preparing a large-scale hydrogen based project for the 2020 Olympics in Tokyo. The project will transport clean, hydrogen-based energy from Fukushima to Tokyo. The speaker concluded by expressing his confidence that this project would be an impetus for creating a hydrogen-based society.

Discussion

The first group's discussant expressed his pleasure that such a productive discussion about human behavior had been conducted. The multidisciplinary aspects and incentives in social innovation need to be improved. We need not only prevention, but adaptation in regard to human behavior, and it must be self-organized. Young people in urban environments need to understand the diverse ways people live as well as the future environmental challenges.

The second representative stated that we need a revolution that comes from the center in order to produce social innovation. Furthermore, more children and youth must be involved in that revolution. Scientific data needs to be used responsibly to implement positive change. More research needs to be done on the link between group and individual behaviors. There must be a stronger link between the public and scientist to make it clear how science benefits them directly. There is a risk that the term "public good" may make the public question how science benefits them. It needs to be made clear that science is the foundation on how humanity progresses.

The third group's reporter brought up how "cool biz" is a social innovation concept in Japan that has led to saving power. An issue, however, is a worrying rise of populist politics and an increasing desire for over-simplistic solutions that do not address the complicated nature of the many problems we face. There is hope, however, in that some simple solutions can provide innovation to complex problems. For example, apps can be used to change behavior. Education is an important issue to address, as it is the youth whose future will be affected. Trust and legitimacy need to be carefully cultivated to prevent the misuse of information. Cultural differences are also barriers that need to be overcome.

The fourth discussant noted that water, medicine, and energy supplies are important issues and that the level of their importance varies by regions and countries. In Africa, for example, resources are the most important issue. The discussant also pointed out that scientific findings do not always necessarily connect to innovation. We need more structures to connect scientific findings to innovation and policy changes, etc. Finally, education is important in changing human behavior as it can connect multiple disciplines.

The fifth group's representative noted that education and information examination are areas of concern. We need to address consumption behaviors of individuals and nations. This must be translated into culture. The younger generation must have a new culture that values conservation. Before innovation comes around, we need to improve simple fundamental initiatives. With that point, the session was then brought to a close.

Concurrent Session 102: [ICT] Internet of Things (IoT)

[Session Chair]

Adly, Noha, Head of Advanced Research Group, Bibliotheca Alexandrina, EGYPT

[Speakers]

Emura, Katsumi, Executive Vice President and Chief Technology Officer and Member of the Board, NEC Corporation, JAPAN

Kawahara, Yoshihiro, Associate Professor, Department of Information and Communication Engineering, Graduate School of Information Science and Technology, The University of Tokyo, JAPAN

Kellett, Jr., Sam, Chairman, Chief Executive Officer and Co-Founder, United Sciences, LLC, U.S.A.

Öwall, Viktor, Dean, Faculty of Engineering, Lund University, SWEDEN

Soley, Richard Mark, Chairman and Chief Executive Officer, Object Management Group Inc., U.S.A.

Opening Remarks

Chair: Adly, Noha

The chair opened by stating that the Internet of Things (IoT) is rapidly expanding and providing consumers with ever increasing services. The sheer power of this technology will improve industries, enhance the lives of consumers, and change the world as we know it. It is expected that there will be 50 billion connected devices by 2020, with an estimated economic impact of $11 trillion per year in 2025.

The potential benefits of the IoT are almost limitless, and new business models are quickly emerging to capitalize on them. This includes the venerable tire company Michelin introducing sensors to its tires and transforming the value of its products to consumers. Nanotechnology is also paving the way to the Internet of Nano Things, which will provide up-to-date pictures of our cities, production, and even our bodies.

While the IoT brings remarkable potential for progress, it also introduces a myriad of technical, ethical, and social challenges. Chief among them are security and confidentiality, which not only involve protecting collected information from falling into the hands of third parties, but also ensuring that the information does not cause harm through the application itself, which was recently seen with the deadly crash of a Tesla automated car.

The IoT will have a tremendous social impact, especially for the jobs of the future. It will make many of our current jobs obsolete, but at the same time, it will open up a host of new fields and employment opportunities. The government must keep up with this innovation, allowing it to foster these new fields while also providing necessary regulation. Following her opening remarks, the chair turned the floor to the assembled speakers.

The first speaker began by describing the computational power and vast availability of knowledge on the internet, with the IoT enabling an enhancement of our own human abilities and sensitivities. For example, smartphones can use sensors to predict human behavior, perhaps better than humans themselves. As we see progress in devices, they are getting closer and closer to our human bodies, with wearable smartwatches a step closer beyond the smartphone. The future of this bodily proximity could be in the form of tattoos inherently connected to the skin. The speaker hoped to further discuss these technological possibilities during the session.

The second speaker talked about important factors in research, stressing the importance of thinking about quantity and quality, saying that although proper data leads to better information, it is the acquisition of this proper data that is the true challenge. He also noted the difficult barrier to connecting organizations, but the issue there is not the technology but our own mindsets that prevent what would otherwise amount to great benefits.

He also also highlighted several challenges, including the appropriate usage of open, real-time data, sifting through noise to get quality data, and the weight that should be given to data related to humans, cybersecurity, and regulation issues. He finished by stating his hopes for a discussion of these issues relating to data.

The third speaker began by saying that beyond the technological aspects of the IoT, what is most fascinating is that it represents a major disruption to industries. The IoT's level of impact on industry will be measured in the trillions of dollars, and its disruption will range from healthcare to manufacturing to financial industries, making them more efficient and effective.

After discussing the industry impact, he highlighted societal elements of the IoT, and cited Chairman Omi's speech in which he stated that the IoT will have a tremendous impact on humanity. He focused on the significance for jobs and the implications for the education of the workforces of the future. While exploring standards, he noted that their creation is difficult because they represent an entirely new arena. Most of the standards that have been created or are currently under discussion deal with the "bits and pieces" but do not capture big picture issues. Thus, an understanding of what data actually is and represents is vital.

He then spoke about the Object Management Group and testbeds that look at real-world implementation of Industrial Internet solutions, and help establish best practices and the understanding and creation of standards. For example, all manufacturing floors have their own unique standards and different tools, but the Object Management Group is addressing this through a testbed that tracks people, parts, and tools. He concluded by saying he was excited to have a discussion on this, including achieving a state in which products no longer fail.

While IoT will transform many industries, the fourth speaker said that healthcare is the new frontier for the IoT, especially with remote patient monitoring that will reduce healthcare costs in the United States by over $200 billion. However, while there is so much potential innovation through the IoT, not much has been accomplished yet. One reason is that sensors do not currently collect information that provides real medical efficacy.

United Sciences is working on the issue of medical efficacy from data, with one initiative being a 3D ear scanner that 3D prints a custom sensor device in the form of a pair of headphones. The headphones collect information on brainwaves from patients as they go about their daily lives, eliminating the previous requirement of traveling to costly special facilities for such data collection. The headphones make the ear a physiological playground of information.

Although continuous health monitoring will provide many benefits, the most important aspect will be giving power back to the patient, reducing the combined billions of visits to doctors that patients must make each year. The speaker said he hoped to speak further with the participants about the development of the IoT for transforming the lives of patients.

Finally, the fifth speaker brought up Prime Minister Abe's comments during the opening plenary session about his personal anticipation for the IoT to improve his health, and noted that his diabetes has led him to hope to see a day in which his own health can be monitored over the internet with devices. He said he wanted to talk about IoT issues that will have critical health implications if difficulties arise, including connectivity, the range and variance of data rates, latency, and battery life.

Discussion

The first representative said his group spoke about printed circuits and screens that can be used for health functions, ethical concerns about information collected through devices and how this information could bring downsides to disadvantaged people, and the importance of achieving a greater good.

The group also spoke about where innovation will come from, and how this will change based on applications by users. The first speaker has worked on measuring moisture levels of soil, with the goal of improving efficiency in farming. Farmers have built upon what this speaker worked on, and their actual application of his technology is different from what the speaker had initially envisioned. There was also discussion on connectivity, centering on the importance of thinking about real world applications in order to have the foresight to achieve synergies of information. The chair agreed that it is important for those developing technology to work with users.

The second discussant explained that his group spoke about societal impact, including privacy issues, data ownership, and standardization. He said his group consisted of "hardware geeks,"

so the conversation naturally turned to computer science issues, including energy consumption, where data will be stored, and who is involved with storage and how. The group's discussion of computer science issues finished with the fact that algorithms must be rethought with distributed AI, and that data work from the past can be adapted to IoT.

The third reporter said that his group spoke about standards and technological unemployment, with an agreement that standards can lead to job loss. In terms of ameliorating the problem, training must increase capacity for flexibility, and standards should bring predictability not only to the market but also to education. Thus, standards can also be part of the solution to retrain the workforce to adapt to workplaces transformed by technology. We should not see IoT as driving job displacement in all areas, as they will not all adopt standards and the accompanying efficiency at the same rate. In fact, many of the hurdles of IoT are organizational in nature, especially with how organizations handle change.

The fourth representative stated that his group spoke about diverse topics related to data, including the possibility of the United Nations creating policies related to taxation and ownership of data. The group also discussed leapfrogging from one paradigm of data collection to the next. Education encompasses many applications of IoT, ranging from small aspects like monitoring the eyeballs of students to gauge concentration to the overall picture of utilizing the IoT to create new skills in employees to lesson job displacement brought about by that very same IoT.

The fifth discussant said that his group explored IoT education, especially for young people. Excellent ideas for education were brought up, including having students build their own devices, enabling project-based learning and a spirit of entrepreneurship. Such education ideas would be an attractive feature to encourage investment in IoT. Finally, the education of politicians themselves is vital to make them understand the importance of the development of IoT.

The final reporter noted one aspect discussed by his group was security, saying that education can lead to coordinating the cyber world with the real world. The group also discussed the IoT and developing countries, especially in relation to jobs. For example, automated driving would put taxi drivers out of business, hurting millions who rely on driving for income. Developing countries will also experience difficulty in creating IoT infrastructure. The group also spoke about ethical issues including privacy and dissemination of information, as well as data monopolies that could have detrimental effects on society in the future.

Concurrent Session 102: [Cities] Megacities

[Session Chair]

Serageldin, Ismail, Director, Library of Alexandria, EGYPT

[Speakers]

Hayashi, Haruo, President, National Research Institute for Earth Science and Disaster Resilience, JAPAN

Koonin, Steven E., Director, Center for Urban Science and Progress (CUSP), NYU, U.S.A.

Onishi, Takashi, President, Science Council of Japan (SCJ); President, Toyohashi University of Technology, JAPAN

Rees, John G., Head, Risk and Resilience, Natural Environment Research Council (NERC); Director, Earth Hazards and Observatories, British Geological Survey, U.K.

Seto, Kinya, President and CEO, LIXIL Group Corporation, JAPAN

Opening Remarks

Chair: Serageldin, Ismail

The chair opened the session by welcoming everyone to the concurrent session on Megacities, noting that discussions would be focused around specific problems associated with cities boosting more than 10 million people. He ended his brief comments by noting that the world was currently witnessing the fastest growth of urbanization in the world.

The first speaker started his presentation by stating that approximately 50 million people were moving to urban areas a year, a trend set to continue for 30 years. How can we make these cities as good as they can be in terms of efficiency, resilience, sustainability, quality of life, and equity among citizens? As megacities grow, we can expect increasing complexity. That will require increasing unity in terms of city management, and big data is one way to achieve this. Big data analytics will improve efficiency, compliance, and in getting citizens engaged in cities. To recognize their potential through data analytics, cities should aggregate municipal records and make them open to the public as much as possible, create the

necessary IT infrastructure, develop appropriate policy, and train a workforce capable in terms of modern data technologies.

Noting the boom of urbanization, the second speaker began by stating that there are around 29 megacities due to exist worldwide by 2025. Currently, seven of the world's top ten megacities will be located in Asia. Megacities are highly prone to disasters, both manmade and not, and this creates large issues for city governments and its citizens. Megacities in Asia in particular have similar issues to one another in terms of natural disasters, examples of which have been highlighted in recent years with flooding, earthquakes, and so forth. Other challenges include slums, crime, homelessness, traffic congestion, and air pollution. Therefore, there are many issues to address from a sustainability and safety perspective.

The third speaker began by introducing the Global Power City Index (GPCI) metric system, before pointing out that cities with larger populations do not necessarily equate to more attractive or healthy urban areas. For cities to be powerful globally, a city must achieve a balanced development between its population and cumulative investment, avoid growing too large, create environments conducive to both business and living, and develop a robust and efficient transportation system among other things. It is also important that metropolitan governments continue to invest in urban infrastructure, as well as create economic, social, and cultural relationships with other domestic or international cities. We should recognize that the concept of megacities and globally competitive cities are different altogether – and that to be both requires powerful implementation.

Even if a city becomes globally competitive, there are still risks to rapid urbanization. The fourth speaker introduced one of these risks, explaining that sanitation was a very big health and infrastructure issue, particularly within growing urban areas located in underdeveloped countries. There are 2.4 billion people worldwide who have no access to proper toilet or sanitation facilities. This is an issue because a lack of proper sanitation can lead to disease and the deaths of many individuals, and there is also an economic loss of over $220 billion dollars due to such issues. There are innovative and affordable business solutions being developed to specifically target areas of poor sanitation coverage and water scarcity, such as those that prevent the transmission of diseases from pit latrines, technology to minimize the amount of water required to flush, or toilet solutions that turn waste into fertilizer. Proper sanitation is often an overlooked subject when it comes to discussion around megacities, but it is in fact a critical challenge.

The fifth speaker opened by stating his opinion that there were many megacities that were on the edge of resilience. In terms of better city management and planning, there is a growing recognition in recent years that we need to look at cities as systems. To achieve such an understanding, we need a very good sense of the environment around the city, and to understand how cities are subdivided into various areas (slums versus middle class areas), which should be addressed in different ways. Sixty percent of the infrastructure required to support expansion of the population by 2030 has not yet been created. Therefore, we must begin to plan for this effectively now, while also understanding the susceptibilities and vulnerabilities of cities. We should focus on identifying, understanding, and quantifying the different parts of the system that make up cities; making sure society and the public buy into a systems based approach (through education and incentivization); and finally, push the scientific community to take a larger role within this process in order to achieve the proper results.

Discussion

Discussions proceeded in each of the tables with one of the speakers acting as reference person and moderator for that table's discussion. Then each table was asked to have a rapporteur share the discussions of that table.

The first representative said their table had discussed the enrichening experience of city living, values and attitudes towards change within cities in conservative countries and cities,

the importance of green living spaces in cities for citizens, and the fact that one city can represent many different lived experiences for different people.

The second reporter spoke about finding alignment on timetables for projects between politicians and technologists, city management, city systems education and thinking for citizens, and the history of the smart city idea. Another discussant brought up the example of Lyon, France in describing the difficult challenge of balancing business competitiveness with a sustainable living environment for its citizens.

The third group's discussant explained that they discussed the theme of megacities emerging in developed countries versus developing countries, and the challenges around infrastructure, population growth outpacing the ability of government to meet infrastructure needs, the relationship between urban and national environments, and the potential impact of informatics and data utilization.

The fourth group's representative noted that each participant spoke about their respective experiences living in their home cities (LA, Colombo, and Tokyo), and the role of universities in combating challenges posed to cities such as regarding sustainability. One discussant explained the background of a project held in Southern California in which a large group of academics and students came together to develop techniques and create projects to achieve better sustainability practices in terms of water resources.

The fifth reporter said their group discussed good practice and better management in terms of cities globally (such as in Colombia, the UK, and the US), and getting local city populations to buy into necessary improvements. He noted that they also discussed whether there was a limit to the growth of cities, taking the examples of Jakarta and Lagos, which are at the edge of their resilience. The discussant also explained that they spoke about the transfer of best practices between cities in terms of city planning and infrastructure. A separate discussant echoed this idea regarding the crucial element in megacity development of working together to build cities.

The chair briefly reviewed the discussions, before concluding the session by reminding participants to place importance not only on the quantifiable attributes of cities such as users and data, but to recognize the inherent charm and magic of certain urban centers and their contribution to human history and development.

Plenary Session 103A: Research and Innovation

[Session Chair]

Matsumoto, Hiroshi, President, RIKEN, JAPAN

[Speakers]

Jeffrey, William, Chief Executive Officer, SRI International, U.S.A.

Repik, Alexey Evgenievich, President, Delovaya Rossiya (Business Russia), National Public Organization, RUSSIA

Sirilertworakul, Narong, President, National Science and Technology Development Agency (NSTDA), THAILAND

Solvay, Jean-Marie, Chairman, International Solvay Institutes for Physics and Chemistry, BELGIUM

Al-Saud, Turki bin Saud bin Mohammed, President, King Abdulaziz City for Science and Technology (KACST), SAUDI ARABIA

Chair: Matsumoto, Hiroshi

Opening Remarks

Dr. Hiroshi Matsumoto began by stating that thanks to science and technology, people live better, healthier, and more productive lives. These are the lights of science and technology. At the same time, our overdeveloped civilizations have presented critical challenges such as infectious diseases, overpopulation, and environmental concerns, which are the shadows of science and technology. The session focused on how research and innovation can be utilized to address these problems.

The 5th Global Summit of Research Institute Leaders held on the previous day looked at this very issue as a meeting of major players at research institutes. While research institutes must of course explore science, at the same time there are expectations that they should help improve living standards and quality of life for all people. RIKEN believes that having a vision crafted by innovation designers will formulate innovation for the future and promote

excellent research. Dr. Matsumoto asked the speakers and participants to think about vision driven by innovation designers during the session.

Dr. William Jeffrey spoke about fostering innovation and leveraging research into practical solutions to society's biggest challenges. He noted that he has an economics-based definition of innovation, entailing the creation of new value for customers in a sustainable way.

Universities have a unique role to play in this, and use technology transfer offices to bring research to the market. However, 73% of these offices are losing money, showing that the majority are not sustainable. There are standards for what constitutes a sustainable technology transfer office: they must be big, long-lived, and have a large amount of intellectual property. Although there is often a jackpot mentality that leads to the hope of striking it big with research, unfortunately 96% of US university patents generate less than $50,000.

We must think about getting research out of the lab and into society. Dr. Jeffrey gave the example of the democratization of small chip design, which separated manufacturing from technology development. This can be applied to university research, and separate technological transfer from intellectual property. This can help universities achieve cost savings and allow them to focus on research that has the potential to help society.

Next, Mr. Alexey Evgenievich Repik spoke about smart regulation, describing an initiative by Russia to build competitiveness in new emerging technology industries which has led to six projects. Mr. Repik shared his vision of the future of healthcare in Russia, with the complete personalization of 24/7 services. Many new critical technologies will need to be developed to achieve this, such as diagnostic and prescription functions, technology related to medicine, and 3D printing. He said the STS *forum* should be a platform for coordination to unveil scientific potential and achieve innovation as soon as possible.

Dr. Narong Sirilertworakul began by citing several statistics that reflect the global challenges in the next 20-30 years, including those related to world population increase and the entailing need for more food, growing inequality, and access to resources. Research and innovation must contribute to overcome these challenges. Going beyond initiatives such as improving the productivity of industrial sectors, Thailand is striving to become an innovation-driven economy by attempting to create ten new industrial clusters or new S-Curves, which focus on innovation, technology, and trade in services. The aims of innovation development in these industrial clusters should also tackle societal challenges in order to achieve a balanced development among competitive growth, green growth, and inclusive growth.

For research and innovation to tackle societal problems, Dr. Sirilertworakul highlighted two mechanisms that NSTDA has implemented: 1) integrating various stakeholders, or a PPP (public private partnership)-type model, to tackle the grassroots or the locals' needs for goods and services and incorporate them as a target for research and development programs or projects, and 2) developing strategic collaborative mobility or research funding schemes with various partners from across regions. Through these platforms, talents can be pooled not only to develop core technologies related to the country's needs but also to help tackle global societal challenges at the same time.

Mr. Jean-Marie Solvay spoke about using innovation to mitigate the changes we are making to our planet, including focused multidisciplinary education management to drive experimental knowledge solutions for the environment. The Solvay Institutes for Physics and Chemistry are widely known for scientific excellence and the Solvay Conferences on Physics and on Chemistry that have played a key role in the development of modern science, especially quantum mechanics which has lifted millions of people out of poverty. The success of the conferences lies in their independence in choosing topics and attendees, and the excellence of the participants. They have a predictive ability to look at the future of science and technology, including dark matter, quantum engineering, boundaries of physics and chemistry, and challenging frontier fields in biophysics and biochemistry. Mr. Solvay said he believed that science has the potential to enact great change, but it must be achieved quickly enough before any detrimental effects take hold.

Mr. Solvay then said that we can learn from industrial innovation winners that are able, through multidisciplinary competencies, to identify new market trends and deliver solutions where they can make a difference. This innovation model based on diversity of human resources will help tackle the challenges facing humanity by capitalizing on the strengths of academia, governments, companies, and startups. This will build a body of knowledge that can be leveraged to provide solutions.

Prince Dr. Turki bin Saud bin Mohammed Al-Saud spoke about Saudi Arabia's plans for science, technology, and innovation, with its centerpiece being Vision 2030 to transform the country into a knowledge-based society by 2030 and resolve its dependence on oil. This would encompass aspects such as regulation and R&D, as well as the expansion of and massive investment in universities. In doing this, Saudi Arabia hopes to break down barriers between educational institutes, research institutes, and industry. For example, the country provides funds that help develop innovation, which require joint proposals that must include both a university and a company.

Discussion

The first audience member questioned Saudi Arabia's goal of ending its dependence on oil by 2030, and Prince Dr. Al-Saud answered that this is the target and noted how oil is being redirected to industry. In response to the second audience member's questions about innovation through PPP as well as technology innovation and competition in large groups, Dr. Jeffrey said that PPP is crucial to solve societal problems. He noted that there is never one single solution to each problem, and competition is critical because it enables getting the best solutions from the multitude available. Dr. Matsumoto agreed that PPP and competition are important for finding solutions for societal problems.

Prince Dr. Al-Saud asked Dr. Jeffrey about his comments on technology transfer, and Dr. Jeffrey said that his idea has not been tried in the United States on a large scale. There is a mismatch between the excellence of university research and bringing it to the market, but currently there are no good solutions for it. He is currently looking at inefficiencies, and has seen that the cost and lack of success in getting into the marketplace means that this is an area ripe for disruption.

Mr. Repik then spoke about competition, giving the example of Japanese technology which in the early days did not have many players despite being excellent. However, Mr. Repik noted the importance of how stimulating competition at early stages can be converted into cooperation that drives innovation.

Mr. Solvay brought up the role of philanthropy in pushing innovation, such as the Bill & Melinda Gates Foundation and its major global impact. Dr. Matsumoto said that this is an aspect that does not receive sufficient attention. Dr. Sirilertworakul then spoke about Thailand's consortium of academia, government, and industry to drive innovation that tackles societal problems.

Dr. Matsumoto closed the session by saying he could see new strides for innovation in the form of "vision-driven innovation." Although initially driven by industry for primarily economic growth, the contributions of innovation are now being used to help all of humanity.

Plenary Session 103B: The Role of Universities

[Session Chair]

Block, Gene D., Chancellor, University of California, Los Angeles (UCLA), U.S.A.

[Speakers]

Gonokami, Makoto, President, The University of Tokyo, JAPAN

Miner, Judy C., Chancellor, Foothill-De Anza Community College District, U.S.A.

Matsuno, Hirokazu, Minister, Ministry of Education, Culture, Sports, Science and Technology (MEXT), JAPAN

Gertler, Meric S., President, University of Toronto, CANADA

Opening Remarks

Chair: Block, Gene D.

Dr. Gene D. Block began by stating that universities must play a key role in the evolving landscape of the world to enable social mobility, progress and innovation. The University of California, Los Angeles (UCLA) emphasizes these ideas - for example, a significant amount of students will be the first in their families to receive a four-year education. However, in several countries, government leaders have questioned the benefits of funding universities, in particular Humanities programs, and there is an influx of for-profit institutions and other such places which do not provide an appropriate education. There is not enough space at many universities, and the in-residence living arrangements once common at universities are also being questioned as students are pursuing other arrangements better suiting their needs. Online education can help meet this demand, but it also may only deepen current inequalities.

Those involved in education must ask some big questions: Should we encourage students to receive a focused or broader education, and which will better prepare them to drive innovation in the modern workforce? The value proposition of a liberal arts degree is being questioned. Should universities pursue more collaborative link-ups with industry actors? Or will the closeness of academia and industry endanger curiosity-driven research? Are the Humanities at risk? Only 8% of students in the U.S. receive such a degree.

Dr. Makoto Gonokami spoke about how the University of Tokyo can contribute to modern society as a non-Western university. As global instability is increasing, and the rate of social change accelerating, a new style of university will be required. Creating knowledge will require the breaking-down of barriers, and it is the duty of a university to support and implement this process to benefit the global public. Universities must welcome scholars from overseas to further diversify the kinds of knowledge that can be created, and ensure there are more perspectives around the table.

In the past, problems were clearly defined, and the challenge was finding how to solve them. Now, the problems themselves must be defined. This must be done in partnership with society, including the private sector. The University of Tokyo has started a new project to promote new partnerships in several fields, including information engineering and sports science. Good health is the basis for good society. Furthermore, even though partnerships between academia and industry must be expanded, academic principles must not be compromised. Like The University of Tokyo, which has been creating new knowledge through integration of Eastern and Western scholarship, universities represent a unique venue for bringing together and sharing the world's knowledge, and this characteristic should be further emphasized to address global issues.

Dr. Judy C. Miner spoke about community colleges, which are a system that allows increased access to higher education, addressing the needs of diverse students in a rapidly changing world. In addition to classic for-credit academic classes, community colleges also offer non-credit courses such as English as a Second Language, parenting, and job training, among others.

In recent years, employers are increasingly demanding a college-educated workforce, and community colleges are uniquely positioned to help students meet these demands. Technological, scientific, and mathematical degrees are on the rise at community colleges, also to help meet these needs. Community colleges have also increasingly been attracting foreign students looking to acquire the necessary skills, with many students from Asia enrolling in institutions in the Foothill-De Anza Community College District.

Minister Hirokazu Matsuno began by reiterating that university reform is underway in Japan. Researchers estimate that a significant percentage of existing jobs will disappear over the next decades, as society's needs and expectations change. Bringing foreign faculty and students into Japanese universities will help drive innovation and reform. In addition, it will soon be required for all universities to publicize information on admissions, graduation requirements, and so on to increase transparency.

In addition, universities will play a key role in furthering science, technology and innovation to contribute to society. The increased network-ization of society is called Society 5.0 by the Japanese government, and the government is involved with various initiatives to promote Society 5.0, including developing A.I.-related technologies with RIKEN. Furthermore, Japan is committed to strengthening efforts to contend with issues facing the world such as climate change, health and the graying of society, among others. The Japanese government will increase its investments in projects with science, technology and innovation and also further university reform.

Dr. Meric S. Gertler began by suggesting that universities can be seen as gateways to knowledge. They contribute significantly to addressing the needs and challenges faced by the world. Universities generate vast amounts of knowledge – for example, in the last five years alone, University of Toronto generated 100,000 peer-reviewed documents. Universities also serve as gateways to opportunities, leading to social mobility for students, especially as the trend toward diversity continues.

Universities also act as conveners in the local community – venues for collaboration – and spaces for international exchange. Universities are inextricably embedded in the international community as well, as international collaborations are on the rise, not only creating new knowledge but also new learning opportunities, serving as invaluable local nodes within global knowledge networks. The myriad functions of universities are central to their importance.

Discussion

An audience member asked about supporting international students, many of whom come from resource-constrained countries. Some students and researchers, once they have access to modern, cutting-edge facilities, do not return to their home country, which represents a significant loss. What plans are there to support the building of academic infrastructure in such countries? Dr. Gertler answered that University of Toronto is involved in several twinning programs with other universities. Dr. Block responded that UCLA has been involved with resource building at global institutions. Such programs require cooperation between all institutions involved to facilitate brain circulation, not brain drain.

An audience member asked panelists to discuss digitalization in general, and online learning in particular. Dr. Gonokami responded that one goal for academia is to make a robust basis for learning opportunities – the University of Tokyo has recently adopted the Massive Open Online Course (MOOC) system for example. Dr. Miner commented that the Foothill-De Anza Community College District is involved in building a database of online courses to be accessible to all the over two million students in its system. Minister Matsuno commented that Japan's strategy to invite more foreign students will involve both public and private funding. It will be important to promote coordination between all educational institutions to further provide opportunities. Dr. Gertler said that when online learning first emerged, it focused on replacing classroom learning with ICT-tool based learning, although recently the trend has shifted to emphasize ICT tools as a complement to classroom learning. Dr. Block cautioned that inequality might occur between students of different income groups if the increased digitization increases. Therefore, it will be important to also set aside in-residence spots to respond to the needs of all students.

An audience member asked what solution there could be to the tension between specialization and generalization as educational approaches. Dr. Gertler answered that despite the many opportunities students have to specialize, he has noticed that many are preferring to have a broader education. Many of the brightest students are pursuing double majors,

and it is necessary to continue allowing them the opportunity to do so. Dr. Gonokami added that the multidisciplinary approach is also key. Recently, a multidisciplinary panel to scientifically explain long-term seismic activity was launched at the University of Tokyo.

An audience member asked whether there has truly been progress in minority representation in universities in the United States. Dr. Miner answered that there has not been enough progress. There is a requirement for greater intentionality in tackling these problems, as is keeping in mind the historical issues that lead to inequality. It is not just "opening classrooms," but it is also about addressing the social and interpersonal factors that could lead to development and growth. Dr. Block added that UCLA has partnered with regional grade schools and high schools to prime minority students for academic pursuits.

An audience member asked what incentives exist in Japan to encourage multidisciplinary research. Dr. Gonokami answered that the simple top-down approach does not work, but if a good example or "flag" is shown, then others will be encouraged to follow. Sharing success stories is very important. Minister Matsuno reaffirmed that from his perspective as an administrator, multidisciplinary approaches are key. One issue with Humanities research in Japan is that it is often too specialized and not connected to society. MEXT has requested universities to reconsider – and redesign – its Humanities programs to better address society's needs.

Dr. Block drew the session to a close, thanking panelists for their frank and engaged discussion, and the audience for their insightful and challenging questions.

Concurrent Session 104: [Energy and Environment] New and Renewable Energies

[Session Chair]

Schlapbach, Louis, International Advisor and Guest Scientist, MANA Materials Nanoarchitectonics, NIMS-MANA, Tsukuba / Prof. em. ETH/Empa, SWITZERLAND

[Speakers]

Engel-Cox, Jill, Director, Clean Energy Manufacturing Analysis Center (CEMAC), National Renewable Energy Laboratory, U.S.A.

Furukawa, Kazuo, Chairman, New Energy and Industrial Technology Development Organization (NEDO), JAPAN

Igarashi, Jinichi, Director, Senior Vice President, JX Nippon Oil & Energy Corporation, JAPAN

Liao, James C., President, Academia Sinica, CHINESE TAIPEI

Sofronis, Petros, Professor, Department of Mechanical Science and Engineering, University of Illinois at Urbana-Champaign, U.S.A.

Opening Remarks

Chair: Schlapbach, Louis

The chair welcomed everyone to the session on New and Renewable Energies and let each speaker provide brief introductions. He commented that they were faced with the issue of steady growth in energy consumption while trying to curb CO_2 emissions. He added that they face three key risks including that of temperature growth and global climate change, risk from old 3rd generation nuclear fission technology, and economic risk if change to the sector occurs too rapidly. He then described the physics (Gravitation, Coulomb and Strong Nuclear Interaction) behind various energy sources, emphasizing that new nuclear technologies and rapidly growing renewables will contribute to the future energy mix.

The first speaker highlighted issues of cost reduction, the stabilization of energy fluctuation in renewable sources, and transport of electricity derived from renewable energy to further

expand the introduction of renewable energy. He also touched upon the use of AI and big data, further developments in battery and storage solutions.

Noting recent innovations, the second speaker spoke about the deployment of clean energy technologies, drops in prices driving the use of renewables, and overall increases in efficiency impacting cost performance. She highlighted various manufacturing developments such as automated and continuous manufacturing, wafer cutting, and improved contact design which have all improved efficiency and prices. She emphasized that this clean manufacturing revolution will drive these renewable technologies forward.

The third speaker commented on reductions of CO_2 emissions in the transportation sector, and developments of renewable energy technologies in Japan. He added that biofuels play an important role in reducing CO_2 emissions and discussed the production of bio-ethanol from lignocellulosic biomass to avoid competition with food.

Energy storage is a major issue for all renewable energy sources, the fourth speaker stated. Unless we can develop a battery that is energy-dense and easier to charge, human habits will be forced to change. He suggested recycling CO_2 from atmosphere and converting it into liquid fuel as a future direction to develop.

The fifth speaker commented on issues with developing new technologies, such as those for the hydrogen economy. He highlighted that hydrogen was a carrier that could be used to store energy, that many tools were already available to study the safety and reliability of material components in hydrogen applications, and that managing strategies for the use of the wealth of information that universities and laboratories were already developing would be vital to further understanding the use of materials in hydrogen environments. He suggested engaging universities and working with young scientists to expedite the development of technologies, and emphasized that face to face interactions could not be replaced with videoconferencing or teleconferencing.

Discussion

The first group's discussant talked about how countries could work together on renewable energy, suggesting that they should just compete, which would lead to a variety of approaches to implementation. He touched upon new technologies such as experiments on and the implementation of thorium, offshore wind platforms, and use of ocean currents. He also stated that economics would play a key role, questioning who would be willing to fund development and to what extent it was possible to profit off of renewables.

The second reporter commented specifically on the transportation sector, the development of more efficient batteries, and the use of biofuels. He suggested that ICT and self-diving vehicles could start a paradigm shift in the sector, adding that smart grids and super grids would also be essential.

The third group's representative highlighted that energy storage remains a challenge, the political issues that go along with the use of nuclear power in the energy mix (particularly in developing countries), and the low efficiency of wind power. He also noted the lack of transmission lines, appropriate policy issues, and sensitivity to timelines affecting energy efficiency.

The fourth discussant commented on battery storage and the use of hydrogen, and suggested that it would be important to focus on energy consumption reduction in buildings and infrastructure.

The fifth group's reporter discussed what the lowest possible cost point for sustainable storage solutions were and the disaggregation of energy policies between countries.

The chair reiterated that there was definite interplay between existing technologies, politics, and economics that countries would need to find a balance for. He then thanked everyone for their participation and concluded the session.

Concurrent Session 104: [Life Sciences] Environment and Health

[Session Chair]

Lindpaintner, Klaus, Vice President and Global Head, Human Genetics and Computational Biomedicine, Worldwide Research and Development, Pfizer Inc., U.S.A.

[Speakers]

Fineberg, Harvey V., President, Gordon and Betty Moore Foundation, U.S.A.

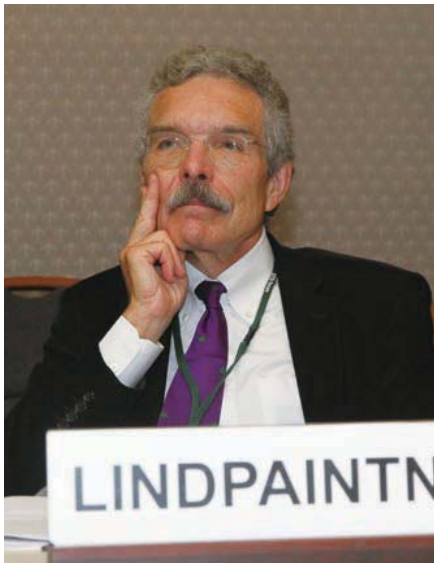
Kimura, Masahiro, General Manager, Global Environment Research Laboratories, Toray Industries,Inc., JAPAN

Kuno, Sachiko, Co-Founder, President & CEO, S&R Foundation, U.S.A.

Suematsu, Makoto, President, Japan Agency for Medical Research and Development (AMED), JAPAN

Valleron, Alain-Jacques, Member of the French Academie des sciences, Delegate for Scientific Information and Communication, Academy of Sciences of France, FRANCE

Opening Remarks



Chair: Lindpaintner, Klaus

The chair opened the session by explaining the well-established relationship between environment and health in human history. There has been a growing awareness among society in recent years of the impact of environmental factors on health, resulting in the development of regulations to tackle them. However, this has gained more ground in developed countries, while in emerging countries such environmental factors are intentionally or unintentionally ignored for the sake of development. In addition, advances in research have enabled the study of the interplay between environmental factors and genetic information, and how to act on that understanding, leading to the development of genetic epidemiology. Another major development is the emergence of real-time sensors, which will produce huge quantities of in-depth data. However, this also poses new challenges, such as developing techniques to make sense of this data, and also addressing the concerns of data privacy.

The first speaker began by detailing the background to the development of the Japan Agency for Medical Research and Development (AMED), a new funding agency launched by Prime Minister Abe to tackle the issues with scientific research funding in Japan. A major challenge for medical research funding agencies is global data sharing. One issue is convincing biomedical researchers to share their data. Efforts are being made to share such information. This has been promising for rare diseases, but less so for common diseases. Data sharing will be very important for many different medical issues, such as understanding the aging of society, tackling the emergence of super bugs in medical institutions, or addressing prion diseases.

Continuing the discussion on the relationship between health and the environment, the second speaker stated that while the final cause of death is never an environmental factor, most of the diseases that cause death are related to or exacerbated by environment-related factors. In fact, one of the main environmental factors affecting our health is air quality, not only outdoors but also indoors. In particular, indoor air pollution arising from cooking using unclean fuel is a leading cause of death in developing countries, particularly among women and children. The issue of air pollution is improving in developed countries, but it is actually worsening in developed countries. The challenge is to accelerate development to the point that these countries can afford to devote resources to tackling air pollution both inside and outside.

Switching the focus from air, the third speaker talked about global water issues and the use of biomass as a renewable energy source. Many parts of the world face serious water shortages. This is a pressing issue that is worsening. A variety of technologies have been developed to tackle this problem, such as direct or indirect reuse of waste water. Despite this, the situation is still dire, and the lack of access to water or sanitation facilities is a major source of disease. As for biomass, this and other renewable energy sources are important for sustainable development, both in terms of reducing resource depletion and reducing CO_2 emissions. Finding a way to use biomass effectively will yield great benefits for society.

Not only limited to physical and chemical factors, the fourth speaker believed that environmental factors also included lifestyle factors and social environments. He also noted that

issues of health had dimensions of both perceived and objective risk. While scientists can be tempted to believe that their role is limited to studying the objective risk and to leave the study of perceived risk to policymakers, this temptation is misplaced. It is worth studying the difference between perceived and objective risk of people exposed to environmental factors and devise evidence-based treatments for addressing them. Advances in information and communication technology enable public participation in research programs. This will foster greater public interest in science, while also making research data more readily available, which can be harvested to advance research further.

The fifth speaker discussed the power of young people to solve the major global health issues faced by the international community. To achieve this, it is necessary to create an eco-system that fosters interdisciplinarity and entrepreneurship among young people, so they can produce the kind of disruptive innovation that will achieve the necessary breakthroughs. In addition, public and private funding, such as social impact investment, must be leveraged to maximize such efforts. Major philanthropic efforts, such as those of the Bill and Melinda Gates Foundation, will also be important. Furthermore, efforts should be made to empower women, who remain a minority in science and technology fields, and to leverage their collaborative abilities.

Discussion

The first group's discussant talked about big data. The integration of research data globally would greatly enhance the value of such data, but that in turn raises both the challenge of mining that data collaboratively and issues of data privacy. Another challenge is convincing researchers to share their data. Additionally, those who have undergone super-aging are a particularly valuable cohort to study as they seem to have resisted more harmful environmental factors than others. Sleep studies are also emerging and are very valuable.

The second reporter spoke about air pollution. The low level of public awareness about air pollution is surprising, given the magnitude of its impact. Both social and technological means can be employed to address air pollution issues.

The third group's representative talked about water and biomass. Efforts need to be made to improve the quantity and quality of water that people have access to. One major issue affecting water quality is salinization. Both management of the systems and application of technologies can contribute to addressing water quality problems. As for biomass, this can be used as liquid fuels, such as biodiesel and ethanol. However, it is important not to use food crops for biomass. Technologies are needed to harvest other biomass sources, such as algae or agricultural waste.

The fourth discussant reported on ways to inform people about the impact of environmental factors on their health. One-sided education is insufficient. Rather than telling people what is right or wrong, it would be more effective to listen to their actual issues and respond to their specific issues.

The fifth reporter spoke about a vision for health and environment. Social impact, entrepreneurship and innovation are important. Another challenge is establishing connectivity between social and environmental issues and businesses as well as between these issues and investors. It is proposed that STS *forum* is exactly the venue for addressing this issue.

Concurrent Session 104: [Engineering and Innovation] Future Nanomaterials

[Session Chair]

Gibbs, Doon, Director, Brookhaven National Laboratory, U.S.A.

[Speakers]

Bona, Gian-Luca, Director Empa, Professor for Photonics, ETH Zürich and EPF Lausanne, Swiss Federal Laboratories for Materials Science and Technology, SWITZERLAND

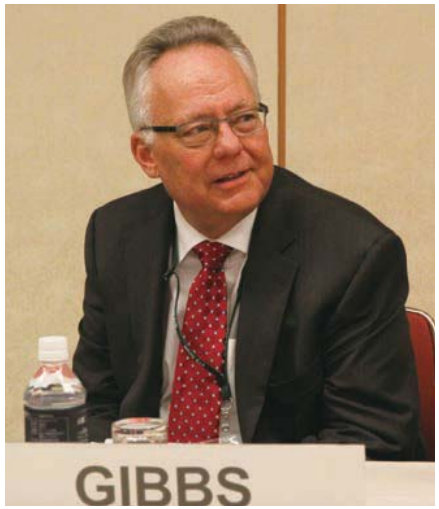
Kitagawa, Susumu, Director, Institute for Integrated Cell-Material Sciences, Kyoto University, JAPAN

Nazar, Linda, Professor and Research Chair, Department of Chemistry, University of Waterloo, CANADA

Ogawa, Ikuzo, Senior Managing Executive Officer, Sumitomo Chemical Co., Ltd., JAPAN

Powell, Robert, Professor, Chemical Engineering; Food Science and Technology, University of California Davis, U.S.A.

Wiesendanger, Roland, Director of the Interdisciplinary Nanoscience Center Hamburg, Dept. of Physics, University of Hamburg, GERMANY



Chair: Gibbs, Doon

Opening Remarks

The chair opened the session by explaining that Nanomaterials continue to offer remarkable opportunities for fundamental research and applications in energy conversion, transmission and storage; electronics; biosciences/biotechnology; medicine and health; and beyond. Their essential characteristic – the emergence of new properties at the nanoscale and their tunability with size – is a great strength when creating new functionalities, but it is also a challenge from the perspective of ultimately designing and controlling their properties. The questions raised for the session were the following:

- What are the emerging directions for new research in nanomaterials, and why are they emerging now? What new nanomaterials with novel properties have been discovered recently? What are their concomitant applications?
- What new techniques have emerged to synthesize nanomaterials and characterize their properties?
- How can we scale up the production of nanomaterials with well-controlled properties to an industrial level, and make them economically competitive?
- What are the most important recent results concerning the implications for the environment, safety and health of the use of nanomaterials in everyday life?
- What have been the most important benefits of nanomaterials (and nanoscience in general) to society so far, and what is their potential for the future?
- Has nanoscience lived up to its early promise of revolutionizing society? Where have we failed? What are the lessons learned?
- What role can the government play in promoting the successful growth and impact of this field? Is there a place for private-public partnerships?
- Are there new or different modes of promoting interdisciplinary research than those that have been recognized before? Are large focused programs more impactful or interest-driven?

The first speaker noted that nanomaterials are going to be hugely important, and noted that nanomaterials have only been embraced in the field of energy storage and conversion in the last decade, but that there has been an understanding of the significance for a relatively long time, such as in fuel cells. In the area of thermal-electric conversion there has more recently been a shift from simple bulk materials to nanomaterials which has made a huge impact. The speaker stated that nature provides great examples of nanomaterials, such as in the leaf, and huge efforts have been made for artificial photosynthesis. Energy storage is also increasingly reliant on nanomaterials to achieve high density, low-cost storage in larger energy storage devices. One hot topic is in solid state batteries where solid state electrolyte has to be mixed with active material at the nano scale. The speaker pointed out that while nanomaterials have so far largely failed to revolutionize society, these are examples where their impact is revolutionary, and there are lots of opportunities for nanomaterials in the future.

Noting some of the problems in working with nanomaterials, the second speaker discussed the challenging aspects of controlling the properties of new materials, which can be dependent on interactions and properties at the single atom or molecule level. Only recently has it been possible to prove that concepts of spintronics can be scaled down to the nano level. There are also several nanoscience discoveries that provide the basis for many new

technologies to be developed. New techniques in materials synthesis have also allowed stable artificial materials to be created through atomic layer-by-layer growth, and one recent discovery was superconductivity in a single layer of a material on a substrate. The speaker stated that nanotechnology continues to offer great opportunities crucial for the development of society including energy efficient information technologies, energy storage, and smart materials design.

The third speaker stated that he is optimistic that new nanomaterials can impact many other fields beyond electronic chip miniaturization, where one has learned to master up to 80% of the elements of the periodic table in large scale production. In future nanomaterials, it will not only be about miniaturization but also about new functions that can be realized when scaled to less than 100nm in size and surface properties are dominating above bulk properties. However, for success in real life applications, new bottom-up design concepts and new fabrication rules which are more forgiving comparable to processes observed in nature must be taken into consideration. It takes time to solve materials issues, but now it is looking very promising for nanomaterials in providing new functions through new synthesis techniques and mimicking nature in ways that we could not do before.

The fourth speaker discussed novel porous materials, noting that in the past there had been concerns that it would not be possible to produce enough food if the population exceeded

4 billion, but we are now at a population of 7 billion, which was made possible by nitrogen fertilizers from nitrogen in the air that enabled a dramatic increase in food production. Ultimately ubiquitous gases, including ambient air with carbon, oxygen, and nitrogen, will serve as energy and chemical resources. Some hurdles exist to employ such gases. To overcome such hurdles, science and technology to manipulate gases under mild conditions (e.g. room temperature, low pressure, and low energy consumption) are demanded. He noted that 40% of energy used by the chemical industry was used in separation processes, and furthermore, about 15 % of the energy produced worldwide today is used to separate and purify industrial commodities (e.g. gases and water), and the demand for these commodities is expected to triple by 2050. To meet today's demand for energy saving and safety, materials that achieve mass storage and highly efficient separation of gases cannot be realized by simply improving conventional technology. If this could be realized and connected to conversion processes, then issues of effectively using resources and reducing CO_2 can be resolved simultaneously. Novel porous materials will play important roles in many areas. The bottom-up synthesis method to provide light materials with regular porosity and high surface area has advantages for efficient storage of gases. Sustainability of the planet is the most important aim, and therefore collaboration to generate action on these themes is required.

Further elaborating on the usage of nanotechnology, the fifth speaker discussed the applications of nanotechnology in foods, including self-assembly and migration of food

components, nutrient delivery systems, and active food packaging. These applications include both methods to better understand existing foods and to help accelerate the innovation cycle. One technique for manufacturing stabilized systems is flow micro-focusing, often meaning stabilizing active constituents against oxidation. Dr. Powell stated that possible innovations in packaging technology include nanometer-sized vacuum deposited coatings, organic barrier coatings, antibacterial coatings, and edible packaging. He also discussed agriculture applications which include ubiquitous sensing for precision agriculture and nanoparticles for plant growth. Nanoparticle forms of plant micronutrients may have significant use in pathogen control efforts. Early data show significant potential for nanoscale micronutrients to suppress disease and increase crop yield. On a more immediate and practical level, there are over twenty fertilizers based on nanotechnology that are under patent protection and may soon be on the market.

Petitioning for increased caution, the sixth speaker stated that we need to pay close attention to the exposure of nanomaterials to the environment through waste and in production facilities. In terms of production facilities, when nanomaterials aggregate in waste they are no longer nanomaterials and care should be taken about their effects. There are still uncertain areas such as inhalation toxicity. These are now being studied through international discussions on creating guidelines on how to measure inhalation toxicity. The speaker noted that the establishment of safety evaluation methods is underway and is an area to watch closely. In many cases nanomaterials are used in composites and therefore industry is encouraged to engage in collaboration early on in research.

Discussion

The first group's discussant stated that nanotechnology has been successful in certain examples, but there are still many markets in which there has been little impact so far despite successful innovations. He suggested that there should be two different streams of research, both proof of concept research and research aiming toward a final application to be taken to market. It was noted that Japan's funding agencies have programs for funding both streams.

The second reporter noted that there are nanomaterial formulations that can be added to things and also the more complicated nanomaterial systems and devices. There have been huge advances in systems driven by improvements in equipment that allow an understanding of nanoscience interfaces, but there is also a huge valley of death due to manufacturing and

scalability of the technologies. There was discussion about how to cross the valley of death, and it was noted that some countries do have programs to support flagship programs and projects. There needs to be standardization of certifications, particularly for highly regulated industries like aerospace.

The third group's representative stated that with regard to scalability and mass production, the culprits are process control, reliability and reproducibility, and the work that needs to be done to go from concept to market. There are not too many cases where this has been achieved, but there is hope for the future. There is also the question of what will replace silicon technology scaling in the future, with the belief that challenges to the continuation of Moore's law will drive development of new nanomaterials.

The fourth discussant reported that inspiration for accelerating the emergence of nanomaterials can be taken from nature, and that the barriers included difficulties in establishing international standards and regulations due to definitions, classification, and categorization. To produce nanomaterials requires groupings of multiple competencies which are rarely found together. There are also issues around identifying the best opportunities that should receive funding.

The fifth group's reporter explained that there are concerns around toxicity and how to test and evaluate, as with nanomaterials there are many different factors that can affect risks and hazards. It is difficult to predict how the combination of properties will affect risks and hazards. Models must be created to rapidly screen nanomaterials due to the number of different materials being produced and the complexity of testing. There is also a need for public education to allow for more rational discussion.

The sixth representative stated that there is a wide variety of ideas on what comprises nanomaterials, and it is important to increase awareness. There are many mechanisms from nature that have already been mimicked, but there is still a lot of room to expand upon these.

The chair summarized that nanomaterials research is an interesting and challenging subject, with a number of new and exciting opportunities for the future. Despite much progress, it is still a relatively new field and there is optimism that breakthroughs are close.

Concurrent Session 104: [Earth Science] Ocean

[Session Chair]

Leinen, Margaret, Vice Chancellor for Marine Sciences; Director, Scripps Institution of Oceanography, University of California, San Diego (UCSD), U.S.A.

[Speakers]

Ausubel, Jesse, Director, Program for the Human Environment, Rockefeller University, U.S.A.
De Mora, Stephen, Chief Executive, Plymouth Marine Laboratory, U.K.
Hernández, Sergio, Deputy General Director of Research Centers, National Council for Science and Technology (CONACYT), MEXICO
Shibuya, Shogo, President & CEO, Chiyoda Corporation, JAPAN
Taira, Asahiko, President, Japan Agency for Marine-Earth Science and Technology (JAMSTEC), JAPAN

Opening Remarks

Chair: Leinen, Margaret

The chair opened the session by thanking the attendants. This year, the session will focus on several broad issues, including the need to balance the use of resources from the ocean with conservation. Additionally, the needs to develop new methods of ocean observation and to increase participation in ocean science will also be discussed.

This year has been important for oceans. There have been advances in sustainable ocean goals, including the inclusion of the oceans in the Paris Agreement. Seventy percent of Earth is covered by oceans, so it was inconceivable to think that the previous agreements did not include them. This is proof that attention has been increasing in this arena.

This year, with leadership from Japan, the G7 examined oceans, especially the need for further ocean observation. Understanding the ocean can give insight into sustainability and resource usage, leading the G7 ministers to call for new ocean conservation efforts.

US Secretary of State John Kerry helped sponsor the Our Ocean Conference (OOC), culminating in a summit featuring ministers from over 100 countries. The OOC series will continue with three future summits, securing a future for ocean research in diplomatic talks.

In recent years, high level attention has been given to oceans, making it an appropriate topic to receive attention at STS *forum*.

The first speaker stated that trends in energy have been based on onshore and shallow water developments. However, offshore deep water developments are growing in importance as the technology and demand increase.

Offshore oil and gas developments will play an important role in the recovery of natural resources. These developments account for 40% of recoverable reserves of oil and gas. CHIYODA Corporation has started a new division for offshore oil and gas projects. With the cooperation of group companies such as Xodus and EMAS CHIYODA Subsea, CHIYODA Corporation can provide comprehensive services from early concept phase to the EPCI phase and subsequent operation phase and decommissioning phase, allowing for further access to recoverable reserves.

Offshore development will hold a prominent position in the future, but the economics of a deep water development project do not meet needs in the current market. Therefore, projects are often postponed or canceled due to high development costs and the influence of the slump of the crude oil prices from 2014.

Perhaps surprisingly, another factor that greatly increases costs to offshore development is the remarkable rise of decommissioning expenses. Large and old platforms become targets for decommissioning. From the environment conservation point of view, those expenses have become much higher than predicted at the beginning of the project. Cost reduction plans for offshore developments are required, along with technical innovation, to reduce the overall project cost.

Despite the potential costs, offshore resource development in Japan has begun, thanks to the discovery of methan hydrade off the continental shelf of Japan. These methane deposits are expected to become a new energy source for the country and have become a national project for both public and private sectors. The goal is to reach commercialization by the late 2020s.

Switching the discussion to the bounty of oceans, the second speaker stated that the exploitation of green bio-resources represents both threats and opportunities for food security and food safety.

The ocean is and has been an important source of nutrition, but its importance will only increase. Current trends have shown that global fish consumption has doubled. It is clear that nutrition from the sea is vitally important, but reliance on sustainable fisheries will require careful management. One step to managing fisheries involves largescale technological solutions. Remote sensing technology is needed on a global scale so that accurate models of the ocean ecosystem can be rendered.

Overfishing has caused catastrophic results for fisheries, but smaller scale fisheries have also depleted local resources. The changes in grazing behavior from human-introduced fish change the ecology of the area. These practices could represent a threat to future human food security. Forming solutions to these problems revolves around education and legislation.

Ocean acidification is a global problem that poses a threat for human food supplies and ocean ecology. Mitigation for acidification is underway, but unfortunately remains small in scale. Methods include the cultivation of seagrass and controlling CO_2 emissions.

Food safety, or the quality of food, is also under threat. Pollution, caused by metals, pesticides, and other manmade products, has become an international environmental crisis.

Enforcing compliance is generally predicated on sophisticated monitoring procedures, limiting the amount governments can do in keeping oceans clean.

There are a range of tools to help with fishery planning, including remote sensing applications to monitor large algae blooms, but this monitoring must lead to better management.

Observing as of yet incomplete areas of research, the third speaker stated that the ocean floor should be mapped more precisely. Understanding the topography of the ocean floor is important to understanding and mitigating disasters. During the March 2011 earthquake and tsunami, after a topographic survey, huge variance in the crust was found. Without knowing this topographic data, there would be no way of knowing the massive movement of the crust.

Seventy percent of the Earth's surface is covered by ocean, but only 13% of the ocean's floor has been mapped. Thanks to satellite imagery and the advances in oceanography, the general image of the ocean floor is known, but the specific topography is still largely unknown. The topography of Mars and the moon have actually been better mapped than the topography of Earth.

The public must be convinced that mapping the ocean floor is a worthwhile endeavor. Cost is the major limiting factor, so there needs to be new cost efficient technological breakthroughs. An understanding of seafloor topography could lead to innovation that would change the entire world.

The fourth speaker noted that the observation of the oceans is an important pursuit. Many kinds of observations are worth exploring, including soundscapes, ocean life DNA, and the naturally occurring petroleum count.

The Census of Marine Life Research Program looked at 210,000 species, and estimated that there are between 750,000 and 2 million forms of ocean life to still be discovered. Previous attempts to categorize species resulted in the identification of far fewer species, so significant progress has been made in this field.

In a typical region, there are about 10,000 known forms of ocean life. Of those, about 12% are fish. New exploration and identification technologies are needed to speed discovery processes and determine whether a species has already been categorized or not. Previously, ships, scuba

divers, and sonar have been used to see whether animals were present or not. Unfortunately, none of these methods have been very effective for looking at a high density of observations.

There are now new possibilities using genetics to identify forms of marine life, displacing the need to capture entire animals. Thanks to the Barcode of Life Initiative, there is now a solid reference library of ocean animal DNA. This gives a reference point to check if collected information is true or not.

By filtering and amplifying naked DNA drifting in seawater, animals can be cross-referenced via this reference library. These extracellular, non-invasive research methods are both cost effective and don't require much of a water sample to conduct, while at the same time being reliable to establish the presence of animals. The collection of DNA may also give an index of abundance, although this would be harder to prove than presence.

There is a need for global collaboration to develop standards and protocols to develop the library further. In the end, the goal is to have a large, open database. In the next decade there are tremendous opportunities to have portable observatories, with observations shared very rapidly. These solutions can be applied to many problems facing the oceans today.

The fifth speaker made it clear that large scale collaboration is essential and that there need to be strategies to utilize national capacities. Financing for marine sciences is limited, and these issues are complex even for large governments to pursue. Major pending aspects of the global agenda can only be addressed by creating large, collaborative programs.

The exploration of deep biodiversity is only starting, despite the availability of technology. Further exploration is required, and measuring the water column goes beyond the capacity of a single nation.

The assessment of marine resources, especially when it comes to large marine ecosystems, needs to be developed with international collaboration, due to the migration patterns of fish. Fish cross multiple national borders, causing problems for research.

Extraordinary amounts of data are required to capture climatic processes. Climate models produce data that must be qualified, quantified, and analyzed, but there is a lack of experts to complete these processes.

Complete participation in programs will result in increased funding, so collaborative programs are necessary.

Discussion

The first group's discussant stated that there is a need to go to deeper places to find and develop more resources. This need means there are more challenges, including increased costs and increased difficulties in monitoring the environment. By creating new approaches, such as developing new equipment and material to reduce cost, developing the construction method to reduce time, and developing environmental rules and monitoring tools for offshore construction, there will be a better impact on the environment and overall cost reduction. This would improve the extraction of energy resources from the ocean.

The second representative explained that global warming has caused a shift in biomes, causing biodiversity and different species' migration patterns to change as a result. It is important to involve more countries in saving the ocean or the consequences of these shifting biomes may be impossible to reverse. Improving remote sensing will help, while utilizing super computers will allow models to be explored further.

The third group's reporter noted that mapping the ocean floor is a huge goal. New technologies will be necessary to meet this goal. Autonomous vehicles could be an example that would help cut costs and ease operation. Satellites could also provide support, despite limited resolution. Accessing existing data represents a problem for analyzing data due

to the complicated legal status that results from multiple companies producing the data. Activism will be required to start conversations about making data more accessible.

The fourth discussant stated that the soundscape of the ocean and DNA analysis will provide greater understanding of ecosystem characteristics. Although it is recognized that the ocean is largely unexplored, new techniques represent exciting avenues for ocean science. These new techniques can also be used as a measure for the environmental impact assessment. From the funding agency point of view, it is hard to rationalize giving more money to science when certain technologies aren't yet fully developed. Despite this, it is worth pursuing these two techniques because of their potential contribution to society. These techniques represent cheaper options than making large vessels, so support will likely increase.

The fifth representative reported that large marine ecosystems are extremely challenging to study. They are inherently transboundary, covering very large areas of the ocean. The natural variability of these areas can extend and be periodic over decades, meaning that studying it at one time is insufficient. Global programs in the past have focused on smaller spatial and temporal resolutions. There needs to be a set of defined priorities to facilitate the study of large marine ecosystems that the international community can readily adopt. If there were no international cooperation amongst the sciences, then there would be great progress in nanotechnology, space science, and other fields, but mapping the global seafloor or looking at large marine ecosystems absolutely requires international cooperation. One country cannot handle the burden alone.

The chair emphasized that while lots of measurements could be taken, data interpretation is the difficult part. Bringing diverse communities together to look at these issues is also a demanding task. By coupling interpretation with modeling, then it is possible to do scenario testing akin to the Intergovernmental Panel on Climate Change (IPCC). The chair concluded the session, stating that a marine version of the IPCC is needed.

Concurrent Session 104: [Cooperation in Science & Technology] Collaboration among Academia, Industries and Government

[Session Chair]

Artavanis-Tsakonas, Spyros, Executive Vice President and Chief Scientific Officer, Biogen; Professor Emeritus, Department of Cell Biology, Harvard Medical School, U.S.A.

[Speakers]

Chun, Miyoung, Excecutive Vice President of Science Programs, The Kavli Foundation, U.S.A.

Imura, Hiroo, Professor Emeritus, Kyoto University, JAPAN

Priyanto, Unggul, Chairman, Agency for the Assessment and Application of Technology (BPPT), INDONESIA

Sankai, Yoshiyuki, Professor, Center for Cybernics Research, University of Tsukuba; Program Manager, JST/Cabinet Office of Japan; Founder/CEO, CYBERDYNE, JAPAN

Sung, Nak-In, President, Office of the President, Seoul National University (SNU), KOREA

Terano, Minoru, Vice President; Professor, Japan Advanced Institute of Science and Technology (JAIST), JAPAN

Chair: Artavanis-Tsakonas, Spyros

Opening Remarks

The chair opened the session by outlining the task for the evening's session – articulating how collaboration between academia, industries, and government can be undertaken. Collaboration is a complex and challenging proposition. He expressed his expectations for a fruitful and far-reaching discussion on this matter.

Medical science is extremely important for society, and it has gone through a revolution over the past decade. Technology has driven this change, and it has given us extraordinary insight and tools to address the health challenges faced by the world. For example, Alzheimer's effects over one hundred million people globally. Developing drugs and treatments for this is a major logistical feat, which in turn requires a global culture of

collaboration. Industry, with the help of government and academia, can together develop medical science into the future.

The first speaker talked about the "fourth point" of the three-pointed collaboration between academia, industry and government, which is philanthropy. Philanthropy provides a critical priming mechanism to facilitate and promote change. They are non-profit, and have collaborative, flexible, and nimble funding mechanisms.

For example, the Kavli Foundation played an instrumental role in the BRAIN Initiative, to promote the study of the human brain. Diverse working groups were established to tackle this undertaking, and the Kavli Foundation created comprehensive funding mechanisms to respond, demonstrating its nimble mechanisms. This represents a new model for undertaking research initiatives. Philanthropy represents a unique actor because it can quickly make changes – in many cases, donors are single people, so there is more flexibility than in public institutions.

The second speaker detailed health care and related industries, in which local and national governments must play active roles. To tackle the increasingly graying society, especially prevalent in Asia, the G7 meetings in Japan this year released outcome documents expressing commitment to dealing with the medical issues that result from this, including the increasing occurrence of non-communicable diseases. To address these issues, deeper cooperation between organizations must be realized.

The speaker then introduced a positive example of local government collaboration. The Kansai Health and Medical Care Innovation Council, established in 2015 by the Union of Kansai Government, has two important missions: to promote healthcare by catalyzing collaboration between industry and government, and to contribute to longevity. A number of concrete initiatives have been launched, including education, discussing of urban planning to better meet the needs of changing population demographics, and so on.

As someone who is active in all the points of the "triangle," – industry, government and academic – the third speaker stated that it is important to promote innovative collaboration between all fields. One such method could be creating new markets or social systems with innovative technology and services. This could be called "social innovation," he said.

One example of "social innovation" was the speaker's efforts to create innovative technologies to improve a patient's brain and neural function as part of "Cybernic Treatment." On the university side, he worked to promote this challenge, but in order to prepare and produce the medical device, approval must be obtained, which required the collaboration and input of a wider set of actors. In short, cooperative business promotion to achieve the goal is important.

The fourth speaker's topic was about locally based innovation. In Japan, there is a unique industrial structure where 99% of companies are classified as small to middle sized companies (SMEs). It is important that they support large corporations by producing a variety of high-quality, specialized products. However, it is not easy for them to get effective information from other companies. As a practical solution to this problem, a venue for exchange was created by Japan Advanced Institute of Science and Technology (JAIST), called Matching HUB Kanazawa.

Matching HUB Kanazawa can act to gather the "seeds" for innovation – university, industry, local government, research institutions, etc. – and create a "chemical reaction" to create innovation on the local level. Since 2012, participation in Matching HUB Kanazawa has grown rapidly, achieving a matching number of 350. To build on this success, another Matching HUB will be held in Kumamoto starting in 2017, which was struck by a major earthquake in early 2016. This will provide a venue for expanding rebuilding initiatives.

Discussing initiatives for creating innovation in Indonesia, the fifth speaker introduced the "innovation ecosystem" which refers to the connections and relations between academia,

industry, and government. The active participation of all actors is key to realizing innovation that will reach across barriers.

To improve competitiveness and productivity, the Indonesian Agency for the Assessment and Application of Technology (BPPT) has established venues for exchanging information and to act as a facilitator to the national government to assist the local government. The establishment of further such venues, termed "Techno Parks" will be undertaken over the next decades. This initiative contributes to the "localization" of innovation, ensuring that it meets local needs and can thoroughly contribute to development of technology and talent.

The sixth speaker discussed how to educate academically and creatively skilled and morally responsible future leaders. Thanks to digital technology, a borderless world has emerged, redefining the definition of a community. But technology has also led to various issues, such as climate change, bioterrorism, and social issues.

Scientists alone cannot solve these problems, nor can a single country – rather, collaboration will be key. Educators must thoroughly understand what is needed for future science experts and not overlook the importance of moral education in addition to scientific education. They must also be sure to instill an international perspective, and a strong sense of social justice, to inform their students' academic endeavors and create a drive for collaboration.

Discussion

The first reporter shared the content of their group's discussion, which was on the topic of philanthropy. Several perspectives were shared, including the central role philanthropy plays in promoting research in Hong Kong. In Canada, mostly individual money was used to build facilities, whereas industrial money goes towards research. Discussion was also conducted on the difference between philanthropy and charity. Philanthropy functions more as an investment, and seeks to provoke creativity.

The second representative shared the content of the group's discussion on the topic of protecting the academic freedom of universities as collaborative partnerships with industry are underway. In Japan, at least, collaboration seems to be more pursued by the younger generation of academics.

The third discussant shared the content of the group's discussion on the topic of how to promote collaboration between industry, academia, and government to engender true innovation. It is important to create communities that will define common goals – and contend with time constraints which are different for industry, academia, and government, as well as legal constraints which are also different for the different actors.

The fourth reporter shared the content of the group's discussion on the topic of collaboration between local universities and major research universities. One challenge is that universities have started to become similar in what they teach. Several country cases were discussed, including Hungary, the Republic of Korea, and others.

The fifth representative shared the content of the group's discussion on the topic of the instruments to catalyze collaboration, including the Techno Parks in Indonesia, and a research center set up within the University of Cambridge by Hitachi, among others. There was also discussion on the research parks in Iran. Finally, there was discussion on changing perspectives on education so that Doctorate Degrees can have industrial output.

The sixth discussant shared the content of the group's discussion on the topic of why companies were not getting involved with universities and vice versa. Many of the discussion points on the barriers overlapped with discussions at other tables. In addition, reform of taxation laws to encourage large companies to invest in small companies will be important, among other matters.

The chair thanked all members for their active participation and brought the session to a close.

Concurrent Session 104: [Science, Technology and Society] Bridging Science and Technology with Society and Politics

[Session Chair]

Boyle, Paul, President and Vice-Chancellor, President and Vice-Chancellor's Office, University of Leicester, U.K.

[Speakers]

Al Hashimy, Reem Ebrahim, UAE Minister of State for International Cooperation; Director General, Bureau Dubai Expo 2020, Dubai Expo 2020 Bureau, U.A.E.

Durongkaveroj, Pichet, Minister, Ministry of Science and Technology, THAILAND

Gather, Ursula, Rector, TU Dortmund University, GERMANY

Glotzbach, Ulrich, Head of Energy, Resources and Sustainability, Energy, Resources and Sustainability, acatech (German Academy of Science and Engineering), GERMANY

Kishi, Teruo, Science and Technology Advisor to the Minister for Foreign Affairs, Ministry of Foreign Affairs, JAPAN

Ngubane, Baldwin Sipho, Chairman, Eskom Holdings SOC Ltd.; former Ambassador to Japan, Embassy of South Africa in Japan, SOUTH AFRICA

Noyori, Ryoji, Director-General, Center for Research and Development Strategy, Japan Science and Technology Agency (JST), JAPAN [Nobel Laureate 2001]

Premajayantha, Susil, Minister of Science, Technology and Research, Government of Sri Lanka; Chair person of National Science Foundation, SRI LANKA

Opening Remarks

The chair opened the session by thanking the participants and expressing his hope for a fruitful discussion. In Europe, the knowledge triangle tends to focus on university settings and evidence shows that science delivers from its investments. For the balance of different types of science, the question of scientific funding is coming into the center. Fundamental science must be funded by the government, but at this time of austerity, the government tends to interfere more and more. There is an increasing recognition that governments need to take scientific advice more seriously. Science and government have different perspectives, and scientific advice will only ever be one part of the equation from the government perspective. The veracity of scientific findings is being questioned more than ever before as various articles and surveys have come under fire due to false or inaccurate information. The chair concluded the funding of science needs to be reevaluated and scientists have to step up to this task and work with the governments to provide advice more effectively and change the culture of science.

Chair: Boyle, Paul

The first speaker stated that human beings have been able to apply science to build an affluent society. However, nationalist aspirations and greed have exploited science and brought about negative effects. Given this background, it is imperative that we apply ourselves to achieving the 2030 UN Sustainable Development Goals. The key is science-based technology and applying a carefully laid out vision, and there must be a revolutionary paradigm shift that is rooted in the youth of the next generation. Our current leaders have little sense of the impending crisis and the current political and economic structures are insufficient to tackle the numerous future challenges. Furthermore, there must be greater connectivity between the citizens and the scientific community. The political failures of today will lead to the betrayal of the children of tomorrow. Although we have seen many innovations, they don't seriously address the question of sustainability.

Referencing their past experience, the second speaker first shared information on the German Hightech Forum, an advisory board of experts from scientists and society that aim to come up with high-tech solutions for the next decade in Germany. The speaker chaired a committee that concluded that the exchange of knowledge, services, and technology are vital to the development of environmental sustainability. The committee worked on instruments that governments can use to conduct these transfers. Governments should fund and support long and large term programs and centers and should support small and free market companies and entrepreneurship. An important vision is to strengthen public appreciation of collaborative research between different sectors. To overcome public skepticism, these collaborations should be as transparent as possible.

The third speaker shared some cases from Thailand where science had bridged the gap with society. The speaker found that demand-driven research tends to obtain more funding. For budgeting, his university focused on an agenda based budget and found it was an easier way to get funding. The speaker then brought up university linkages, which have faced difficulties. The Talent Mobility program seeks to connect the private sector with the public

universities. So far 250 people have gone from universities to the private sectors and the program has allowed students further access to private facilities. Drought and floods have been a major problem for Thailand, and efforts have been made for villages to use scientific instruments to better deal with this phenomenon.

Discussing the efforts to bridge science and technology in Sri Lanka, the fourth speaker noted that Science and Technology for Scoiety Forum has been established to close the gap. Mr. Omi attended the Forum and was an inspiration to all the participants. Sri Lanka needs to further implement measures to improve policy making and turn scientific findings into reality. The Science and Technology for Scoiety Forum in Sri Lanka was innovative in that it addressed the role social media can play in closing the gap between science and technology. Sri Lanka is doing its part to reach the millennial development goals and is calling upon all parties, policy makers and scientists alike, to achieve sustainable national development.

The fifth speaker talked about his insight on the topic based on his academic and political experience. Most policy makers and scientists recognize the role of science in bridging the gap between science and society/policy. Though science should be independent and impartial from the policy, it is important to mobilize scientific voice to political purpose. Evidence-based policy making should be emphasized in this manner as it was recommended in the G7 conference and TICAD VI as "scientific advice." Science plays a key role as a crosscutting instrument

to achieve goals given by the 2030 Agenda for Sustainable Development. Scientific knowledge combined with the "big picture" becomes useful wisdom for policy makers, and this is why the networking among scientists and policymakers is essential.

The sixth speaker continued the discussion on policy, noting that his organization, acatech, has an expert's panel that consists of internal expert groups and experts from outside the academy. They present various evidence and discuss and dispute various issues in order to provide scientific advice to the government. No policy maker can ignore the increasingly complex scientific questions and their decisions can have far and sometimes unexpected consequences. It is commonly assumed that politics is about power and science is about truth, which is a misconception. They are two different forms of rationality based on values, as there is no such thing as value-free science since there are many ways to frame a question. To address these many challenges, acatech is attempting to create solution-based advice that provides many options in front of the policy makers.

The seventh speaker began by expressing his pleasure with the recent TICAD conference and the good scientific advice the African countries received from Japan. The knowledge triangle raises questions about the roles the different players have, which is especially relevant to developing countries. His company, Eskom SOC Holdings recognizes the importance of private and public entities and there is a move toward reducing the carbon footprint, and looking at renewable energies. Eskom SOC Holdings is also investing in the youth. The chasm between science and society is still too wide, preventing further actions on climate change, etc. and scientists need to do a better job in transmitting their findings to the public.

Discussing the process by which science helps society thrive, the eighth speaker talked about "Innovention" as the key word to the process, as science has evolved and played an important role in recent human history. We have never been safer or more prosperous as a species. Science and technology cannot be systemized, but you can put yourself and society on the path by building bridges. Today, science, society, and politics cannot be seen as separate and must be the backbone of progress. Technology in the future will mix seamlessly with culture and sports as demonstrated by the developments for the upcoming 2020 Tokyo Olympics. The young must grasp that science affects us all. In the UAE, science and youth education are the keys to ensuring the country has a bright future. To build these bridges the right questions must be asked, the right structures must be built, and the youth empowered.

Discussion

The first representative stated politicians could provide further assistance in data sharing. In developing countries, there is often a lack of data, and they need political help to get this open. International sharing will assist in this endeavor as well. There is a low presence of people with scientific backgrounds in government and scientists to participate in politics more proactively. Finally, the various ministers of finance should be invited to STS *forum*.

The second group's reporter explained that public data, not just big data, is more important now than ever before. This presents opportunities for science but is going to require more accountability and transparency from the government and the science community. Challenges with the media need to be addressed as scientific literacy is decreasing, and further scientific literacy should be encouraged in the political arena as well.

The third group's discussant said that there is an unnoticed role of scientific advisors present in several countries, which is to directly collect voices from the citizens. The need for women's greater involvement in the scientific community was also highlighted. Additionally, there is difficulty in striking a balance when carrying out research activities while taking various factors into account, which can happen in cases where the influence of donors decides the topic.

The fourth reporter said that the intermediation of scientific results to reach the public and private sector is important. We are living in the golden age of television and documentaries, and there are many opportunities there. The private sector will always fund science that it finds useful, but there are parts that are undiscovered due to lack of interest by the private sector that require further inquiry.

The fifth representative stated the timeframe of "science for politics" is challenging as it often comes too late. Thus, scientists need to be more proactive. Scientists need to be patient and not get frustrated when their advice is sometimes ignored. Finally, further SSH funding is an important factor to consider. With this statement, the session was brought to a close.

Concurrent Session 104: [ICT] Big Data

[Session Chair]

Kitano, Hiroaki, President & CEO, Sony Computer Science Laboratories, Inc., JAPAN

[Speakers]

Anderson, Warwick, Secretary-General, International Human Frontier Science Program Organization (HFSPO), FRANCE

Kaiserswerth, Matthias, Managing Director, Hasler Stiftung, SWITZERLAND

Markl, Volker, Full Professor and Chair, Database Systems and Information Management (DIMA) group, Technische Universität Berlin (TU Berlin) and Head of the Research Group Intelligent Analytics for Massive Data, German Research Center for Artificial Intelligence (DFKI), GERMANY

Tsukamoto, Yoshie, President and CEO, NTTCom Online Marketing Solutions Corporation, JAPAN

Waller, Donovan, Group Head of Technology Development, Group Technology Development, Anglo American plc, U.K.

Chair: Kitano, Hiroaki

Opening Remarks

The chair opened the session by stating that big data on its own is not useful, and that the challenge going forward will be how to acquire, handle, and utilize it. It is fascinating to look at the progress of big data and see how far we have come, and also to look to the future in which we will see AI using massive amounts of data. The chair raised several groundbreaking big data case studies including Google's DeepMind and IBM Watson that are changing the way we think and function. However, there are many privacy issues associated with big data, including how industry, governments, and academia handle and utilize data.

The first speaker said that there is currently a second wave of transformation that is changing society, business, and the world as a whole. This is being driven by huge amounts

of data being collected and the algorithms that bring all of the data together to be useful. In order to structure the challenges of big data, there are five dimensions of technology, legal, business, societal, and application issues, and we should look at the skills that are required to deal with each dimension.

The speaker also spoke about how big data can not only bring about disruption, but also create sustaining features that help improve existing business models. Standards are also an important topic related to big data, as well as data access issues and how data is traded. He then spoke about the issue of skills, focusing on data scientists. We must use technology to make the tasks of data scientists easier and allow them to use data to derive insight. He concluded with the statement that data is a critical resource for our modern society, and can be thought of as the new oil.

Noting its innovative nature, the second speaker said that big data will transform the biggest industries in the world, especially healthcare. For a little over $1,000, we can sequence the human genome and harness this knowledge to combat genetic illnesses. However, there is also the issue of our environment's impact on our health. There is a huge opportunity for big data to address the complex interplay between genetic health aspects and our environment.

The speaker stated that healthcare is an incredibly data-rich and data-diverse area, and touched upon leveraging big data as healthcare costs balloon all over the world. There is no single answer on how to do this as all countries have unique issues. Data collected from the most mundane aspects of citizens' daily lives, such as purchases at supermarkets, can help governments make informed decisions about healthcare.

He then identified the endpoint challenges of using data in a smarter way in health, including the issue of privacy which is perhaps even more important than we currently perceive it to be. Many countries have strict privacy laws that will make it difficult to collect data for interpretation. Those who use big data need the trust of the public as they work with governments to deal with these laws, but unfortunately there have been recent incidents that have shaken the public's trust.

The speaker's final point was on use of big data within the healthcare industry. Primary data will still be gained by medical professionals, who tend to be conservative, which can be a good thing when dealing with many issues. However, to get the benefits from big data, the tension between clinical trials and the fluid AI approach must be reconciled.

The third speaker opened his remarks by saying that big data is the big new buzzword, and the term encompasses issues of volume, speedy processing in real-time, and the great variety of data. The fourth aspect was the veracity of big data – whether we can truly trust it. With big data, algorithms that are given bad data will make bad decisions, and we must look at who is responsible for such bad data and bad decisions.

The third speaker agreed with the first speaker's assertion that data is the new oil, and pointed out that the biggest companies are now IT companies that deal with huge amounts of data. Thus, legal organizations and related players must start working on the diverse issues related to data. One approach would be looking at data as a physical good. However, data has unique features, including the fact that unlike physical goods like cars that can be returned, data can be copied and then returned. This naturally leads to a discussion of ethics, and the second speaker said that companies need to establish ethics boards that look at how their data is used. He also noted that big data tends to be owned by wherever it is stored, and this limits its study by third parties.

From the perspective of an industry veteran, the fourth speaker said she would discuss the business side of big data as the president and CEO of a technology company that deals with data-driven marketing solutions. She noted that relatively primitive usage of data analysis is currently being utilized in many businesses, and companies are timid in undertaking more advanced applications.

Nevertheless, even the most primitive usage lead to big benefits. One example lies in Japan's karaoke businesses, which previously tended to use physical plastic cards to track customers. NTTCom Online Marketing Solutions Corporation advised one karaoke company to create computer profiles of karaoke booth users, and the company discovered that though it thought its biggest customers were businessmen, they were in fact students. The company ended up earning millions of dollars in profit by changing its business strategies to target students.

She then spoke about disruptive innovation, stressing that companies must work on services and business models that incessantly collect meaningful data with the more-than-willing participation of customers. An example of a company that has achieved this feat is Uber, which provides an excellent taxi service for which users happily give up huge amounts of personal data, including their GPS locations and movements. Uber uses this information to identify customer clusters and sends taxis to the crowded areas within five minutes,

and such uses of data in turn make its customers even happier. The speaker concluded by encouraging discussion on the business uses of big data.

The fifth speaker said he would focus on user benefits of big data and AI. AI enables the ability to separate in time and space decisions on current and future data sets. Skills in one generation or location can be applied to the next generation or another area. In essence, AI has allowed for more consistent operational performance and eliminating problems caused by skill gaps, and allows us to set new benchmarks for performance. He then related this to the mining industry. Mines have long histories, and AI allows all-encompassing looks at past use to create better operations plans for the present.

Discussion

The first reporter said his group spoke about challenging monopolies of big data, if we are collecting too much data, how to speed up data analysis and use it in real time, and who is creating and enforcing standards. There is a difficulty in building skillsets and costs are rising for educating data scientists. Finally, the group spoke about the quality of data and the signal to noise ratio. He summarized the discussions by saying that we are still in the early days of big data and there are currently more questions than answers.

The second group's discussant stated that big data is excellent for areas such as marketing and helping the environment, but his group concluded that research must be done to increase the efficacy of big data to predict problems such as natural disasters and financial crises. There is also the issue of achieving group and community consent in terms of collecting data, as we often only look at consent on an individual level.

The third group's discussant said he would start by describing the negative topics of the discussion, including big data's destruction of anonymity, issues with neutrality of data, business risks, and how to protect data. Positive aspects included work on a cure for cancer and efficiency improvement. Challenges include the veracity and authentication of data, cybercrime and international cyber warfare by nation states, and data forensics as a big future business.

The fourth representative stated that his group looked at input and output analysis of data, especially for how this relates to the central goal of businesses of bringing in profit. His group also looked at benefits of high cloud computing power that are hampered by time lags, as well as developing algorithms.

The fifth reporter said that one long discussion focused on ownership of data, a core issue which in fact has existed long before the existence of the concept of big data. Data has traditionally been controlled by players such as banks and doctors, but now is available to many others. The group agreed that there should be clear legislation to cover the diverse aspects of ownership.

The group also spoke about the most disruptive innovations, with a look at what innovation truly means. One example concerned the use of cars, as the car industry would be transformed if people preferred having a pool of communal cars over owning personal cars.

The final discussant said that his group spoke about data collection from various sources and how to utilize that data. The group also discussed new business models, especially Uber. The mood turned pessimistic during talk about AI and whether it is truly a good idea to give so much data to IT systems.

The chair summarized the session as having touched upon data management issues, saying a legal framework should be created to manage this. His second point was about disruptive innovation and Uber, a service which would not be possible without big data, again emerged

as the discussion focal point. Uber is now looking into autonomous driving, representing its move beyond crowdsourcing of labor. The company is also going into food delivery in Japan, a very different business model from what it does in other countries that will entail new uses of big data and AI. The chair also spoke about the use of AI for labor, especially in countries like Japan which are experiencing population decline.

The chair concluded the session by pointing out that all the themes he had mentioned have been repeated many times at most conferences concerning big data. He said that although most people are quite good at pointing out problems, he hoped to reach a stage that would include actual disruption in relation to these issues.

Concurrent Session 104: [Cities] Smart Cities

[Session Chair]

Komiyama, Hiroshi, Chairman of the Institute, Mitsubishi Research Institute, Inc., JAPAN

[Speakers]

Dahlman-Wright, Karin, Vice-Chancellor, Karolinska Institutet, SWEDEN

Kaneko, Kiyotaka, Senior Manager, Business Development & Company Promotion Center, General Engineering Dept., Infrastructure Systems & Solutions Company, Toshiba Co., JAPAN

Kohno, Michinaga, President and Chief Executive Officer, Michi Creative City Designers Inc., JAPAN

Poitras, Claire, Director, Urbanization Culture Society, National Institute of Scientific Research, CANADA

Quinton, Patrick, President, Civic Innovation NW, LLC, U.S.A.

Opening Remarks

Chair: Komiyama, Hiroshi

The chair opened the session by welcoming everyone to the Concurrent Session on Smart Cities and giving a brief background of the history of the session, as well as explaining the structure of discussions. He concluded his remarks by noting that there was a huge increase in average life expectancy globally due to advances in science and technologies, which was a fact intrinsically tied to the current and future of cities and communities globally.

The first speaker began by noting that Portland, Oregon was considered by many to be a successful smart city model. Approximately 40 years ago, Portland changed the way development occurs in the city, their approach to public transportation, while adopting a new climate action plan and strict rebuilding process with highly environmentally sound approaches, and additionally making significant investments in infrastructure. Portland currently has one of the fastest growing metro communities in the world, as well as very low carbon emissions compared to the national average, which is an example of what happens when you have the right policy

implemented over many decades. However, there are challenges and hurdles that remain, such as growing inequality, susceptibility to natural disasters such as earthquakes, which must be addressed going forward.

Switching focus to a European city, the second speaker began by explaining the background behind the New Energy and Industrial Technology Development Organization (NEDO) smart community development project held in Lyon, France. The four main tasks are construction of a positive energy building (PEB) that produces more energy than it consumes through the active introduction of renewable energy and storage batteries; the introduction of an electric vehicle (EV) management system and an EV car-sharing system that utilizes PV power generation; promotion of energy saving behavior among residents through "visualization" of energy consumption in existing households (ConsoTab); and the development of a community management system (CMS) that compiles energy information collected in Tasks 1, 2, and 3 and provides indicators used by the entire community. The project started in 2012 and will conclude in 2017. While initial results are positive, there are issues which remain such as how to adapt smart city solutions to existing infrastructure in terms of efficient and productive operation for not only the municipality but citizens as well.

The third speaker began by stating that she would speak about smart city models from a social science perspective. Metropolitan areas are becoming increasingly important as centers of economy, society, arts, and community. But with growth in such areas come

challenges such as increasing social inequality, climate change and mitigation, complex travel patterns, and the need for more robust public infrastructure amongst others. Smart city models are well positioned to address such issues, as the model emphasizes efficiency, order, environmentally friendly practice, and competitiveness. The focus on technological solutions can address some of these issues, but there are social and cultural dimensions of the smart city model that need to be raised. They need to engage communities directly as the need to plan for diverse, social communities grows. We should be aware that different groups of experts need to work together and engage the skills of technologists, architects, social scientists, citizens, and others in order to make the smart city model a success.

The fourth speaker began by explaining that he would touch on the history of smart cities before discussing its future going forward. In 2007, smart city emerged as a buzz word, and at the time its definition was highly based on the application of ICT. However, there was some disappointment surrounding the idea, which resulted in the initial collapse of the model. However, the idea was slowly revived. While today ICT continues to be an important part of the conversation, the development of applications and solutions are now being made not just by industry, but by independent organizations and individuals. Several real world examples of this prove that the concept of smart cities is alive and well.

The fifth speaker began her presentation by explaining that the city of Stockholm was attempting to position itself as a center for big pharmaceutical companies, bio tech companies, and universities. However, they have transport problems and a lack of affordable housing, among other issues. The government of Stockholm is doing what it can to make the city more livable and competitive in terms of transportation, education, and housing. However it is clear that to achieve all of this, a unique smart city model must be developed to help them achieve their goals. Knowledge is also a crucial key for welfare and improvement of human health, so we must emphasize education to create free and equal societies.

Discussion

The first group's discussant said they spoke about the importance of user-friendliness, designing smart city solutions with a renewed focus on citizens, and open data solutions, such as those used in the Lyon project.

The second representative said they talked about decision making for the future and how many cities don't have a comprehensive view of changes to come, changing attitudes

regarding transport such as through car sharing, renewable energy and its cost effectiveness, green spaces in urban areas, and the positive effect of increased communication between experts and various cities/communities.

The third reporter said they spoke about the need to place the citizen at the forefront of smart city models, the need to include citizens in the strategic planning and development of sustainable development goals unique to their communities, preserving resources, and the ability to respond to different communities' needs.

The fourth group's reporter said they talked about the need for a good business model and what citizens want when discussing new smart city models. He noted that they talked about some smart solution demo projects which started strongly initially, but eventually lost momentum. He added that discussions were also had on open data, and the importance of sharing such information for the betterment of all.

The fifth discussant said they talked about the term, "smart city," and the need to rethink of a name that would better represent the comprehensive nature of the idea. He stated that discussions surrounded finding an appropriate name that would mean "a city for human security and well-being," such as Happy City, Quality City, Well-being City, Easy City, or Harmony City. Another discussant proposed Cool City.

The chair thanked all participants for joining and the session was concluded.

Day 2

Plenary Sessions 200, 202 (A-B), 204
Concurrent Sessions 201, 203

Plenary Session 200: Lights and Shadows of ICT

[Session Chair]

Fuchs, Alain, President, French National Centre for Scientific Research (CNRS), FRANCE

[Speakers]

Ishikawa, Masatoshi, Dean, Graduate School of Information Science and Technology, The University of Tokyo, JAPAN

Screven, Edward, Chief Corporate Architect, Oracle Corporation, U.S.A.

Higashi, Tetsuro, Corporate Director, Corporate Advisor, Tokyo Electron Limited, JAPAN

Holt, Jr., Rush D., CEO, American Association for the Advancement of Science (AAAS), U.S.A.

Opening Remarks

Chair: Fuchs, Alain

Prof. Alain Fuchs questioned whether the advancement of science and technology always benefited society. There are both opportunities and threats. For example, artificial intelligence technology has continued to develop, far exceeding humans in many capacities, such as mathematical calculations or the game of go. However, for example in the case of automated driving, such technology raises important ethical questions. To what extent should we trust machines and artificial intelligence? Additionally, the ICT revolution has enabled the provision of various genome-related services by IT companies. However, given the sensitivity of such information, this again raises ethical and security concerns.

Prof. Masatoshi Ishikawa presented some of the developments at the Graduate School of Information Science and Technology. For example, it has developed a robot capable of beating a human every time at the game of rock, paper, scissors. Such intelligent systems are already more capable than humans in many other regards as well. They have the potential to greatly change our lives for the better. However, they can also bring problems into our lives. If such technology is not accepted by society, regardless of the developers' intentions, it will fall from the lights into the shadows. ICT researchers must make a great effort to inform public. Moreover, education about ICT should be more widespread, not only for social acceptance, but also to foster future experts who will be able to manage the risks related to ICT.

Mr. Edward Screven explained the evolution of computing capabilities and power from programming mainframes to the Internet of Things (IoT). The fundamental nature of computing innovation has changed from simply enhancing computing capability, to enhancing a combination of computing capability and massive amounts of data. Important questions that this raises include who owns the data, in what ways can the data be used, and what can be achieved with such data. In general, the public does not realize the sensitivity of the data they make available to social media and what can be done with it. There is a truly huge potential of what such data can be used for and it is therefore invaluable to hold open public discussion about this. Another issue to consider is the dangers of machine learning based on data created by humans. If we are not careful, machines could learn from the inherent biases in such data.

Mr. Tetsuro Higashi spoke about the development of semiconductors and the implications for computing. Semiconductors have continued to grow smaller and more powerful, enabling the development of super computers. The main areas in which super computers affect society are artificial intelligence, virtual reality, and autonomous driving. Semiconductors have been the enablers of all such technologies. While such developments can greatly benefit societies, there are obviously also concerns. Artificial intelligence raises fears among workers that their jobs may be replaced. There are also cases of game-obsessed players getting into accidents while using virtual reality. Another example is how the failure of a driverless car could take the lives of its passengers. However, these are not the fault of the technology. It is up to humans to use or abuse technologies. The damage that can be caused by one hacker taking control of an automated car is damaging, but one can only imagine the damage that could be caused by such a coordinated attack by a group of terrorists. Software and hardware designers must collaborate to build fail-safe security systems.

Dr. Rush D. Holt, Jr. explained the goal of AAAS to ensure that science was harnessed to the benefit of society. All technologies come with ethical implications that need to be considered. This is not a new development. Rather, it is simply the case that technologies are more numerous and powerful than ever before. All engineers and scientists must consider

these implications for their technologies. Moreover, they should not do so themselves. They must not only communicate with each other, but also engage the broader public. They must help the public understand the science and technology to make the necessary ethical judgments for themselves. To do so, new and more effective communications methods are needed. Traditionally, scientists have focused on providing simplified descriptions of technologies, namely the "what," but they must also explain the implications, in other words, the "so what." Scientists should make more proactive efforts to foster such understanding, even before the establishment of regulations. In the same way that technological transfer is built into the research and development process, so too should societal debate.

Discussion

A question was raised by the member of the audience regarding how ICT had the capacity to connect the entire globe. What is the best way to govern this facet of ICT?

Mr. Screven agreed that while the scope of ICT was global, the way it was governed was fractured. However, he did not have any fundamental concerns. To some extent, the development of the Internet was achieved by ignoring such national boundaries. For example, the development of TCP/IP came about as part of the development of competing technologies around the world. Of course, ICT must be steered in an appropriate way, but there is also a tendency for some governments to overstep their bounds.

Dr. Holt believed that most governing bodies were ill-equipped to discuss such matters themselves. It is therefore necessary to hold public debate, together with scientists, to put these issues in a context that the public can understand.

There was a follow-up comment from the audience. While there may be issues that need to be addressed, there is no alternative governance system that is clearly superior to the current model. That said, we cannot neglect the fact that we have seen a rebellion of the public at large to what exists today.

Mr. Higashi commented that in the past, ICT technology was less advanced, less widely available to the public, and less commercialized. However, the advancements of technology since then require public debate and the development of governance codes. Furthermore, scientists must ensure safety and privacy associated with the use of such technologies.

Another comment was raised by a member of the audience regarding the U.N. Broadband Communication for Sustainable Development. The aim of the commission is to encourage technologists and governments to empower societies around the world through ICT.

Mr. Screven responded that the empowerment of people through ICT had allowed Oracle and other companies to become truly global. ICT has also allowed various nations, such as India or certain countries in Eastern Europe, to refashion themselves as IT-centric nations. It truly has the power to fundamentally change the lives of people around the world.

The next question from the audience concerned the ability of ICT to revolutionize domestic life, such as through distance learning or online banking.

Dr. Holt believed that it was a common desire of mankind for ICT to enhance people's quality of life and enhance, rather than reduce, human capability.

Mr. Higashi was sure that ICT would enhance the healthcare and other aspects of people's lives, not only in developed countries but also developing countries. There are also of course downsides, and if left unmanaged, they could potentially be more dangerous than nuclear weapons. That is why governance, education, and positive action are required.

Mr. Screven commented that one aspect that was often lacking from distance learning was the opportunity to learn in groups and interact with others. That said, distance learning also allows for the better tracking of learning progress and ability, which can facilitate the improvement of education systems and methods.

Prof. Ishikawa spoke about the importance of education on ICT and the value of globalizing education systems through ICT. Educating people about ICT can be very difficult given the rapid pace of technological advancement, which is why universities around the world should collaborate with each other, using ICT, to share the latest information and research.

A member of the audience commented that the key for data learning lay in the quality not the quantity of data.

Mr. Screven agreed that the exciting aspect of machine learning was that machines could do a far better job than humans in sifting through masses of data to identify useful information. There are in fact two quality issues that need to be addressed. At the lower level this is simply about distinguishing low quality versus high quality data. However, at a higher level, an issue that is much harder to tackle is to avoid treating conclusions drawn from machine learning systems as fundamentally authoritative, because, by learning from data produced by humans, they can in fact reinforce our existing biases.

Next a question was raised about the many ongoing dialogues regarding ethical concerns on ICT technology, such as autonomous weapon systems.

Dr. Holt noted that besides robotics and artificial intelligence, for most ICT and other technologies at large, while there may be much ongoing dialogue, most of it was ad hoc and not systematic.

Concurrent Session 201: [Energy and Environment] Nuclear Technology Prospects

[Session Chair]

Mason, Thomas, Laboratory Director, Oak Ridge National Laboratory (ORNL), U.S.A.

[Speakers]

Birkhofer, Markus, Senior Executive Vice President R&D and Innovation, R&D and Innovation, Areva, FRANCE

Fuji, Yosaku, Advisor to the President, The Kansai Electric Power Co., Inc., JAPAN

Oka, Yoshiaki, Chiarman, Japan Atomic Energy Commission (JAEC); Emeritus Professor, University of Tokyo, JAPAN

Pain, Reynald, Director, National Institute for Nuclear Physics and Particle Physics (IN2P3), CNRS, FRANCE

Rising, Agneta, Director General, World Nuclear Association, U.K.

Opening Remarks

The chair welcomed everyone to the concurrent session on Nuclear Technology prospects, highlighting that nuclear power generates approximately 10% of the world's energy and that about 60 new reactors are currently under construction around the world. He noted challenges, such as market structures being a headwind to utilize nuclear technology, certain jurisdictions limiting the use of nuclear technology (leading to rises in CO_2 production in those areas), and the implementation of cost effective waste management solutions that are safe and publicly acceptable. He discussed the possibility for international partnerships and gave the floor to the first speaker.

Chair: Mason, Thomas

The first speaker began by stating that nuclear technology was a critical component of the world's advance to clean energy, highlighting UN Global Sustainable Development Goals that support its use. She added that small countries had difficulty building nuclear power

plants, but noted examples such as Sweden that put 10 reactors online with a population of only 8 million and no prior experience with nuclear power systems.

Commenting on the Japanese government's announcement of its energy mix goals in the near future, the second speaker talked about efforts to restart power plants by implementing enhanced safety measures and the operational status of nuclear plants across Japan. He continued, stating that due to the effects of the Great East Japan Earthquake resulting in the decrease in energy production through the use of nuclear power, it was important to restart the plants, extend operation periods to 60 years and build new plants or replace old ones. He also touched upon the importance of maintaining and developing human resources in order to maintain the use of nuclear technology.

The third speaker pointed out the importance of preventive approaches to risk management and the influence of national culture on safety culture. He commented that safety improvement and economic benefit coexist in the USA after the TMI accident. This will be the direction of nuclear power utilization in Japan. Both nuclear energy and renewable energy contribute to the mitigation of the effects of global warming, however the characteristics of the energies are quite different. The policies and rules to be applied to the energies should be different from each other, even though the goal of reducing global warming is the same. It is necessary to learn lessons from the USA and Europe.

Highlighting challenges and conditions of energy progression, the fourth speaker mentioned four criteria that will be used to develop future nuclear power structures. One – safety: a new design optimum between fuel and reactor to handle more accident scenarios at the core level with reduced need for additional safety systems must be developed. Two – nuclear waste management requires further improvement to improve public acceptance. Three – there is a need for increased flexibility for future nuclear energy to maximize value in a decarbonized energy system and adapt to renewable production. Four – economics: in addition to competitive LCOE, future nuclear energy needs to be attractive for private financing. Today's nuclear systems require up to 30 years to recuperate initial investment.

The fifth speaker discussed current global energy mixes, the costs of maintaining existing nuclear plants, the need to study breakthrough technologies, the possibility of uranium recycling, the use of liquid fuels in thorium cycles, as well as opportunities for international collaboration and various needs in terms of the future energy supply.

Discussion

The first group's discussant commented on the economics and competitive situation for natural gas and nuclear energy; the learning curves associated with those technologies; sentiment and public attitudes often being mixed, including within the scientific community; safety concerns; as well as the use of nuclear batteries in relation to the dispersion of heavy metals used in other batteries.

The second representative spoke about international cooperation, fundamental rules that could serve the interest of the population while also supporting energy needs, pricing issues in certain countries, public acceptance of the use of nuclear energy, as well as the use of used cooling as a form of energy.

The third reporter summarized how to incentivize various players to promote the use of renewable and nuclear energy, dealing with human resource issues, the commercialization and other various approaches to R&D, and how nuclear energy could compete when public policy favors the dispatch of renewables. He also discussed language issues involving educating the public globally in order to promote the acceptance of nuclear technology, and touched upon the thorium cycle as well as the lack of information in terms of how China will implement its energy mix in the near future.

The fourth discussant questioned why nuclear power was needed, noting competition from CCS and renewables in the future, and added to the discussion on public acceptance, highlighting the influence of government policy. He discussed the importance of making waste management efficient, lowering waste production overall, the effect of the entry of renewables into the market, standards and licensing procedures regarding new designs of reactors, the importance of regulators being independent and credible, as well as the significance of international cooperation.

The fifth group's representative commented on the role of uranium- and thorium-based nuclear power; the issues of rising expenses and insurance for nuclear power; the peaceful use of nuclear technologies, such as its role in medicine; robust safety regulations; as well as the issue of education to sensitize the pubic. He also touched upon nuclear technologies and its effect on agriculture and food security. The chair then thanked everyone for their participation and concluded the session.

Concurrent Session 201: [Life Sciences] Infectious Diseases

[Session Chair]

Collins, Mary, Dean of Research, Okinawa Institute of Science and Technology Graduate University (OIST), JAPAN

[Speakers]

Kurane, Ichiro, Director-General, National Institute of Infectious Diseases (NIID), JAPAN

Sakuntabhai, Anavaj, Head of Unit, Functional Genetics of Infectious Diseases, Institut Pasteur, FRANCE

Wilson, Mary, Adjunct Professor of Global Health and Population, Department of Global Health and Population, Harvard University; Visiting Professor, Epidemiology and Biostatistics, School of Medicine, University of California San Francisco, U.S.A.

Yamada, Koichi, Director, Manager of T-705 Product Group, Deputy General Manager, Business Development Department, Toyama Chemical Co, LTD., JAPAN

Opening Remarks

Chair: Collins, Mary

The chair began the session by speaking about emerging infectious diseases, mentioning that the idea of the emergence of diseases from animals, such as pandemic influenza, are not new. Respiratory diseases, such as MERS and SARS, pose the challenge of being airborne. The Ebola virus requires close person-to-person contact to be transmitted. However, such contact is difficult to avoid in resource-poor countries and the transmittance chain is not trivial to break. With regard to Zika, no one expected the disease to have such pathogenesis. Control of the insect vectors provides an opportunity, but this requires collaboration between both epidemiologists and ecologists. Another challenge in the area of infectious diseases is the development of vaccines and the fact that it is not possible to predict where and when the next outbreak will occur. The issue of healthcare in resource-poor countries is another concern, which was highlighted by the Ebola outbreak. In addition, we must also consider the impact of international mobility on the spread of disease.

The first speaker discussed viral diseases. Most emerging infectious diseases are zoonotic viral diseases, primarily mosquito-borne diseases. It is probably impossible to eliminate them, but it is certainly possible to control them. Mosquito-borne diseases are one of the leading causes of death in many regions around the world. While most of these diseases occur in subtropical climates, a number of them also occur in temperate climates. In addition, while scientific studies and knowledge has accumulated on this subject, there is still much more we need to learn. Moreover, mosquito control is not subject to only scientific factors, but also social factors. Another challenge is that not all mosquito-borne diseases can be studied using animal models. Additionally, at least in the case of Japan, funding and educational resources in this field are limited. On the commercial side, sometimes vaccine developers are not interested in developing highly effective but highly localized vaccines. Additionally, at least in the case of Japan, funding and educational resources in this field are limited. Another concern is that climate change will surely also have an impact. In addition, diagnostic tools that can easily be used in resource-poor countries are needed. Finally it is important to continuously study each disease and how to tackle it, rather than constantly shifting funding and focus to the disease that has most recently come under the spotlight due to an outbreak.

Talking about the recent explosion of the Zika pandemic, the second speaker noted that this virus was previously believed to have limited health ramifications. 80% of infections are asymptomatic, which has allowed it to spread undetected. Zika is primarily spread by the Aedes aegypti mosquito, populations of which, through the enhanced international mobility of humans, has spread worldwide. Zika can also be spread sexually. In addition, asymptomatic pregnant women can spread the virus to their fetuses, while asymptomatic men can spread the disease sexually. There are therefore many complicated aspects to dealing with the virus. However, various animal studies are underway, as well as the development of various vaccines, including a DNA vaccine. Some important questions to consider are what factors have resulted in the current outbreak, what can be expected in Asia, what are the most important policy and research questions, who should decide who pays for the vaccine, and how other approaches, such as the control of the Aedes aegypti population, can be used.

The third speaker began his talk by explaining about Toyama Chemical's anti-viral drug for treating Ebola patients. The company teamed up with a French medical team to conduct clinical studies in Guinea. There are some lessons to be drawn from this experience. Firstly, even if a drug is not expected to completely cure a disease, each drug has a role to play and

represents a step towards the desired final outcome. In addition, regardless of how effective it was, the fact that a drug was available was important and needed to be communicated. If potentially infected patients did not know there was a drug available, they would remain in their own community and eventually die, making it almost impossible to follow the trail of infection, but if they heard a drug was available, they would come to treatment centers and help prevent the further spread of the disease. We must prepare for future pandemics. We do not know when or where, but it is certain that they will occur. It is necessary to build an international stockpile for better preparedness. Research and development activity in the area of vaccines and anti-viral drugs should also be encouraged.

Sharing the experience of Institut Pasteur, the fourth speaker noted that the institute has conducted studies of Chikungunya, Ebola, Zika, and Dengue. These studies raise a number of points that need to be discussed. First is the fact that people can be infected by tropical diseases in temperate climates. In addition, an important question is how to build up vaccines stockpiles to prepare for future outbreaks, given how long it can take to develop vaccines. Another question is who should take responsibility for mosquito control. In particular, there is a large gap between the three main players, namely public health authorities, industry, and academia, which needs to be bridged.

Discussion

The first group's discussant spoke about diagnostics and chronic effects. With regard to the former, there is a need for rapid diagnostics and effective means to deploy them in real time as well. Besides these diagnostics, there may be other deficiencies in the system, such

as access to healthcare institutions or trust in the health system. Rapid diagnostics cannot be left to pharmaceutical companies alone. To prepare for pandemics, public investment and research funds need to also be made available. However, there can be downsides. For example, the stockpiling of Tamiflu in the U.K., which was eventually not needed, created an image of waste. Understanding the mutations and changing pathogenicity of diseases are also important. For example, what has driven the change in the Zika virus that has resulted in the recent outbreak? Monitoring of infectious diseases, and the sharing of information regionally and globally to inform such work, are essential. As for chronic effects, there is often more funding and interest in acute disease effects. However, sustained funding for the study of the chronic effects of diseases is essential. In addition, it should be recognized that while the continued education of healthcare workers is important, they are just one part of the healthcare system, and the system as a whole should be considered when dealing with infectious diseases.

The second representative shared some points on infectious diseases. Diseases such as Zika and Chikungunya have existed and been known about for a long-time, but it was not until deaths started emerging that adequate attention was paid to them. Another issue is who should pay for vaccine development and research, and the issue of how public funding for such diseases can be much more attractive to governments when an actual outbreak occurs.

The third group's reporter spoke about the Zika virus. Rapid diagnosis is important, not only of humans but also the mosquitos that bear the disease. The Zika outbreak also demonstrates how rapidly science progresses when such an outbreak occurs, due to increased public awareness, the availability of funding in response, the leveraging of existing networks for collaboration, and the involvement of researchers from other related fields. The connection to climate change is also interesting to note, as it may lead to new infections in areas where they previously did not occur.

The fourth discussant explained the importance of drug and vaccine development. For drug development, the sharing of data (including negative data) is essential. In addition, it is necessary to build up a minimum stockpile of vaccines or anti-viral drugs in advance of a pandemic.

The fifth group's representative highlighted the importance of government-industry-academia partnership to treating infectious diseases. However, there are problems with such collaboration. For example, national regulations and research competition are major stumbling blocks to data sharing. This raises the question of whether international, as opposed to national regulation, is needed. Another point is the importance of conducting necessary research, regardless of the research metrics or impact factor. There is also a need for truly cooperative partnerships, not predatory partnerships, between countries. Another question is who should fund research on infectious diseases and vaccine development and also who should decide which areas to prioritize. It may also be worthwhile in future meetings for STS *forum* to hold a session on microbial resistance and neglected diseases.

The chair concluded the meeting with a few points. Systems, sharing and partnership are needed for addressing infectious disease. Leaders around the world should spearhead efforts to establish networks for working together on infectious diseases.

Concurrent Session 201: [Engineering and Innovation] New Manufacturing Technologies

[Session Chair]

Kikuchi, Noboru, President, Toyota Central R&D Labs., Inc. and Roger L. McCarthy Professor of Mechanical Engineering, College of Engineering, University of Michigan, JAPAN

[Speakers]

Horiba, Atsushi, Chairman, President & CEO, HORIBA, Ltd., JAPAN
Kramvis, Andreas C., Vice Chairman, Honeywell International Inc., U.S.A.
Nunes, Pedro de Sampaio, Head of the EUREKA Secretariat, EUREKA, BELGIUM
Pinto, B. Mario, President, Natural Sciences and Engineering Research Council of Canada (NSERC), CANADA
Scholtz, Ernst, Group R&D Strategy Manager, ABB, SWITZERLAND
Shen, Simon, President and CEO, New Kinpo Group, CHINESE TAIPEI

Chair: Kikuchi, Noboru

Opening Remarks

The chair opened the session by stating that primitive 3D printing was widely used under the name of rapid prototyping, but 3D printing has now gone far beyond this. The biggest change is in infrastructure changes, where we are shifting to an environment in which everything is interconnected, cloud-connected, and big data analysis has become possible. In addition social media technologies have expanded the geographical scope of group discussions, and virtual reality has enabled training to be conducted with remote offices around the globe. While there are many concerns raised about security, it is expected that this will become embedded in hardware as a standard feature integrated with software.

The first speaker discussed the challenges of management in an international business, and how to transfer skills from generation to generation in an environment which is increasingly automated and where newcomers to the industry no longer get the experience of producing items from scratch and learning to think from basics. He noted that there are also issues related to outsourcing parts production to vendors, as there is again the risk of losing the knowledge of production of those parts.

Discussing a new technological frontier, the second speaker talked about the explosion of cloud-connected sensors providing data and enabling analysis. He also spoke about bringing together design teams and plant process management, which were previously separate roles, to build an AI that can predict issues occurring in production based on all of the data generated. The expectations are that this will improve overall outcomes, but often changes in organization are required for expert-provided solutions to work at a global level. Perhaps sharing systems information with external experts to gain benefits of increased specialization will become a common practice. The speaker stated that taking advantage of new approaches would enable levels of productivity that were previously not possible to be achieved.

The third speaker described the approach of putting factory equipment online in all of his company's factories worldwide. He also spoke about the development of internal social media communications applications and how data gathered from large amounts of sensors could be used to predict failures. He then described how his company uses their own 3D printers to create parts for their products.

Discussing how new materials and new manufacturing technologies can be used to improve costs and deliver new functionalities, the fourth speaker stated that modified manufacturing processes can dramatically reduce time and energy requirements by using simulation to verify designs. This directly leads to reduced costs as well as reduced environmental impacts. He also spoke about how 3D printing, in addition to rapid prototyping, can be used for replacement parts. Finally, the speaker stated that his company sees great disruptive potential to uproot the existing value chain of centralized manufacturing and shipping.

The fifth speaker described the growth of EUREKA to its current size (representing 44 countries) and its activities in advanced manufacturing technologies. He noted that the world market is now dominated by ICT companies, each of which have far greater market capitalization than the major manufacturing companies. In two EUREKA Clusters, Advanced

Manufacturing Technologies and Metallurgy Europe, the major manufacturing companies are coming together to address common ICT challenges that need to be addressed to enable them to grow and match up to the competition coming from Silicon Valley. The speaker stated that some of the issues that must be raised include security, interoperability, and preventing monopolies so as to spur innovation.

As the head of a major funding agency during the past year, the sixth speaker noted that he responded to several requests for briefings with ministers and government officials on the so-called fourth industrial revolution, which is the confluence of digital, biological and physical worlds. He asked the participants to imagine a world with 100 trillion active sensors connected to one another, generating information that needs to be securely mined with analytics to be interpretable to humans. He gave the example of the area of precision agriculture and integrated autonomous vehicles that can adjust their operations based on a multitude of sensor inputs to increase crop yields. This rapid advance in technology raises the issue of how to identify the best programs to support with investment to create the greatest value and the highest number of groundbreaking firsts. He further stated that there have been many successes through this approach in achieving major firsts in both battery technology and quantum transportation. One key research challenge for the future is scalable methods for the production of materials such as graphene and their integration into devices. He also noted that there is a lot of work to be done in the area of human-cyber interface design as digital and AI technologies advance.

Discussion

The first group's discussant highlighted several issues, including how to pass on tacit knowledge from one generation to the next, how to use AI together with existing technologies, and the importance of the new central role of data and the related issues of data ownership and how to make data more understandable and usable for humans. There was also discussion of new manufacturing techniques that are coming forward in adjacent domains, and how to deal with the convergence of diverse technologies requiring a complex skillset.

The second reporter questioned when it makes sense to follow a certain technology path and the aspect of the appropriate timing to move toward new technology given the risks of rapid obsolescence. The increased complexity of the manufacturing landscape means that it is now important to understand the full value chain. The changes in control systems also mean that operators will need different skillsets, which has an impact on the types of training that should be provided.

The third group's representative noted that 3D printing has the potential to reinvent business models, but it is not yet at the level where it can replace a manufacturing line. Some critical aspects currently for 3D printing are speed of printing, formulation of materials, and high costs. Deployment of 3D printing will also require different skillsets and can potentially result in reduced overall labor resource needs.

The fourth discussant stated that 3D printing still has a lot of opportunity to be included in certain new processes and areas, such as embedded electronics or in printing the chemistry of batteries. There are issues about ownership and usage of 3D printers, with the current most common uses being in niche areas. There is great potential for 3D printing in space exploration, but one of the conclusions raised was that what we are really looking for is a replicator and not 3D printing.

The fifth group's reporter stated that 3D printing has the potential to trigger a shift in manufacturing locations to the point of use, which changes the way business is structured and has impacts on education policy. In some countries there is a trend toward closer links between education and the needs of companies in local areas. There was some discussion of whether education should tend be more applied and whether there is an opportunity for bridge companies or institutes that can transition students from a research background to a manufacturing environment.

The sixth representative stated that workers will move into new types of jobs, but great care must be taken to provide the right education and training to facilitate this shift. Professors should be given the opportunity to work in industry so that they can pass on that knowledge. There was agreement that students must be taught to be adaptable with critical thinking skills, and in societies where this is not such a natural trait, there is the issue of how to maintain the good qualities of that culture while developing critical thinking skills. Lifelong learning will be the best proactive strategy to ensure social and economic impact.

The chair concluded the session by commenting that he looked forward to continuing the discussion with everyone at the session next year.

Concurrent Session 201: [Earth Science] Water

[Session Chair]

Burkhardt-Holm, Patricia, Head of Man-Society-Environment Programme, Department of Environmental Sciences, University of Basel, SWITZERLAND

[Speakers]

Abraham, Philip, Senior Vice President & Global Head, Research & Innovation, Veolia, FRANCE

Arafat, Hassan, Professor, Chemical and Environmental Engineering Department, Masdar Institute of Science and Technology, U.A.E.

Ueda, Shinjiro, Project Leader / Representative Director, COI at Shinsyu University / Infrastructure Systems Company, Hitachi, Ltd., JAPAN

Yamamoto, Kazuo, Professor, Environmental Science Center, The University of Tokyo, JAPAN

Chair: Burkhardt-Holm, Patricia

Opening Remarks

The chair opened the session by welcoming the attendants and introducing the main topics for the session based around the sustainable development goals (SDG), including techniques for minimizing the impact of water usage.

She stated that among the sustainable development goals, SDG 6, clean water and sanitation, and SDG 14, life below water, were amongst the most important. These are often not connected in discussion, but these topics are strongly linked due to the continued rise in demand for water and earth materials faster than supply can sustain. More than half of accessible fresh water is used by mankind, driving up global prices.

The effects of global warming and poor water infrastructure further exacerbate problems, and the tackling of these issues lags behind global targets. Additionally, there are great differences between regions and countries in terms of resource availability, population growth, and demand, causing further difficulties in solving issues surrounding water.

SDG 14, life below water, calls upon participating nations to conserve and protect marine resources. Technologies can help achieve these goals, meaning that water quality and water quantity challenges can be tackled.

Challenges facing water quantity include water scarcity and are a big problem in arid and semi-arid areas. There are solutions like desalination, but they have drawbacks. New solutions are under development, such as carbon-based membranes.

Meanwhile, eutrophication is a major concern facing water quality and represents one of the leading causes of pollution in fresh waterways. Eutrophication can lead to an increase in algae blooms, which can produce toxins, harming and killing humans and animals. Eutrophication can also lead to hypoxia, affecting fisheries. Many mega cities are at risk due to their adjacency to contaminated coasts.

Microplastics and micropollutants also present a topic of contention for water quality. Microplastics are the intermediate products in plastic production, pellets added to cleansing and care products or the result of plastic debris fragmentation. They contribute to great garbage patches and are ingested by many organisms. As much as 80% of these plastics are distributed to the oceans via river. The Rhine River alone contributes 191 million microplastic particles to the North Sea per day, which amounts to 10 tons of plastic per year. Each of these particles can be ingested by organisms.

In her research group, microplastics from the Rhine are being studied to elucidate their sources and entry pathways. Especially the high proportion of more than 60% spherules in certain parts of the river is striking, and it is still open where these particles come from and what they were used for.

The first speaker started by emphasizing the importance of water, quoting the poet W. H. Auden, “Thousands have lived without love, but none have lived without water.”

The paradox of water is that it constitutes more than 70% of Earth’s surface, but less than 1% is usable by man. At any one time, half of the world’s hospital beds are occupied by patients with waterborne diseases. One third of the world’s population has no access to sanitation facilities. Water must be treated with respect.

Leakage is a big problem for the water network. In some countries, like the Netherlands, the leakage rate is only 3%, while in some areas of France, the rate is closer to 40%. It is possible to pinpoint leaks via technology, and Veolia is being proactive in using this technology.

For countries with agriculture as the primary industry, 30% of water usage goes to cultivation purposes. It has been found that there is no detrimental effects of salinity or toxicity by using recycled water for irrigation. If organic waste is treated and made into compost, we would be sequestering carbon and avoiding the usage of water in one technique. Additionally, using compost can improve water retention.

Industry needs to play a role in changing the way that water is used. Today technology makes zero liquid discharge possible, but there is a cost. Industry needs to be prepared to make zero discharge the new standard, otherwise water will continue to be used inefficiently.

Other problems include the introduction of pollutants like endocrine disruptors, which have an impact on human health. A cutting-edge technique involves using genetically modified tadpoles that can filter endocrine disruptors from water. Emerging technologies can help water quality.

Climate change is causing flood disasters. In the US, the number one disaster is flooding, causing an annual 2 billion dollars in insurance claims. In contrast, a flood control system using weather data was developed in Copenhagen, making it possible to manage water flows to avoid flooding situations that were previously commonplace. Citizens were integral for the formation and adoption of this system. Partnerships with insurers will be useful to help citizens come up with proactive solutions.

Of 3% of the world's manufactured plastics (representing 3-5 million tons), only 3% of that ends up as floating, or easily cleanable, plastic. The rest is too difficult and costly to clean by the time it makes it to the ocean. We must work "upstream" to prevent pollution before it happens by educating industry, government, and citizens. Once the true cost of water is established, then one can look at the mitigating steps with greater meaning and clarity.

Everything, including water, has a cost, but the cost of water is not as simple as the price that appears on a water bill. Treating water as a capacity of outputs and inputs is more appropriate when thinking of externalities. More must be done collaboratively by citizens, scientists, governments, and industry to make a difference in the true water costs.

Stating that one of the available tools to meet the gap between water supply and demand is desalination, the second speaker explained how the global desalination market has increased 15 fold in the last 20 years, most notably in the Middle East. The population growth in this region meant that groundwater supplies were no longer sufficient to meet demand.

This trend is not unique to the Middle East. The US is the 2nd largest desalinator in the world. The shift to seawater desalination is happening in places like California to combat long periods of drought.

Fossil fuel is the main power source in desalination. Renewables are yet to be utilized in desalination, and relying on desalination may not be sustainable. The environmental, social, and economic impacts must be taken into regard before blindly turning to this technology.

The environmental impacts of desalination are severe. Oil must be burned to extract minerals from water, greatly increasing the carbon footprint from this process. Once freshwater is extracted, the remainder of the salt is dumped back into ocean along with byproduct chemicals. This greatly affects marine life. In countries like the US and Australia, these environmental impacts have been the main drive behind the resistance to desalination adoption.

The economic impacts of desalination are also heavy. The costs can be prohibitive to people living in emerging countries, suggesting that the process could be affordable by a few. Only countries who can afford the infrastructure can take advantage of the technology, leading to a gap between countries with sufficient access to fossil fuel and those without such resources.

Government subsidization in arid regions has worsened certain social aspects of water consumption. The misguided perception of infinite water supply via desalination leads people to consume water at a much higher rate than other areas, even though these regions are considered water stressed.

Another social issue is national security. Centralized desalination systems mean that entire populations would be placed at risk if these plants are subject to damage.

Desalination is not going away anytime soon, so it is imperative to improve the systems. Desalination processes must be changed to rely on renewable resources instead of fossil fuels while simultaneously examining other ways of procuring safe, high quality water.

The third speaker stated that water is the most important resource for humans. Population increases, improving living standards, urbanization, and climate change have led to serious water scarcity around the world. Constructing safe water systems around the world is a daily challenge.

One important way to combat water scarcity is to desalinate seawater. Using a reverse osmosis desalination method became a trend in the 21st century due in part to lower energy consumption rates when compared with analogous techniques. Approximately 20 billion cubic meters of water are being produced annually using this method.

The Mega-ton Water System was originally made in Japan to make this process more efficient. Its goal is to produce 1 million tons of water a day with half the cost of conventional systems. The technology is projected to be complete and ready for international distribution after 2020.

For future desalination, the most important technology is the continued innovation of reverse osmosis membranes. Today's membranes are made from polymers that are not particularly stress, heat, or acid resistant, nor do they have high longevity. A new high performance membrane, perhaps made of carbon or graphene, which could overcome these weaknesses, is expected to be produced in the future.

There are cooperative efforts between Japanese industries and universities to research and develop novel membranes. These will create breakthrough changes for the next generation, while contributing to a sustainable water system for the world.

Stating that we are facing climate change challenges causing floods and droughts worldwide, the fourth speaker warned that these phenomena lead to areas of water scarcity, increasing worldwide suffering.

Urbanization, especially in the mega cities of Asia, are growing rapidly. This has led to the mismanagement of wastewater in developing countries, deteriorating the local environment. It's important to maintain a clean water environment to achieve global water sustainability.

In urbanized areas, we can't rely on natural purification cycles. Wastewater must be treated to keep the water environment clean. By keeping the environment clean, it is possible to use local water instead of relying on imports or expensive technology. In this way, the cheapest water possible can be consumed by the general population.

There are 3 R's in waste management: Reduce, Reuse, and Recycle. In water management, due to the fact that water has a cyclical nature on the globe, Reduce and Reuse are more focused on. A huge amount of reclaimed water is indirectly reused via rivers and lakes.

Proper treatment of wastewater means that there is enough available for the population while having enough for agricultural and industrial purposes.

In the Tokyo metropolitan area, there are many wastewater treatment plants, but they're called water reclamation plants. Dry weather causes rivers to flow through Tokyo, with more than 50% of this flow from treated wastewater. It is safe for a variety of reuse purposes. This is an example of the wise management of indirect water reuse.

There are two types of wastewater management systems: centralized and decentralized. Developed countries typically have centralized systems, but developing countries sometimes have improper management systems. A centralized system takes time and the initial cost is high, making it an unattractive option for developing countries. A decentralized system is recommended for a cost effective approach. However, decentralized systems possess challenges of their own. Operation and maintenance system complexity increases with decentralized system span.

If there was a system to simply monitor water conditions from Internet of Things (IoT) devices, such as smart phones, it would be easier to collect big data and create smarter data management. Novel, technology-assisted wastewater management techniques must be considered now.

Discussion

The first group's discussant stated that membrane technology is important for urban areas. Sewage water is an important water source, so furthering membrane technology will allow for further efficiency in processing it. Social systems must also be managed to bring water and water-related technology down to the lowest possible cost.

The second representative stated that the usage of fossil fuels for desalination in the Middle East is an important conversation for the SDGs. This topic has already invited discussions about what governments should aim for in real costs and goals. Another complication of desalination is the extraction of valuable minerals, reducing the cost-effectiveness of the process. Efficiency in both water and energy use are extremely important for the current turbulent situation.

The third group's reporter stated that as a species, the air and water are being polluted, thus polluting our food supply in turn. Water should be considered the natural successor to climate change as the next worldwide concern. There needs to be social innovation in hand with technological innovation to tackle these issues. This is a very complex problem, and the solution should be system-wide.

The fourth discussant stated that centralized and de-centralized systems both have trade-offs. Decentralized systems are quick to produce, but centralized systems are especially efficient in densely populated areas in the long run. There should be a balanced approach, such as starting decentralized systems while working toward centralized systems. Rainwater collection is another potential solution. There are places dependent on hydroelectricity, but with unpredictable droughts, this method becomes unstable to rely on. Pricing issues and treating water like a commodity mean that there are issues of fairness and access. There is a perception problem of reclaiming water, which can be solved through indirect systems.

The fifth group's representative stated that the importance of investment in technology and application in water management is important. Education and mass awareness are also important. Changing lifestyles that center on over-consuming water represents a true problem for solving global water issues. For solutions, there should be integrated strategies, including changing laws to motivate industry insiders to change their patterns of behavior while providing more education programs.

Concurrent Session 201: [Cooperation in Science & Technology] Science and Technology Diplomacy and International Collaboration

[Session Chair]

Yuthavong, Yongyuth, Senior Specialist, National Center for Genetic Engineering and Biotechnology, National Science and Technology Development Agency (NSTDA); The first President, National Science & Technology Development Agency (NSTDA), THAILAND

[Speakers]

Alessa, Abdulrazak Abduljaleel, Minister, Ministry of Higher Education, IRAQ

Colglazier, E. William, Editor-in-Chief of Science & Diplomacy and Senior Scholar, Center for Science Diplomacy, American Association for the Advancement of Science (AAAS), U.S.A.

Kajita, Takaaki, Special University Professor, Director, Institute for Cosmic Ray Research, The University of Tokyo, JAPAN [Nobel Laureate 2015]

Shoukri, Mamdouh, President and Vice-Chancellor, Office of the President, York University, CANADA

Yang, Henry T., Chancellor, Professor of Mechanical Engineering, University of California, Santa Barbara (UCSB), U.S.A.

Chair: Yuthavong, Yongyuth

Opening Remarks

The chair opened the session by stating that science and technology diplomacy (S&T diplomacy) is instrumental in furthering international collaboration. It can be a key way to tackle regional or global challenges, handle large-scale projects, and implement multi-lateral North-South collaboration. S&T diplomacy can also help the world meet the Sustainable Development Goals (SDGs) which were the outcome of COP21 in 2015.

In recent years, an open model for innovation has become increasingly more common, and the further pursuit of S&T diplomacy and international collaboration will continue

to support the creation of deeper links. It allows for increasingly diverse and large-scale projects across the world. For example, with medical studies, openness can allow access to data sets from all over the world, including gene pools and so on. Scientists are not diplomats by training, but they should be diplomats in spirit – expanding their network, forging connections, and never forgetting the moral and social dimensions of their work. Emphasizing collaboration between academia, industry, and government can help address global issues. The chair mentioned the UK Newton Fund and Japan-based Science and Technology Research Partnership for Sustainable Development (SATREPS) as two organizations promoting collaborative research targeting global issues.

The first speaker said that science and technology is a great asset for diplomacy. It creates opportunities for developed countries to create diplomatic links with developing countries, and for developing countries to partner with developed countries in joint scientific research and technology-sharing projects. To maintain close diplomatic ties, and establish new relationships, scientists have a duty to convince policy-makers to facilitate S&T diplomacy around the world into the future. Governments must build a more robust ecosystem for promoting S&T diplomacy on a global scale.

S&T diplomacy can also contribute to realizing the SDGs. There is a general consensus emerging that collaboration on a global scale is essential in this pursuit. The goals cannot be reached with each country working alone. It will be a long-term process – lasting until 2030 – which means that future-oriented diplomatic links must be established. In thinking from a long-term perspective, it is important to remember that science and technology expand the capability of young generations to meet and address future challenges, so education and mentorship must not be overlooked.

Commenting on several recent trends, the second speaker spoke on international collaboration in the field of physics.

First among these is that new research endeavors are more complex and demanding than they have been in the past. Therefore, collaboration must be more granular, and occur on various levels and on a multi-disciplinary basis, if current challenges are to be addressed. Second, due to the different cultural backgrounds of researchers involved in collaborative projects, a consensus-based approach must be taken, sensitive to these differences. However, involvement from diverse researchers will inevitably lead to benefits. Projects will be approached bearing in mind the strengths of both parties. Third, international collaboration

can allow smaller or less technologically advanced countries to participate and gain experience in large scale research projects. Finally, as many projects have expanded time frames and a larger scale, international collaboration-based projects can help to reduce burdens on single institutions or governments.

The third speaker discussed the role of universities in S&T diplomacy. One definition of S&T diplomacy is the interaction between nation states with a goal of advancing the frontiers of knowledge, as well as addressing the pressing issues facing the world, such as climate change and so on.

However, universities can also play an instrumental role in catalyzing S&T diplomacy, and indeed, they have in the past. For example, during the Cold War, when relations between Eastern and Western states were strained, universities continued their collaborative projects. They contribute to maintaining open lines of communication and facilitating information sharing, and also work on capacity building. York University has been involved in several capacity-building efforts, including one where facilities to train teachers in Kenyan refugee camps have been provided to support the development of young people in this unstable environment. Finally, the long-standing presence of universities on the world stage mean they have rich experience and knowledge to contribute to S&T diplomacy.

The fourth speaker opened with a quotation from Louis Pasteur: “Science knows no country, because knowledge belongs to humanity.” Indeed, S&T diplomacy building has played a key role in overall diplomatic development. Additionally, when it comes to earth, sky and sea, there are no boarders for science and, every university has a vision for furthering international collaboration in these various fields. Healthy competition helps to complement collaboration. Recruitment of talent also knows no boarders. To tackle global challenges, a global mind trust is key.

Japanese organizations are major partners for the University of California, Santa Barbara (UCSB) in furthering cutting-edge scientific and technological development. For example, a space telescope to observe the first moments of a star is being developed, and the project is sure to be a boon for the field. This example represents a valuable multi-disciplinary project exploring the endless frontiers of science.

Introducing recent developments in the field of education in Iraq, the fifth speaker explained that dozens of state universities have been established, and tens of thousands of students

are enrolled at all levels. Recently, an e-management system, an e-library, and open-source programs have created a flexible and responsive education system, including incubators and other contributors to open innovation. Initiatives to further S&T diplomacy are also underway, with an eye on creating powerful partnerships.

Discussion

The first discussant shared the content of their group's discussion. The first point was that we need to build an infrastructure for collaboration between academia and government in advance to make implementation easier. The second point was that there is a missing link in getting scientists and policy-makers to talk. The mutual and shared benefits must be made clear to both parties. The final point was that societies are using science to inform policy, so policy-making and social responsibility should be embedded in scientific training.

The second reporter shared the content of their group's discussion. They emphasized the importance of people-to-people relationships. By focusing on the human aspect, various barriers and borders can be overcome. Scientific education must involve ethical and policy training as well. The question of accountability must also be raised – governments must be accountable to people. Long-term commitment is also important, so the involvement of diverse collaborators is key.

The third representative shared the content of their group's discussion. They talked about the need to engage developing countries in scientific collaboration. A multi-discipline, multi-national approach is increasingly taken. For example, 60% of articles published in the journal Science were written by an authorial team from different countries. Also, there are too few funding opportunities for establishing joint projects with developing countries, so more funding opportunities, like ODA funds and scholarships, must be introduced.

The fourth discussant shared the content of their group's discussion. This group affirmed the importance of science and technology for diplomacy and were generally optimistic. The importance of person-person exchanges, and mechanisms to promote it, cannot be overstated. There was discussion of programs to give scientists from developing countries opportunities to study, work and research in developed countries. Sharing best practices and knowledge is key. One positive example from Kazakhstan was introduced, where students are given two advisors, one from a domestic institution, and one from abroad.

The fifth reporter shared the content of their group's discussion. They discussed the difference, but equal importance, of "science for diplomacy" and "diplomacy for science." Also, international collaboration is key in improving relations between countries. There were discussions about the constraints which can emerge from student and researcher visas, which can impede collaborative work. Therefore, the possibility of introducing new systems should be considered. Capacity building was also discussed.

The sixth representative shared the content of their group's discussion. Science diplomacy is absolutely necessary. Every country educates people differently, so people-people interactions must be undertaken to find common ground. Also, IP is important because it protects research. "Parallel diplomacy," which means finding common callings or goals despite differences in culture and ideas, should be a central concept.

The chair thanked all members for their active participation and brought the session to a close.

Concurrent Session 201: [Science, Technology and Society] Science and Engineering Education

[Session Chair]

Mazur, Eric, Area Dean of Applied Physics; Balkanski Professor of Physics, Harvard University; President Elect, The Optical Society, U.S.A.

[Speakers]

Bhumiratana, Sakarindr, President, King Mongkut's University of Technology Thonburi (KMUTT); President, Thai Academy of Science and Technology (TAST), THAILAND

Bourguignon, Jean-Pierre, President, European Research Council (ERC), European Commission, BELGIUM; Professeur honoraire, Institut des Hautes Études Scientifiques, FRANCE

Engl, Heinz W., Rector, Office of the Rectorate A, University of Vienna, AUSTRIA

Inaba, Kayo, Executive Vice-President, Gender Equality, International Affairs, and Public Relations, Kyoto University, JAPAN

Malcom, Shirley, Head, Directorate for Education and Human Resources Programs (HER), American Association for the Advancement of Science (AAAS), U.S.A.

Ponomarev, Alexey K., Vice President for Industry and Strategy, Skolkovo Institute of Science and Technology (Skoltech), RUSSIA

Chair: Mazur, Eric

Opening Remarks

The chair opened the session by reflecting that problems in society can be traced back to a lack of education. Scientists lay the foundation for future engineering advances and this interplay is vital for economic growth and increasing quality of life. However, society as a whole is not as engaged as it should be in science and engineering. Given what science and engineering have accomplished for society, this is problematic. Human beings are born as curious scientists with a desire to learn about the world around them, and education plays a large role in fostering this curiosity. However, since education tends to focus too much on abstract ideas rather than discovery, there is often a loss in this curiosity. Education is no longer about merely disseminating information, it is about collaboration and applying knowledge.

The first speaker raised the point that the training of scientists and the training of engineers are often separated, however, this gap is increasingly diminishing. The change of the role of technology in society and the rise of big data are some of the forces behind this decreasing gap. In addition, engineers need to know more biology, and both types of students are becoming more exposed to internships to learn how to mobilize knowledge and to learn about collaboration.

Detailing his experience at the University of Vienna, the second speaker noted the challenges of bridging science and engineering there. A major question to emerge recently is ways to increase the attraction and retention of students to the sciences. At a comprehensive university such as Vienna, bridges can be built between science and the social sciences and thus increase awareness. A more multidisciplinary approach needs to be taken in universities. Life sciences now require more mathematics and scientific computing requires basic analysis. The key to make science and engineering even more attractive is to adjust the way mathematics is treated in education.

The third speaker stated that an important issue to address is how to build collaboration with industries. The Skolkovo Institute of Science and Technology, a private research university in Russia, is trying to educate students to adapt to new markets and industries and has established collaboration with rapidly growing companies. The institute discovered that companies need customization and flexible employees who are well educated. The institute needs to teach not only content, but it needs to teach adaptability and flexibility using a wide range of tools such as internships. A problem universities are facing is how to keep the traditional faculty culture while balancing these new industry demands. The key message is that now is a time of rapid change, and we must find new methods to assemble a mix of educational cultures and tools to be aligned with the realities.

Raising the point that science and technology must support the SDGs, the fourth speaker discussed the incorporation of science and engineering education into basic education. In education, there is a need for greater emphasis on how to influence social impacts and a more multidisciplinary approach. There should be more attention to those who have not been recruited into science, especially women and minorities. Increasing the use of

new pedagogies and incorporating them into the teaching and learning process is another important step. A foundation must be built in basic education in order to improve tertiary education. This will be a challenge as teachers are not being prepared to teach in this manner. Bringing professionals in closer alignment with primary and secondary teachers can play a role in improving the situation. 57 million children are not enrolled in primary education, and most of them are girls, so this is an important issue to resolve for the SDGs. Providing a more hands-on experience for students that incorporates service should be something education aims for.

The fifth speaker delivered his talk from the perspective of a developing country and the challenges of education. Thailand is a country where the national innovation system remains rather weak, and they are trying to close these gaps. Thailand is also making efforts to achieve sustainable development, and thus, science and engineering education is of the utmost importance. The STI infrastructure must be improved, and further collaboration with rural communities must be achieved. There is a need to improve education in the rural areas and provide further opportunities for the youth in those areas. King Mongkut's University of Technology Thonburi in Thailand is focusing on improving teaching and pedagogy for the faculty and is developing further workshops and other methods to provide further training to its students. Students and the faculty must be given more chances to understand science and engineering in the context of society and industry.

Noting that Japan is facing many demographic problems, the sixth speaker said that in this situation, Japan must secure innovation in order to maintain international competitiveness. The advancement of woman will be a key component. At Kyoto University, the speaker is actively engaged in promoting the advancement of women in science and engineering fields. However, the ratio of female researchers in Japan is one of the lowest among the OECD countries. The government is currently aiming to increase the percentage of female researchers to 20% in science and 15% in engineering. Meanwhile, the ratio of female students is 27.1% for science and 14% in engineering. This is the result of a misconceived attitude that male students are superior to women in these fields. Women must have further confidence instilled in them in their early years of development that will allow them to overcome fears of failure or stigmatization in these fields, especially when they are in the junior high years. In the industrial sector, it is important to expand human resources that provide support to women.

Discussion

The first group's discussant stated that Society 5.0 and the rapid advancement of science are progressing. One question is about addressing the inequalities and gaps that have arisen as a result of this. The realization of joint cooperation between different disciplines is going to be key. Focusing on education and focusing on real life problems are essential. Improving inclusiveness of women in education will also be vital. There needs to be continuous training of educators, and the value of teachers needs to be raised.

The second reporter explained that there is a need for a personalized and customized mathematics education to take away the fear of mathematics. A problem-oriented approach is essential to garner further interest. Educating teachers is an important aspect to address. Teachers participating in research processes with universities will allow them to relearn how people learn. Male students also need to learn how to better include female students.

The third group's representative explained that the gender gap in the science and engineering fields is vital to solve. In some situations, the cost of education can be a deterrent to female participation in education. Parents must be reached to help close the gender gap due to their large influence. A more flexible education also needs to be set in place.

The fourth discussant stated one of the most important aspects of education is introducing the history of science so students can come to appreciate science. Another factor

for improving education is addressing education not just from a national level but on an international and intercultural level as well to encourage global thinking. Career role models and mentors can engage students from the beginning to inspire an interest in science. The knowledge triangle must be improved. The government can provide further incentives for students to gain internships and other real life experiences.

The fifth group's reporter said that the development of talented people is necessary. Talented people in countries such as Hong Kong often do not take up teaching positions due to a lack of jobs. The perception of academia as an ivory tower is another perception to overcome. Possible solutions could be practical projects such as hackathons, etc. Another option is mobility fellowships, which expose students to real life companies and entrepreneurship, promoting active (rather than passive) learning.

The sixth representative stated that large lecture style classes send the wrong message about interconnectivity and equality in education. A more personalized and flexible education is lacking and needs to be further implemented.

The seventh reporter explained that in Japan, mothers often play a large role in educating the children at home in the areas of math, engineering, and science. However, society is starting to slowly change.

The eighth discussant stated that modeling, big data, etc. need to be emphasized and developed more in universities. The different sectors often live in their own bubble and there should be inter-departmental cooperation.

Concurrent Session 201: [ICT] Security in ICT

[Session Chair]

Romine, Charles H., Director, Information Technology Laboratory, National Institute of Standards and Technology (NIST), U.S.A.

[Speakers]

Agbabian, Paul, Vice President, Fellow, Chief Technology Officer, Enterprise Security Division, Symantec Corporation, U.S.A.

Brandenburg, Karlheinz, Director, Fraunhofer Institute for Digital Media Technology IDMT, GERMANY

Brinksma, Ed, Rector, The University of Twente, NETHERLANDS

Budil, Kimberly S., Vice President for National Laboratories, Office of the National Laboratories, University of California, Office of the President, U.S.A.

Nielsen, Paul D., Director and CEO, Carnegie Mellon University's Software Engineering Institute, U.S.A.

Shinoda, Yoichi, Professor, School of Information Science, Security and Networks Area, Japan Advanced Institute of Science and Technology, JAPAN

Opening Remarks

The chair began by highlighting the extreme optimism that often accompanies discussion of the possibilities presented by technology and the extreme pessimism that tends to engulf ICT security discussions. He referenced Prime Minister Abe's Society 5.0 initiative as an example of this optimism and said his enthusiasm for progress in areas like robotics and AI was remarkable. Nevertheless, as is true for all new technology introductions throughout history, starting with the introduction of fire, we must recognize the downsides as well as the benefits. Ultimately, we should aim to find a reasonable middle ground while balancing benefits and risks through a management of risk approach.

Chair: Romine, Charles H.

The chair noted that the Information Technology Laboratory at NIST has rededicated its approach to building trust in ICT and innovation, which starts with managing risk by educating people and providing them with tools. Examples of this approach include NIST's guidance on cryptology, which can be difficult to use well and in a way that cannot be compromised. NIST also has an identity management program, which is vital for managing risk and information systems.

NIST has recently begun to focus on assessing risks to privacy, a topic which has seen a lag in the attention it is due. NIST employs psychologists, sociologists, and computer scientists in a team to study how people interact with technology, and to assess how to achieve security based on an understanding of human behavior. NIST also works on ensuring we do not enter an age in which government regulation stifles innovation.

The first speaker said he was interested in technology waves and the security issues that accompanied them. In the early days, computers were owned by companies and other organizations. Then came the era of personal computing, which opened up the problem of information leaks via physical access, such as through a floppy disk. We then reached the age of interconnectivity, and now unauthorized people can gain virtual access to information. Recently we have seen the wave of social networks and a host of new security aspects, with one defining characteristic being how much more personal the information online is now than in the past. This social network wave has also raised questions about drawing the line between data that is intended to be public and shared, and what should be kept private.

We have also seen the shift to the IoT and cyber-physical systems, with many devices being connected that are very difficult to keep secure. With cyber-physical systems, physical properties such as dams and other infrastructure are being controlled by systems, leaving them open to attacks that could cause damage on a very large scale. The next technology wave will encompass AI and autonomous systems, which will also lead to increases in impact and scale of attacks. At the same time, this autonomy will allow us to better handle the sheer volume of threats and recognize patterns of similar attacks.

These technology waves have changed our lives in a positive way. Interconnectivity is bringing people closer together than ever before, and also opening up new connections to education. In addition, global access has enabled increased access to markets throughout the world. However, we are at the point in which technology advances are outpacing our policies and practices, and we do not know how to react. We must create common rules

and laws to handle security issues, and learn to prioritize what is most important and focus especially on protecting it.

Beginning by stating that he wanted to speak about technology and its human users, who are often termed the "weak link," the second speaker introduced social research conducted by students, who were able to pose as Microsoft specialists and lie their way into obtaining personal information of computer scientists as part of the research. The speaker also spoke about research conducted by the University of Twente with Twitter on metadata to see if accounts had been hacked.

The speaker also spoke about failures of Holland's flood prevention system, which has led to the development of software to assess the state of flood barriers. Although the system was developed in order to avoid human failure and oversight, human guidance is still vital to deal with real life situations. This is especially true for system failures, and humans need to have the ability to override systems.

Moving forward with his discussion of the unique abilities of humans, the speaker talked about machine learning and facial recognition. Although the technology can recognize the faces of CEOs, it cannot recognize CEOs who have the additional factor of being successful. By contrast, humans are able to look at face images and recognize successful CEOs. With this example in mind, Prof. Brinksma called for integrated research that combines technology and the interaction of humans for compensating for system failures. He also made the point that social scientists should be tech-savvy, and said the new generation of social scientists and engineers should be exposed to project-based learning during their education.

The third speaker explained the new direction of measures for information and cybersecurity. There has been a large amount of investment in this area in recent years, but despite this, the threat level is rising and security breaches are happening more frequently, are larger in scale, and are closer to us. The Microsoft Security Intelligence Report shows the rate of compromised computers around the world on a color scale. If you place these graphics from over the years side by side, it clearly shows that the situation is getting worse – we cannot even maintain the status quo, much less make it better.

Thus, we must explore measures by understanding the structure of the cyber threat environment. We should look at markets for people who commit cybercrime, where information on attack trends can be found and toolkits can be purchased that make it easy to commit

attacks. We must look at the entire picture of our adversaries' raison d' être and what is going on in their world.

The next aspect to examine is how governments react in cyberspace. They often act in risky ways, since they do not truly understand the risks involved. Unfortunately, there is usually no direct economic motivation to prepare for cyber threats, and we need funding that recognizes their significance. In addition, there should be a global consensus on rule building for cyberspace. The speaker concluded his comments by displaying a chart showing the structure of measures, strategies, and policies for cybersecurity.

Noting that her work had made it clear that there should be a flexible framework for approaching cybersecurity (especially in an academic environment), the fourth speaker stated that cybersecurity has become a great challenge at large, complex institutions like universities where students are constantly introducing a broad range of threat actors onto university networks. These problems are growing faster than the measures to handle them have innovated.

The basic approach to developing a system has to be both aware of risks and tiered. Security in these environments requires knowledge of the system in order to identify real risks and static in the background. The unique atmosphere of academic environments means that the notion of gathering data on network traffic is contentious, and thus assurance must be given to assuage fears regarding invasion of privacy and the academic spirit.

This leads to the necessity of a culture change related to how people behave around technology in order to promote and ensure security. Universities have seen the evolution of norms, and related people have accepted different restrictions when they are given a clear understanding of risks. Thus, open, flexible, and transparent policy frameworks are essential.

The fifth speaker stated that issues of technology and security have symmetry with "real life" issues. Physical crime has been committed for thousands of years, and we have developed best practices for dealing with it. This does not change when we look at the internet. However, there are problems unique to technology and security that must be addressed.

The first area is the fact that there is an underground economy for cyber criminals. Contrary to their portrayal in pop culture, not all hackers are sophisticated computer geniuses. In fact, amateurs can quickly acquire tools to hack systems through online markets. For every

Sony hack committed by experienced hackers, there is another hack by inexperienced people getting into email accounts by doing things like using brute force to get passwords. Just like con men in the real world, people online can use social engineering to fool others into giving up their information. For security specialists, IoT stands for Insecurity of Things. Vulnerabilities in code in devices can persist for a long time, in particular in items that unite the physical and cyber, such as medical implants in the body that affect health.

Toolkits used to carry out distributed denial-of-service attacks can be purchased through these dark markets on the internet, and targeted attacks can be used as hybrid warfare. Virtual methods are used to gain an understanding of and take out physical objects. For example, in western Ukraine, power grids were taken out through a combination of cyber intelligence (effectively, Trojan software used to find critical infrastructure), and then a telephone denial-of-service attack prevented people from communicating the problems.

The sixth speaker began by harkening back to the time when there was great debate about rules for setting and changing passwords. His other point was about early efforts to curb illegal media downloads. Since that era, one topic that has been overlooked is strengthening authentication – not just identifying yourself, but also seeing if media has been manipulated.

The speaker then posed a number of intriguing questions that he hoped would stimulate discussion. Regarding economic drivers to push attention to security, he asked how to frame them so organizations will incorporate security risk management at the same level they do for financial risk management and reputation risk management. He also asked how we can encourage an understanding of human behavior through engagement with social sciences, and how to achieve security by making it easy for people to do the right thing and difficult to do the wrong thing. There is also the question of culture change, and how we can ensure the decisions we make on security are based on sound science. His final question was about how we can secure AI when we do not truly understand its operations.

Discussion

The first discussant said that his group's discussion started with securing password systems. Frequently, organization insiders are responsible for attacks, whether it is directly and on purpose or by accident. We must be cognizant of this. Many of the people pushing the envelope in IT stress that education and creating the right kind of culture are vital for

addressing this. This leads to the question of social engineering, and countermeasures such as simulated exercises, motivational factors, and when service should be denied.

The second reporter said that his group came to the conclusion that education is the easiest way to cross the chasm of cultural differences. On the economic side, there is a large economic driver for cybersecurity at the board level because there is much at stake for them. The group also discussed education and privacy agreements, as companies can completely deny service to customers if they do not agree to their conditions regarding privacy.

The third group's representative said that many systems are maintained in unsecure environments, and there was a discussion about enforced expiry dates of operating systems to adapt to security situations. Europe has the European Computer Driving License that ensures people have a basic understanding of computers and helps maintain a certain level of security. There are many international conventions that explore cyberattacks, but there is a lack of specialists and funding. Thus, there is much work to be done, including the creation of enforceable countermeasures to take on the current profitability of cybercrime.

The fourth discussant said that his group spoke about economic drivers and then quickly moved to social drivers. One participant said banks are investing huge amounts of money in security, but it is not clear if their focus is on just protecting themselves or their customers. Customers must be made aware of security issues that affect them. Although they recognize that the internet is not a safe place, their urge to be connected has led to security problems.

The fifth reporter said his group also combined discussion of social and economic drivers, and stressed that everyone in organizations must be aware of security risks, not just the people in the IT departments. It is difficult for experts to be open about risks because they can damage the reputation of a company. Insurance can be a motivating factor for promoting better security systems, but we need to be able to measure threats to organizations for this. There was also discussion on the "bring your own device" movement, in which people want the convenience of bringing their own devices to the workplace. The discussant finished by stating that carbon (humans) has the edge in some areas while silicon (computers) is best in others, and we must find a way to combine and optimize them.

The sixth representative said her group discussed banking and how it is difficult to calculate losses, with challenges including security of networking of customers and providers. There was also discussion of current events, and it was observed that people seem much more interested in security breaches at Wells Fargo over Yahoo. The final topic was social science. Humans might be the weakest link with problems such as social engineering, but they of course still have roles to play. We should find a way to build the human factor into systems with new technologies.

Plenary Session 202A: Population & Resources

[Session Chair]

Abdul Hamid, Zakri, Science Advisor to the Prime Minister of Malaysia, Office of the Science Advisor, Malaysian Government, MALAYSIA

[Speakers]

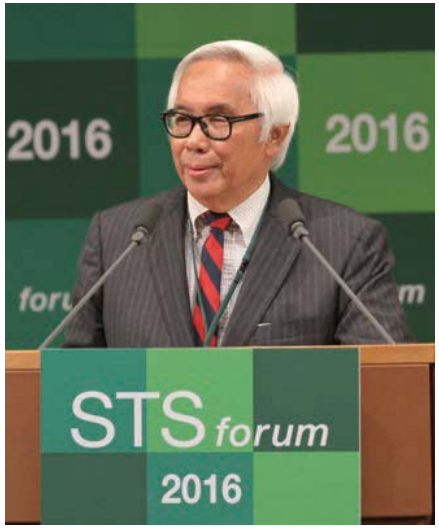
Arima, Akito, Chancellor, Musashi Academy of the Nezu Foundation, JAPAN

Baptiste, Philippe, Chief Technology Officer, R&D Division, Total S.A., FRANCE

Lim, Chuan Poh, Chairman, Agency for Science, Technology and Research (A*STAR), SINGAPORE

Sakaguchi, Masatoshi, Director; Executive Vice President, General Manager of Nuclear Power Division, Chubu Electric Power Co., Inc., JAPAN

Farhadi, Mohammad, Minister, Ministry of Science, Research and Technology, IRAN



Chair: Abdul Hamid, Zakri

Opening Remarks

Prof. Zakri Abdul Hamid opened the plenary session by noting his admiration for the excellent panel of speakers that were present. The Earth's exponentially growing population is causing an enormous amount of stress to the environment. This exponential population growth, coupled with climate change and excessive consumption threaten the sustainability of the Earth, as the law of diminishing returns dictates that a biomass can only sustain a limited number of a population. Problems such urban sprawl are increasing, as over 50 million people in the Asia-Pacific region alone are estimated to live in urban slums. We will have to work as a global community to solve these issues. Last year, the international community got together and accomplished steps for sustainability with the COP 21 Paris Conference. Future protection of the environment and the ways we can use our ingenuity and entrepreneurship to tackle various issues remain crucial questions to address. The chair then invited the speakers to make their opening remarks.

Dr. Akito Arima raised the point that in order to solve the climate problems and achieve sustainability, the education of the entire world would be of paramount importance. In particular, education must be spread to the developing world. In addition, the mechanisms of natural disasters must be further understood and it is vital that we develop technologies for disaster prevention. The true cause of global warming must be investigated and the emission of greenhouse gases must be curbed and alternative sources of energy developed. However, renewable energy in its current form has its limits and therefore, we must look for other sources of energy, such as nuclear energy. To guarantee safety, new and safer reactors will be necessary as will innovative and safer ways to dispose of nuclear waste.

Dr. Philippe Baptiste noted that COP 21 has deeply changed the public perception of energy related issues. The history of humankind is closely related to energy sources and energy is absolutely key for social and economic development. With the current mix of energy, this means large amounts of CO_2 will be emitted, creating a vicious cycle where climate change will worsen. We must research and prepare for the future of energy. We must develop renewable energy, improve energy efficiency and reduce the amount of CO_2 produced by human activities. Two key ingredients to achieve these goals are shifting from coal to gas and developing carbon capturing and storage techniques. Furthermore, long-term partnerships must be established between industry, government, and universities to create market incentives to curb climate change.

Mr. Chuan Poh Lim first noted that population growth, in addition to longer life expectancy, would place a burden on our limited amount of resources. Singapore is a country that has experience in dealing with a dense population with limited resources. Its rapidly aging population will put further pressure on its resources, in particular its healthcare system. The Government of Singapore decided that it will embrace technological development and innovation to solve this impending problem. It is hoped that companies will also join in this effort and bring technological advances to Singapore. Singapore has launched various initiatives to augment research on aging that will allow senior citizens to live healthier and more active lives. Robots are increasingly being deployed in Singapore for health monitoring of the elderly and for the facilitation of public services.

Mr. Masatoshi Sakaguchi first noted that Japan began its nuclear development in 1955 when the Atomic Energy Basic Law was enacted. Nuclear energy has a significant role to play as a power source in Japan. However, the 2011 disaster caused major setbacks for nuclear energy in Japan. The long-term shutdown of nuclear plants means that Japan relies on thermal energy for 90% of its power generation and it is causing a high spike in electricity charges. The Japanese government is aiming to lower greenhouse gas reduction targets and reduce the cost of electricity. It is therefore essential to maintain nuclear power plants with high standards of safety measures. Although over half of the population in Japan opposes the resumption of nuclear plant operations, nuclear energy will be essential to Japan's energy and environmental sustainability. We are committed to maintaining efforts to work on enhancing nuclear safety, while also developing human resources and handing over technologies to future generations for the continuous use of nuclear energy.

Dr. Mohammad Farhadi first noted that Iran was facing challenges with populations and resources. In particular, Iran is facing migrations problems and a brain drain that is causing economic and social difficulties. This creates unsustainable development, which will cause problems for the world. The countries where brain drains occur experience negative economic and human resource impacts.

Discussion

Prof. Abdul Hamid then opened the floor to discussion. The first audience member noted that the Sustainable Development Goals were at play with regard to population and sustainability. Although COP 21 listed a 1.5-degree temperature increase as the limitation-target by 2050, the current amount of CO_2 produced is putting us on a track to a 2.5-degree increase. This will affect the tropics and desert regions even further and will lead to fewer resources and more poverty. Therefore, the larger countries must be proactive in their efforts to curb greenhouse gases.

The next audience member noted that there was not enough emphasis on enabling factors to development. Two prominent enabling factors are education and the formation of human capital. In addition, markets should function properly and roadblocks to sustainability should be removed. SMEs can be a key element of development in this regard.

The next audience member asked about the migration issue and noted that there are negative and positive aspects of migration. Positive aspects include solving demographic issues and negative aspects include brain drains.

Dr. Arima noted that in order to solve the problem of integration, education is of the utmost important. Without education, there will be poverty, which will create further deficiencies in education. Support for UNESCO's activities for world education is important to solve this problem.

Dr. Baptiste stated that renewable energy is valuable and will play an important role in the future. At the same time, it cannot replace all of the current sources of energy and it will take time to fully implement it. We need to think of ways to further integrate renewable energy.

Mr. Lim noted science and technology were important solutions, but other tools were needed to supplement them. Societies on different levels of development have different challenges and thus a diverse number of solutions are necessary. For the brain drain problem, he noted that it was important for each country to create conducive environments that offered many opportunities to both retain and attract talent.

Mr. Sakaguchi stated that renewable energy is important in addition to nuclear energy.

Minister Farhadi noted that human resources are the most important resource for a nation. A global regime should be put in place to mitigate brain drain and regulate the flow of migration. He stated that all countries and especially the dispatcher and new host countries of scholars, should start to cooperate in this vital field. With this comment, the session was brought to a close.

Plenary Session 202B: Science and Technology in Business & Finance

[Session Chair]

Khosla, Pradeep K., Chancellor, University of California, San Diego (UCSD), U.S.A.

[Speakers]

Kobayashi, Yoshimitsu, Chairman, COCN; Chairman, Member of the Board, Mitsubishi Chemical Holdings Corp., Japan

Schütte, Georg B., State Secretary, Federal Ministry of Education and Research, GERMANY

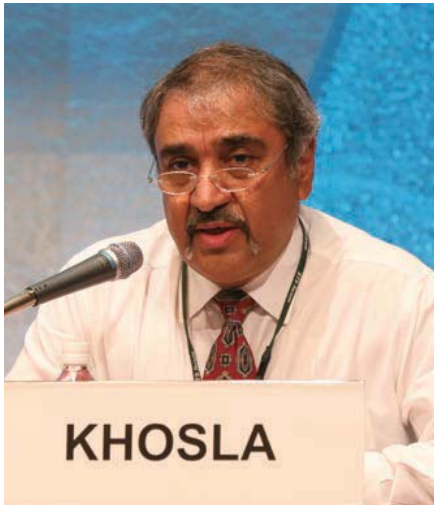
Noyer, Christian, Senior Advisor, International Technology Solutions, FRANCE

Tanizaki, Katsunori, Senior Managing Director, Member of the Board, IT Planning Dept., Data Management Dept., IT Innovation Dept., Operations Planning Dept., Operations Support Dept., Inter-Market Settlement Dept.; Senior Managing Director at SMBC, Sumitomo Mitsui Financial Group (SMFG), Sumitomo Mitsui Banking Corporation (SMBC), JAPAN

Zerhouni, Elias Adam, U.S. Science Envoy; President, Global R&D, R&D, Sanofi SA, U.S.A.

Williams, Keith E., President and Chief Executive Officer, UL LLC, U.S.A.

Opening Remarks



Chair: Khosla, Pradeep K.

Dr. Pradeep K. Khosla welcomed everyone to the plenary session on Science and Technology in Business & Finance, and provided a brief introduction for each of the speakers. He emphasized that technology has driven economic development all over the world, that globalization and innovation had to happen simultaneously for growth, and that it has been changing the nature of work and employment worldwide.

Dr. Yoshimitsu Kobayashi spoke about his experience in material science and how corporations could manage their investments in R&D. He highlighted the importance of management of earnings, technology, and sustainability in achieving positive results. He proposed aspiring to make meaningful contributions to sustainable development in the years to come.

Dr. Georg B. Schütte discussed the scaling up of green financing in order to achieve a sustainable financial system, the emergence of technology disruption across the financial sector which is opening up avenues for inclusion and connectivity, and touched upon crowdfunding, blockchains, and mobile payments.

He emphasized themes of decentralization, transparency, and effectiveness in the innovation of the financial sector, without the involvement of banks. He then highlighted risks and opportunities, such as the current lack of regulation among fintechs, and how governments could cushion the potentially painful outcomes in the event of a crisis. He concluded with the key question: How can the system in the future be innovative and yet sustainable?

Mr. Christian Noyer commented on the growth of fintech being around US$19 billion, and contemplated what the benefits and costs of fintech were. He noted speed and connectivity as benefits, and the potential for fraud and cybercrime as downsides. He questioned how we could effectively promote innovation while also maintaining financial stability and consumer protection, suggesting soft regulatory measures for fintechs and further international cooperation as the Internet had no borders.

Mr. Katsunori Tanizaki discussed the use of technology in the banking sector, concerns of security, as well as developments in artificial intelligence and deep learning that could disrupt business models.

Dr. Elias Adam Zerhouni spoke about the new innovation model in biomedical research which has gone from a centralized structure to a decentralized one with innovators in very specific technologies. This has therefore affected the financial models as well, leading to the importance of financial engineering.

He then focused on the new technological models in R&D, touching upon big data affecting the move from simple molecular models to structures that are quite complex. This can lead to the development of combination therapies, integrated data on drugs and devices, as well as monitoring individuals as opposed to statistical sampling of population health.

Mr. Keith E. Williams discussed the emergence of large corporations that had very little physical assets, the emergence of products as a result of this innovation that could bypass current regulations, as well as its impact on manufacturing.

Discussion

Dr. Khosla questioned the impact and disruptive potential of AI on the banking sector that could result in many of its functions being fully automated as well as its implications on policy.

Mr. Noyer emphasized that an efficient ecosystem would have a much larger effect on productivity that would allow for greater strides in innovation.

Mr. Tanizaki stated that ICT security was a constant issue and expressed concern of a collapse in the finance sector due to fintech. Dr. Zerhouni added that regulatory frameworks should be developed in order to mitigate risks that would otherwise develop.

Dr. Schütte commented on the issue of trust among banks, noting that blockchain would be the next big development among fintechs that would be able to guarantee trust. Dr. Khosla then thanked everyone for their participation and concluded the plenary session.

Concurrent Session 203: [Energy and Environment] Best Mix of Energy

[Session Chair]

Goldstein, William H., Laboratory Director, Lawrence Livermore National Laboratory (LLNL), U.S.A.

[Speakers]

Cashmore, Roger, Chairman, United Kingdom Atomic Energy Authority (UKAEA), U.K.

Kunitomi, Kazuhiko, Director General, HTGR Hydrogen and Heat Application Research Center, Japan Atomic Energy Agency (JAEA), JAPAN

Ozawa, Noriaki, Director-General, Energy and Environmental Policy, Agency for Natural Resources and Energy (ANRE), Ministry of Economy, Trade and Industry (METI), JAPAN

Zimmer, Markus, Economist, Ifo Center for Energy, Climate and Exhaustible Resources, Ifo Institute - Leibniz Institute at the University of Munich, GERMANY

Chair: Goldstein, William H.

Opening Remarks

The chair welcomed everyone to the concurrent session on the Best Mix of Energy, commenting on the Paris Agreement and the effect on the degree of the global consensus. He noted the importance of an effective energy mix needing to be secure, diverse, and interconnected. He provided examples of California's energy mix, noting it is scheduled to be nuclear free in the near future, and discussed various options such as the role of nuclear, hydrogen, or carbon capture storage.

The first speaker then discussed the effect of COP 21 being widely accepted, stated that aggressive action was needed for the immediate reduction of CO_2, and noted the effect of the transport sector on climate change. He added that energy consumption in the UK (a developed country) has remained fairly constant over the last 40 years (despite a ~20% increase in population) with an increase in transport being compensated by a decrease in use by industry due to outsourcing, and

that energy mixes will most likely vary from place to place due to geography, policy frameworks, and sentiment. He mentioned that Great Britain plans to implement roughly one third renewables (mainly wind), one third nuclear, and one third gas for its energy mix. He also stressed that the UK had essentially removed all use of coal despite sitting on massive resources of coal.

The second speaker questioned what the appropriate definition of "best" in the context of best energy mix would actually entail, and started with examining the economic perspective of reaching emission targets at the lowest cost. He emphasized that an energy mix also included not only electricity but also heat and traffic. He stressed that the ultimate goal should be the reduction of global carbon emissions, and that policymakers, by focusing on efficiency targets or renewable energy share in energy production, do not necessarily contribute to the aim of lowering global carbon emissions. He illustrated this problem with examples of national climate policies contradicting European wide multinational climate policies which resulted in low prices in the European Emission Trading System, the renaissance of coal combustion in German electricity production and carbon leakage. As a final point he emphasized the importance of extending the concept of evaluating the "best" in the context of energy mix to include amenity values, social and cultural aspects, acceptance issues and especially the often neglected redistribution and social equity considerations.

Commenting on the energy policy of the Japanese government, its focus on ensuring a stable energy supply, to improve economic efficiency, and to reduce CO_2 emissions, the third speaker highlighted that renewable energy is expected to be about 22-24 % of Japan's energy mix, and he placed importance on the diversity and balance of energy sources in order to achieve an optimum energy mix. He also stressed that international cooperation was critical to achieve global goals and solutions as no one country or region could achieve the goals alone.

The fourth speaker talked about using various clean energy sources to achieve emission reduction targets, and the use of HTGR, or high-temperature gas-cooled reactors, and the use of hydrogen. He emphasized that through the use of HTGR, Japan could reduce greenhouse gas emissions by about 30%. He emphasized that HTGR could have the largest impact in the non-electricity sector and urged its implementation in other regions.

Discussion

The first discussant summarized their group's discussion on the role of nuclear in their respective energy mixes being dependent on geographic location, intermittency and the adoption of renewables, the economics of renewables and the drivers of prices, the effectiveness on caps and trading, the role of carbon content in goods, the opportunity in the developing world to implement renewables, as well as the scalability of relevant technologies.

The second group's representative commented on the role of innovation in enabling different energy mixes, the potential shifting of problems to other sectors as opposed to solving the emissions problem, the futility of trying to come up with models for energy mixes that neglects public opinion, and the externalities associated with CO_2 emissions that are not calculated such as large transmission costs.

The third reporter discussed what could be done on the demand side of energy to reduce the carbon footprint, as well as the technicalities of using biomass.

The fourth group's discussant emphasized that the best energy mix could not be decided by policy, and talked about issues associated with gas and carbon capture storage, particularly investment. He mentioned that the technology for the implementation of nuclear power was available, and noted the practicality of hydrogen. He added that fuel cell vehicles were more

effective than electric vehicles, and concluded by stressing that the successful implementation of all available clean technologies was dependent on politics and economics.

The fifth representative spoke about the importance of public satisfaction in successfully implementing nuclear energy, and the trend of the increasing use of renewables. He noted that storage was a key challenge in the use of renewables, and added that fossil fuel power generation must be utilized alongside renewables. He mentioned that nuclear plants will most likely appear in regions where public opinion was not as strong.

The chair then thanked everyone for their participation, emphasized that not one person stated that the Paris Goals could not be obtained, expressed his hope for the future on the fulfilment of the Sustainable Development Goals, and concluded the session.

Concurrent Session 203: [Life Sciences] Healthy Aging

[Session Chair]

Kurokawa, Kiyoshi, Chairman, Health and Global Policy Institute; Adjunct Professor, National Graduate Institute for Policy Studies (GRIPS), JAPAN

[Speakers]

Akiyama, Hiroko, Professor, Institute of Gerontology, University of Tokyo, JAPAN
Andrews, William H., President & CEO, Sierra Sciences, LLC, U.S.A.
Duszyński, Jerzy, President, Polish Academy of Sciences (PAS), POLAND
Holt, Matthew, Co-Chairman, Health 2.0, U.S.A.
Jones, Allan, Chief Executive Officer, Allen Institute, U.S.A.
Oni, Tolu, Senior Lecturer, Division of Public Health Medicine, School of Public Health and Family Medicine, University of Cape Town, SOUTH AFRICA

Opening Remarks


Chair: Kurokawa, Kiyoshi

The chair began the session by explaining that life expectancy had almost doubled, from the 40s to the 80s, in the last 100 years. This is undoubtedly a positive and outstanding achievement. However, it also creates new challenges, such as the increasing number of people suffering from dementia or Alzheimer's. A number of countries have recognized the importance of tackling dementia. For example, the UK in 2013 hosted Dementia Summit at its G8 Summit, starting the World Dementia Council. In addition, statements were issued on the subject at the G7 Ise-Shima Summit and the G7 Health Ministers' Meeting in Kobe. Nevertheless, more efforts are needed, and leaders in government, academia, and business have a shared responsibility to address the issues associated with the aging of the world's population.

The first speaker raised three points. First, it is not enough to simply think about how to treat medical issues resulting from aging. Efforts for prevention and health promotion are

also needed. These must begin at younger generations. Second, for the first time in the world, there are more people living in urban areas than rural areas, and it is necessary to take into account issues associated with such demographic changes. Third, it is important to consider the question, "healthy for whom?" We cannot promote human health to the detriment of biodiversity, the environment, and so in addressing healthy aging, we need to be cognizant of, and aim for, equilibrium between a growing population living longer and planetary health (i.e. implications for the environment).

The second speaker explained four stages in which the delivery of healthcare was changing. The first stage is the introduction of social, mobile, analytics, and cloud (SMAC) into healthcare. The second stage is users connecting with physicians through Skype and other online means. The third stage is for healthcare to continue to reach patients in their home, not only in the doctor's office. The fourth stage is finding a way to use data to drive personalized healthcare. In addition, smartphones are becoming an important tool for diagnostics, prevention, and treatment, which can be leveraged to provide healthcare to senior citizens. Robotics also has a role, for example, in making up for a lack of healthcare workers. Despite these advances in technology, ultimately, the most important question in relation to healthy aging is a human one, namely, "how do we want to age?"

Talking about aging in Japan and a possible solution, the third speaker stated that the public likes to believe that everyone ages gracefully. However, that is not the case, and in fact many people suffer from various diseases and ailments in old age. Japan is about to be

hit by a so-called "Silver Tsunami." In 2030 approximately 30% of the population in Japan will be over 65. By 2050, that number will be 40%. There will also not be enough younger people in the workforce to look after the elderly. One solution may be to stop or delay aging, so that people can stay healthy, "young," and being a part of the workforce. Research has revealed that telomere shortening is responsible for aging. Preventing this would not only solve the issue of aging, it could also cure diseases such as AIDS, which accelerates telomere shortening in immune cells. Researchers have found a way to lengthen telomeres, which could prevent aging. Telomere lengthening has already been achieved in animals, and in a few years it will become possible in humans.

The fourth speaker discussed the implications of the aging of society. In recent years, two conspicuous social phenomena are experienced globally: an explosion of the human population, mostly in poor countries, and the aging of society, mostly in affluent countries. The aging creates huge economic burdens for these societies. It also exacerbates the issue of the explosion of the human population. For example, countries with aging populations are rather reluctant to open their borders to migrants because they are afraid to take on an additional burden to their already strained welfare system. An international solidarity is challenged and walls between countries are constructed as a result. To address the issue of aging, in addition to scientific approaches, social innovations are also needed. Young people should be educated on how to change their behavioral and mental attitudes and be encouraged to greater physical and intellectual lifelong activity to prevent an early onset of unhealthy aging.

Explaining trends in the aging of Japanese society the fifth speaker stated that most people lose their independence due to such as frailty and disability later in life, and it seems more men remain independent. The scientific community can contribute in three areas, namely biomedical research, improving living environments, and improving individual lifestyles. While biomedical research is advancing, much more can be done to improve living environments and individual lifestyles. One viable approach is for the academic community to pursue "Action Research," which is research conducted in collaboration with multiple stakeholders and which aims to understand the issue and recommend actions to address the problem.

The sixth speaker explained aging from the perspective of basic biology. As people age, at the genome level, they accumulate mutations in their somatic and germline genes. At the cellular level, humans experience the aging of cells and inflammation. At the tissue level, aging can create disequilibrium, which causes failures in different systems in the body. Fortunately advances in science and technology offer promising solutions at all the aforementioned levels.

The chair shared additional information about aging in Japan. In Japan, 87% of 60,000 plus centenarians are women. Furthermore, women are twice as likely to develop dementia at comparable ages than men. The chair then asked each group led by a speaker to make one recommendation to the Government of Japan, because Japan is the most aged country.

Discussion

The first discussant recommended that Japan address the three S's: salt, sleep, and smoking. This means better dietary habits (to reduce risk of hypertension and subsequent cardio-vascular disease), healthy sleep (as poor sleep, particularly in urban areas and amongst working population, is associated with many common conditions including cardiovascular disease and neurocognitive deficits later in life), and reducing smoking (to address the burden of chronic respiratory disease, lung cancer, and cardiovascular disease).

The second group's representative spoke about the revitalization of ghost towns and the relationship between activeness and dementia.

The third reporter pointed out that while exercise, healthy diets, and healthy lifestyles could delay aging, aging still occurred. Therefore, in addition, funding should be devoted to research for modifying the biochemical pathways that affect aging.

The fourth group's discussant recommended that Japan take global leadership on dementia and Alzheimer's disease, and share its research from a variety of fields.

The fifth representative emphasized the importance of social interventions to build a sense of community and purpose among the elderly to promote activeness and a good quality of life.

The sixth group's reporter highlighted research for supporting people to lead productive lives for longer and good end of life care, for overall improved quality of life.

The chair concluded the session by stating that the creativity of the private sector should be leveraged, with various services that improve the general wellbeing of the elderly in community and society at large.

Concurrent Session 203: [Engineering and Innovation] AI and Robotics

[Session Chair]

Arkin, Ronald C., Regents' Professor, Associate Dean for Research, Director of the Mobile Robot Laboratory, School of Interactive Computing, College of Computing, Georgia Institute of Technology (Georgia Tech), U.S.A.

[Speakers]

Bischoff, Rainer, Head of Corporate Research, Corporate Research, KUKA Roboter GmbH, GERMANY

Matsuo, Yutaka, Associate Professor, Graduate School of Engineering, University of Tokyo, JAPAN

Spiropulu, Maria, Professor of Physics, Division of Physics, Mathematics and Astronomy, California Institute of Technology (CALTECH), U.S.A.

Sugiyama, Masashi, Director, Center for Advanced Integrated Intelligence Research (CAII), RIKEN; Professor, Department of Complexity Science and Engineering, The University of Tokyo, JAPAN

Opening Remarks

Chair: Arkin, Ronald C.

The chair summarized the profound issues that exist related to the aspects of ethics in autonomous systems, with the main issue being that policy and legal systems are not keeping up with technology. He asked the participants to consider the best course of action, from the one extreme of leaving the area unregulated to see what happens, to the other extreme of banning AI technology, or any path in between.

Putting forward the point of view that AI can be used to accelerate scientific discovery, the first speaker stated that she was very focused on how to make the most of these technologies for the good of society. She then stated that the reason that we are talking about AI everywhere now is that cloud data storage and computing power have become so cheap that we are truly now in a big data society, and yet this is still an immature technology that is not yet commonplace or taken for granted in the way that mobile technology is now. The speaker then noted that in science deep learning techniques can help to significantly accelerate discoveries compared with traditional statistical methods which can also dramatically reduce costs.

The second speaker stated that deep learning is unable to solve everything, including problems with small samples. He gave the example of identifying problems with aging bridges. He discussed the problems of training a classifier using only data in a single class and unclassified data. He also noted that spurious correlations are a major issue in trying to identify causal relationships in data, and work is being done to try to identify spurious correlations. The speaker said that strategies must be developed to foster the necessary human resources for research in the area of AI.

Noting that machine vision with deep learning has been a huge step forward, the third speaker mentioned the example of automated identification of medical conditions from medical imaging. Deep learning, together with manufacturing robots, also constitutes a potential solution to the issues of aging societies and the associated reduction in the workforce. Finally, the speaker hoped also for greater discussion on how to use AI for peace rather than for military uses.

The fourth speaker stated that the automotive industry is the main driver of innovation in robotics for manufacturing. He noted that the largest market for industrial robots is China, and the market is still growing fast. Service robots have overtaken industrial robots by volume, but still represent a small proportion of the market by value. He pointed out that automation is responsible for keeping production in developed nations with a resultant increase in jobs. He also noted that designing and programming robots to flexibly carry out activities is extremely hard, and to overcome this they must be developed to the point where they can learn from humans by example, and there must be robots that can work in harmony with humans, with the goal of reaching human-equivalent performance. He also cautioned about the tendency to overregulate in Europe which stifles innovation.

Discussion

The first group's discussant questioned whether AI in warfare will result in a war of drones or whether humankind can create rules of engagement when it comes to drone and robotic warfare. There was also discussion of whether we will have nano-robots within the human body with AI to identify and treat diseased cells, and the possibilities for hybrid and augmented humans.

The second reporter noted that we lack people in the area of research and development in AI and robotics, even in Japan, mainly due to the best brains being attracted away by highly paid jobs in high-tech firms, and therefore there needs to be an understanding between industry, academia and government to support sustained research in this area. In terms of ethics there needs to be consideration to appropriate rules that cover many social aspects. It was noted that not so much progress has been made in the fundamental drivers in this area in academia in recent years, and there also needs to be robust policy coordination between industry, academia and government to drive forward research in this area.

The third group's representative stated that in the future AI might be able to discover knowledge at an unprecedented speed that humans are unable to understand. There are issues regarding the balance between the potential uses of AI to provide safety through surveillance and the protection of privacy, and different people may have different preferences in this regard.

The fourth discussant noted that there was a philosophical aspect of whether we need to fear AI and robotics, and societal values about what it means to be a human and to have

a wisdom-based and value-based society. There was also more pragmatic thinking about the tradeoffs that we are facing now such as the pleasure of driving against the potential safety benefits for all road users of automated driving. It was noted that while technology on standard hardware platforms such as mobile phones is moving fast, it is not that fast when robotic hardware comes into play that has to meaningfully interact with its dynamic environment, as there are major difficulties with affordable and high-performance mechatronics in combination with cognition still to be overcome.

The fifth group's representative stated that autonomy is not a binary distinction but something that has been gradually introduced into technologies for a long time, and in many cases the biggest challenge is in a mixed environment where there is a combination of human control and autonomous decisions, where there is the possibility of mistakes in the design of the systems. It was felt that it is important to have not only AI and robotics specialists involved in research but also psychologists and sociologists to study the human factor aspects.

The chair reflected that the main takeaway is that it is hard to come to any closure on what we should be doing, but that these discussions must be continued in this and other forums.

Concurrent Session 203: [Earth Science] Climate Change -Adaptation and Mitigation-

[Session Chair]

Sumi, Akimasa, President, National Institute for Environmental Studies (NIES), JAPAN

[Speakers]

Douglas, Rowan, CEO, Capital Science & Policy Practice, Willis Towers Watson, U.K.

El-Beltagy, Adel El Sayed Tawfik, Chair, International Dryland Development Commission (IDDC), EGYPT

Korhola, Eija-Riitta, Delegate, Consultative Commission on Industrial Change, The European Economic and Social Committee, FINLAND

Mason, Glenn, Assistant Deputy Minister, Canadian Forest Service, Natural Resources Canada, CANADA

Nguyen, Van-Thanh-Van, Chair, Department of Civil Engineering and Applied Mechanics; Director, Brace Centre for Water Resources Management; Professor, Endowed Brace Chair Professor in Civil Engineering, McGill University, CANADA

Wheeler, Tim, Director, Science and Innovation, Natural Environment Research Council (NERC), U.K

Chair: Sumi, Akimasa

Opening Remarks

The chair started the session by welcoming the attendants. He stated that the main purpose of STS *forum* is to combine the forces of government, the private sector, and academia. This type of communication can lead to actionable policy.

The first speaker stated that environmental NGOs were originally opposed to measures to adapt to climate change. The prevailing discourse was around solving or mitigating climate change instead of adapting to it.

The Kyoto framework viewed adaptation as taboo. However, as it became visible that climate change could not be prevented, it became known that mitigation would not be enough. Mitigation alone does not provide solutions for the analogous phenomena of climate change, population growth and coastal construction. Preparedness for resulting suffering is also not supported by prevailing mitigation methods.

In fact, adaptation was a taboo topic until the Nairobi Conference, when the less developed countries demanded recognition for adaptation. The opposition to adaptation has made all societies ill prepared to weather the effects of climate change. Both emission reductions and adaptations are needed for now and the future.

Mitigation methods, as they are now understood, haven't necessarily proven beneficial, even in regions where there were huge efforts in international politics. For example, the EU shifted its carbon production out of its member states, and consequently, increased its consumption. This represents a net increase in emissions. Mitigation cannot be considered mitigation if carbon leakage exists.

The Kyoto framework, and future agreements, must take into account both production and consumption. The consequences of the near-sighted approach of past agreements have resulted in increased emissions, a counterproductive result.

Instead of emission ceilings, strategies could be based on emission floors. There should be a minimum quantity of clean production and consumption as opposed to a maximum quantity of polluting practices. The Japanese model on sectoral targets would provide a good base for this method.

The second speaker began by explaining the distinction between climate variability and climate change. Climate variability has been happening now in the present period, and hence, appropriate measures need to be developed to deal with this variability in the operation and management of our existing infrastructures. In addition, there is a broad scientific consensus that the global climate will be changing for future periods. As a result, engineers need to re-examine the current practices in the planning and design of our infrastructures in the context of climate change.

Consequently, there is an urgent need to develop suitable climate scenarios for planning and design purposes. It is recognized that significant scientific advances in climate modeling and simulation have been achieved in recent years, so we could expect that it is possible

to attain this goal. In particular, while there is still a large uncertainty in the climate change projection results at the global scale, practical decision-support tools are presently available, and these tools could be used to provide an assessment of climate change impacts or to identify some adaptation measures at the regional and local scales.

However, it is still difficult to determine the best adaptation measure given the high uncertainty in the information related to climate change as well as the need to consider various socio-economic, financial, and institutional constraints in the decision-making process. Therefore, suitable performance indicators need to be developed to identify the best adaptation procedure for coping with climate change in consideration of all necessary constraints.

Stating that wildland fire is becoming more severe and occurring more often, the third speaker noted that this phenomenon is becoming more common all over the world. These fires are so powerful that they can in certain instances create their own weather patterns, including lightning that produces separate fires.

Cumulative disturbances, particularly a drying trend and rising temperatures, will create drought, which would lead to a doubling of the annual area burned by the end of the century. Alongside the increase in insect outbreaks, there will be enormous carbon emissions by forests, which already represent significant emissions. Moreover, large wildfires can release toxic compounds into the air that pose threats to human life. Wildfires must be included into current environmental discussions.

Impacts carry costs to all facets of society and government. Industries can be forced to shut down during the fires, leading to country-wide shrinkages in economies.

There are now technologies to help sense and fight against wildfires, including remote sensing and model applications. These technologies can help predict how fires will grow and how to manage them. During times of extreme fire danger, systems like these will help. Supporting programs like Fire Smart, which help forest-based communities mitigate their risks, can save up to 90% of homes in certain cases.

As wildland fires escalate, challenges will begin to exceed capacity. Within a decade, agencies will spend more parts of their budget to manage wildland fires than ever before. To meet even moderate growth, many countries will need to increase their wildland fire management expenditures. As suppression costs rise, collaboration is vital. Sharing technology, data, and

science, and strengthening policymaking capabilities and creating legislative reforms will be needed to deal with cross-border fires.

Mitigating and adapting to extreme fire seasons necessitates action on many fronts. Society must play a role in this work. The current situation cannot be maintained. Further pressure could trigger irreversible environmental changes. Solutions need to address both fire and vegetation vulnerability to fire. There should be a Green Helmet initiative, aimed at fire disasters, equivalent to the UN's Blue Helmet initiative.

The fourth speaker explained that there is a way in which resilience and adaptation will lead the current environmental debate and re-drive mitigation arguments, while techniques of engineering will lead the conversations on risk-sensitive markets that are becoming both common and required.

The re-insurance market deals with insuring insurance companies against extremes. Re-insurance companies need to understand the extremes of Mother Nature in order to do business profitably, and every year 200 billion dollars are paid out in claims.

In the last 25 years, we've improved the global situation through the adoption of engineering-based techniques, founded on measurements of hazard, exposure and vulnerability. Finance regulators mandate that risk must be understood, and these are the tools through which risk is analyzed. This risk must then be encoded into economics and public models.

Climate change is a risk people think about 30 or 40 years in the future, not something they think about in the present. Economies should have to express, on their balance sheets, their current exposure risk to climate change over a 100 year return period. Most cities, companies, and countries are not aware of their risk exposure. The extremes being faced now are the first time they're ever being faced. The worst natural disaster year on record was 2011. The global loss from natural disasters from that year was about 400 billion dollars.

The current 1 in 100 risk that the world faces in 2016 is just over 1 trillion dollars. If this figure were encoded in the financial system, it would change everything. It's the integration of economics, engineering, and science with critical systems that exist within the re-insurance industry that will accelerate and evolve current mitigation and adaptation practices.

According to the fifth IPCC report, the fifth speaker began, all aspects of food security are potentially at risk from climate change. This affects all aspects of food security from production, access, and utilization to price.

Climate change will counter the increasing demands for food production and pose a challenge for increased food quality and sustainable development goals. Climate change could potentially interrupt progress toward a world without hunger.

These impacts will not be even around the world, varying from country to country and increasing in severity over time. The poorer parts of the world are most at risk. A recent census of more than 1000 studies in Africa concluded that the average regional food crop yields may drop by at least 10% by the middle of the century.

Alongside a decrease in the production of food, there will be an increase in inequality to access of food. The least developed nations will find it harder to adapt due to the extent of local impacts.

Adaptation actions for climate change can also be components of sustainable agricultural practices. Agriculture accounts for 15% of global greenhouse gas emissions, so the industry has a part to play in reducing emissions.

Although aspects of food security are potentially affected by climate change, some aspects are not well understood. More research is needed to understand important interactions between water use, soils, food trade, and policy.

The sixth speaker stated that we are riding a roller-coaster in relation to adaptation and mitigation. The debate lacks a sense of global responsibility and the feeling of human unity. The planet is small, so everyone will suffer. In 2015 and after, with the Sustainable Development Goals (SDGs) and the Paris Agreement, there is potential for positive impact.

There are questions whether current agreements will be carried out with strong political will. It will take time to really manage emissions, followed by a longer period of waiting to see the effects of mitigation. There should be an international movement to share knowledge, restore function, and increase management and coping and adaptive capacities.

Navigation of this movement should be conducted on both a global and a local scale, with resilience kept in mind. Additionally, assessments must be made to address the effectiveness of the impact of climate change on the regional and local levels and in individual communities.

The developing world will be affected disproportionately by climate change, so there should be international support in order to share knowledge, build up resilience, and decrease vulnerability in these regions especially. Experts in analyzing advanced models will also need to be deployed to these nations, because they don't have the resources to afford both data collection and analysis on the regional and local level.

It is the responsibility of the worldwide community to create a shift in consciousness away from self-centered programs that defy moral and ethical codes of humanity. Politicians cannot accomplish this alone. They think in the short term. The science community is freer to think about long term consequences. The price of doing nothing is shame as human beings.

Discussion

The first group's discussant stated that we need to understand and communicate in order to realize policy measures in an effort to reduce emissions. One way would be to suggest efficient policies which do not push big trade programs on other countries. It has been discussed for many years that increasing the carbon tax would be good, but this would be hard to study from the international level. It could be studied at the regional level.

The second representative said that there are big consequences in developing nations. The impact of climate change can be massive. It can be the size of one country's GDP, an issue which is beyond reasonable resources. This is an issue that must be kept in mind when we discuss global policy. We need a global joint effort working on climate science and developing models that enable us to understand the reality of the present. There could be much more done as a global science community. The results of science also have to be made available to the global community.

The third group's reporter stated that climate change is here, and all countries are ill-prepared. We need to incorporate the issue of change into the curricula of school and colleges and apply technology to handle the situation. Climate change is going to have a more severe impact on the developing world than the developed world, resulting in large scale immigration. There is inadequate and ill-planned financing in this area, which needs serious attention. Climate change is a global issue and global commitment is needed.

The fourth discussant exclaimed that food security affected by climate change is an urgent issue that needs to be addressed. Several methods have already been taken. Nutritional change in the crops affected by changes in temperature are not yet well understood. Impacts of economy, trade, and policy also affect the relationship between climate change and food. Trade and supplier industries can affect consumption patterns and can encourage sustainable food production. More indirect and complicated impacts of climate change should be addressed. If these discussions are seriously considered, then corporate balance sheets should reflect these issues.

The fifth group's reporter explained that legislation should be working toward a legally, globally binding international agreement. Local legislation can be applied where this system fails. All industries will not agree on the same emission boundaries, but trying to do it across single sectors would be easier. We need good metrics and communication. No progress is possible without these two things.

A participant noted that Central America has seen over 20 years of loss to climate change. Numerous national disasters have taken lives and interrupted economic progress.

Concurrent Session 203: [Cooperation in Science & Technology] Science and Technology in Developing Countries

[Session Chair]

Malone, David M., Rector, United Nations University (UNU), JAPAN

[Speakers]

Abdulrazak, Shaukat Ali, Director, Department of Technical Cooperation, Division for Africa, International Atomic Energy Agency (IAEA), AUSTRIA

Hamaguchi, Michinari, President, Japan Science and Technology Agency (JST), JAPAN

Hara, George, Ambassador and Chairman, Alliance Forum Foundation; Special Adviser to the Cabinet Office, Prime Minister of Japan, JAPAN

Hassan, Mohamed Hag Ali, TWAS Executive Director a.i. & IAP President, The World Academy of Sciences (TWAS) for the advancement of science in developing countries & InterAcademy Partnership, ITALY

Tangau, Madius, Minister, Ministry of Science, Technology and Innovation (MOSTI), MALAYSIA

Yamagiwa, Juichi, President, Kyoto University, JAPAN

Chair: Malone, David M.

Opening Remarks

The chair opened the afternoon's session by introducing the United Nations University (UNU), which is headquartered in Japan and has presence in over eighteen countries. The UNU's work in Japan is mainly related to the fields of environmental issues and disaster risk reduction. The developing world is evolving very quickly, but in many respects the gap between the most scientifically advanced nations and those still with deficits in the field continues to grow because of brain drain and other difficult-to-eliminate issues.

He later drew attention to two initiatives: The African Institute for Mathematical Sciences (AIMS), also known as the "Next Einstein Initiative", which provides high-quality graduate-level education in Africa (in Cameroon, Ghana, Senegal, South Africa and Tanzania), and which has been successful in attracting generous funding given its impressive execution of

an ambitious project. Likewise, the long-running African Economic Research Consortium, which, among other objectives, provides doctoral tutoring and post-doctoral research opportunities for economics students throughout Africa, having successfully helped to incubate a number of Central Bankers and Finance or Economic Ministers over the past three decades, and which also has secured the loyalty of generous funders given the high quality of its work and impressive achievement of its own ambitions, not least to retain in Africa valuable local talent. Thus, building the foundations for top-quality research is possible in Africa as elsewhere, something African governments have not always recognized given their own serious budget constraints. But African governments are now becoming more ambitious for and supportive of high quality research-oriented study, joining Asian and Latin American governments which have done so for many decades.

The first speaker began by indicating that there is no clear definition of what a "developing country" is. However, several major global organizations adopt the perspective that developing counties are low- to middle-income countries. Recently, another term has emerged: "least developed countries," or the countries from which 0.2% of scientific research emerges. There is a huge gap between North and South in this respect, and it is widening. To meet the SDGs established at COP21, development indicators must be met in these countries. However, not just North-South, but South-South cooperation is also key. Programs are emerging to meet these needs, providing invaluable opportunities through funding and venues for open innovation.

He highlighted the need for increased collaboration to achieve the SDGs in the least developed countries. Not only is supporting research and providing venues and mechanisms for collaboration important, but so is having a market-based perspective as well, encouraging the commercialization of new technologies.

Discussing the issues facing the African continent, the second speaker noted that one central issue is how to improve access to education in the region. He has been engaged in discussions to practically solve those problems. Deep-rooted issues of lack of access to food not only affect the physical growth of children but also their mental growth. In turn, this affects the economic, scientific and technological growth of African countries.

To address these issues, the development of accessible proteins is key. One such opportunity in Africa is spirulina, an algae-based protein which is easy to grow. Over the history of colonial occupation, the cultivation of spirulina fell out of popular practice as the colonial occupiers introduced artificial proteins. Currently, there is an initiative involving 19 countries on the continent to explore the reintroduction of spirulina.

The third speaker spoke about the issue of the least developed counties. Africa contains 26 of the 34 least developed countries that are benefitting from technical cooperation with IAEA. One perennial issue is dealing with funding in these countries. The time has come to establish funding priorities in the African region, demystify science to attract more young people, and also engage the media to help disseminate information. Technology should be a servant, not a master. Scientists must be proactive in policy-making, and policy-makers should be informed about scientific matters.

The speaker also outlined some peaceful uses for nuclear technology that have great benefit in Africa, in areas such as human health and nutrition, agriculture and food security, water and the environment, radiation technology and industrial applications, and energy planning and nuclear power. Nuclear technology can be used to control epidemics, and contribute to medical research. The IAEA, along with its partners in the region, moved into countries where Ebola had struck, and was able to provide medical support with diagnostic technology. Radiation therapy and nuclear medicine represent a major opportunity to joint research in developing countries.

Speaking about Malaysia's development goals and its initiatives to meet them by 2020, the fourth speaker discussed the "Policy for Science," an initiative that contributes to these goals and that will have significant outcomes. These policies are based on principles of COP21, because the Malaysian Government believes that it will have great impact on the development of science and technology.

Malaysia was inspired by other countries in the region in terms of their development initiatives, such as Japan and the Republic of Korea, whose economies are powered by science and technology. For Malaysia to achieve the same level of economic development, it must be through the development of science and technology. The National Science Council was established to contribute to meeting these goals. They are also considering how to manage their research funds to best meet national needs and their development goals.

The fifth speaker discussed the activities of the Japan Science and Technology Agency (JST) and its Sakura Science Plan initiative. It aims to cultivate personnel who can contribute to the growth of Asia in the field of science and technology. It was started in 2014 to support

short-term visits of foreign students, researchers and academics to Japan. As of 2016, there are 35 eligible countries and regions for the program, and it targets youth – from high school students to postdoctoral researchers under the age of 40. There are two sub-programs of the Sakura Science Plan. First, there is an open application program, through which JST provides funding for selected exchange programs. Second, there is the Sakura Science High School Program, which invited excellent high school students to Japan for one week to gain experiential science and technology-related training. Japanese Nobel Laureates even give lectures and conduct lab experiments with students. A target of 5,000 invitees for 2016 was announced.

Goals for the future of the program are to leverage alumni as soft power, develop Sakura Science Program through international cooperation, and continue to provide Asian youth an opportunity to deepen their studies in science and technology, and finally to create a powerful network of young leaders.

Giving an example of a successful program conducted by Kyoto University in the Republic of Gabon through the Japan-based Science and Technology Research Partnership for Sustainable Development (SATREPS), the sixth speaker stated that based on the needs of the global and local communities, SATREPS undertakes initiatives in four areas: energy, biodiversity, natural disaster prevention, and infectious disease control.

The SATREPS project in the Republic of Gabon aimed to contribute to biodiversity conservation and promote ecotourism in some of the country's many national parks. The purpose of the project was to devise an appropriate method for community-based biodiversity conservation, develop scientific methods for ecotourism, and enhance the capacity of the local community for providing ecotourism and preserving biodiversity. Through various projects and initiatives, Kyoto University is committed to promoting the scientific and technological development of Africa.

Discussion

The chair invited all participants to ask questions about the various presentations, or share information about the science and technology development initiatives underway in their own countries or institutions.

Participants also shared initiatives from Brazil, Portugal, Indonesia, Malaysia, Benin, Ghana, Namibia, Morocco, India, Kuwait, Kazakhstan, among other countries. Common threads between the discussions included the importance of regional or multi-lateral collaboration, in addition to bi-lateral or North-South collaboration. By approaching regional cooperation holistically, regional issues of common interest can be addressed. The importance of collaborative development initiatives that aim to realize the SDGs and other development guidelines were emphasized. Also, giving opportunities to younger generations, through exchanges, the provision of appropriate funding, and others, was emphasized. Finally, ensuring the connection between academia, government, and industry is strong, based on mutual understanding, and planted on common ground, is key.

A participant discussed initiatives to channel scientific and technological innovation into the practical application of disaster risk reduction. Reflecting innovations in the governance system, and also understanding the cultural dimensions of innovation within organizations and multi-lateral collaboration mechanisms is key.

The chair commented that many of the Africa-based organizations discussed are very ambitious, and in many cases, their ambitions have been proven effective. However, it is still important to demonstrate to policy-makers the value of these initiatives.

A participant discussed her experience working in academia in the African region. Cooperation initiatives have been successful, but often the dialogue focuses on the

socio-economic challenges facing the continent. Poverty and lack of water are underlying issues. To overcome these issues and drive powerful innovation, academics must take a multi-disciplinary approach, and properly understand when it is time to pass on the mantle to the next generation. National and regional approaches to these challenges are underway.

Another participant reiterated that the importance of partnerships, and involving more diverse partners, from different fields and areas, will be key in driving innovation.

The chair seconded this point, and added that relying on governments as the sole or principal source of funding will no longer be the best approach. It is important to innovate the business model of supporting research in developing countries.

Another participant shared his experience with working at an NGO, and the importance of a "people-first" approach. Each situation is different so a flexible approach should be taken. It is important to view the people one is trying to help as investors. Rather than donating or providing technology, it is important to make products that are affordable for everyone.

The chair invited each speaker to make brief final remarks. One speaker pointed to the importance of a free and open internet, accessible to all, as well as continued efforts to empower women in developing countries. Another speaker reiterated the importance of nutritional issues, and added that technologies must be spread via "mid-developing" countries like Thailand and so on to the least developed counties. Another speaker pointed out the necessity of a holistic approach to encouraging collaboration in science and technology, and also the importance of capacity building. Another speaker emphasized the importance of foresight studies in developing technologies which will lead to commercialization. Another speaker identified a lack of trust and mutual reliance between academia, industry and government. To further collaboration, common ground and mutual benefits must be unearthed. Strong managers will be important in realizing this. Finally, another speaker emphasized the importance of fostering young scientists to promote innovation.

The chair wrapped up by stating that high-level research must be spread throughout the world, not just in developed counties. The chair then thanked all members for their active participation and brought the session to a close.

Concurrent Session 203: [Science, Technology and Society] Public Engagement in Science and Technology

[Session Chair]

Kleiber, Michał, Vice President, European Academy of Sciences and Arts (Salzburg, Austria); former President, Institute of Fundamental Technological Research, Polish Academy of Sciences; former Minister of Science and Technology, Polish Government, POLAND

[Speakers]

Murayama, Hitoshi, Macadam's Professor of Physics, Department of Physics, University of California, Berkeley; Director, Kavli Institute for the Physics and Mathematics of the Universe, The University of Tokyo, JAPAN

Scott, Matthew P., President, Carnegie Institution for Science, U.S.A.

Szostak, Jack William, Professor of Genetics, Department of Genetics, Harvard Medical School; Investigator, Howard Hughes Medical Institute, U.S.A. [Nobel Laureate 2009]

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

Wünning Tschol, Ingrid, Senior Vice President Strategy, Robert Bosch Foundation, GERMANY

Opening Remarks

The chair began the session by welcoming the participants and expressed his confidence that the discussion would be productive and fruitful. The fate of humanity depends on the utilization of knowledge, and there are growing gaps between knowledge users and producers. In order to change this and better provide people with the benefits of scientific research, the scientific community needs to bridge these gaps. Demonstrating the usefulness of new knowledge, integrating public concerns into sustainable and responsive knowledge, making the world more accountable with scientific advances, and improving education are important areas to address.

Chair: Kleiber, Michał

The first speaker noted that in the US, science and technology are playing an increasing role in foreign policy. There are many areas where scientific issues are being input into global issues that are of paramount importance. Many government entities are recognizing this. Engaging nations through diplomacy is important for a smart engagement strategy. It is critical that science and forming policy be public engagement policies as these changes will affect the public in staunch ways. Recent polling has shown that a majority of US adults were worried about recent technologies. These concerns will only grow and reveal a lack of connection between the public and the scientific community. Public engagement does not mean a one-sided lecture at the public, it is a process that begins with education and creates an ecosystem of engagement. These engagement efforts need to be ramped up now. The US has integrated the SDGs to energize the global science enterprise and the public needs to be engaged to secure the prosperity of all citizens of the world.

Stating that one area of concern is denialism and skepticism with scientific truths (such as with climate change, vaccines, and GMOs), the second speaker noted that there are many causes, but among these are many examples of industries that falsify data or misconstrue facts, leading to a loss of trust in science. Religion also plays a role. For example, in the US, religion often promotes disbelief in concepts such as evolution and opposition to stem cell research. However, there are topics that effectively lead to further public connections, such as space exploration. Even with such topics, the science must be very carefully presented to be clear, free of jargon, and engaging in order to avoid turning the public off from the message. The analysis of images and data from space, and the reporting of ecological observations are two examples of programs that have been very successful in actively engaging the public in science; getting children involved earlier as active participants in science will also have an enormous effect on increasing public engagement in science.

The third speaker noted that the Kavli Institute for the Physics and Mathematics of the Universe in Tokyo is making efforts to popularize science to a larger audience. Though his experience, he has come to learn the value of engaging well with the media. Recently, for example, data came out of Europe revealing that neutrinos go faster than the speed of light. A reporter misconstrued the facts and reported that time travel was possible. Another example was after 2011 when people panicked after they read that the radiation level in Tokyo had doubled, even though the level of radiation was not dangerous. Through this, he learned that working with media and disseminating the facts in a responsible and correct fashion is of the utmost importance. Education must be improved as it is too often taught that there is only one solution to every question. This misconception must be corrected

and critical thinking encouraged. Scientists must learn to communicate and become an interpreter of technical, scientific language to everyday language.

Noting that the Carnegie Institution for Science engages the public in a variety of scientific fields, the fourth speaker stated that getting people to inquire about the amazing facets of the world, from volcanos to animals to genetics, is a way to entrance the public with what motivates the scientific community. Stories and ideas that are purposeful must be conveyed, and then scientific thinking must show how it can address these questions. Defense, traffic, health, information analysis, navigation and other issues are areas that everyone has to confront and can further engage the public. All of this relates to science and can benefit scientific thinking. We need to show that science requires creativity and imagination at the same level of art, something that too often does not happen at public schools where only the facts are laid out. It is very crucial to consider the social and ethical implications of the scientific findings.

The fifth speaker noted that what comes to the public mind when Africa is mentioned is often negative and science does not get talked about. However, the ability of African countries to develop themselves in a sustainable way depends on their technological capacities. The African public and leaders must therefore be scientifically engaged. The Einstein Forum gathers excellent and young African scientists, and the core of the program lies with the youth who are selected. The participants receive training from TED conference speakers on how to speak to the public. The Einstein Forum demonstrates the continent's untapped potential. The presenters at the forum have presented on a variety of issues and presented innovative ways to overcome them, and there are many Africans who want home-grown solutions to solve the problems facing Africa. The Einstein Forum made a big step in changing the public perception of Africa and its scientific potential, and African scientists are now increasingly invited to global scientific conferences and forums.

Discussion

The first group's discussant stated that the scientific community, as well as STS *forum*, would benefit from the participation of more women. For women and minorities, often times, the interest in science is larger if social concerns are addressed, which highlights how different demographics have different concerns. Thus different groups require different strategies. The question of the cause of scientific skepticism is an area that needs to be further debated.

The second reporter stated that women need to be engaged further in the STEMs. Furthermore, denialism is an area that needs to be better dealt with. The way scientific language is translated to everyday language is of utmost importance when engaging with the public. Using available resources such as museums and laboratories to allow the public to experience science first hand is a way to engage the public without massive amounts of funding. Training in science communication must be further developed.

The third representative explained that every technical language is different and that it is up to the scientists to adapt to these. It must also be noted that traditional media is losing ground to social media. Thus, using social media to promote science is another way to engage the public, such as through short YouTube videos. We need to focus on positive framing rather than negative, as it sticks in the mind of deniers.

The fourth discussant stated that there is a very positive attitude toward science in Africa, which is cause for celebration and hope. Thus, scientific dialogues and exchange programs in Africa have much potential. Frugal science and frugal innovation will be the keys in Africa's scientific development.

The fifth discussant raised the point that science museums have an important role to play. However, "museum" is a bit of a misnomer as they are more like science centers that allow interactive public engagement and with science.

The sixth group's reporter raised a point about the Science Media Centre of Canada, which is a center of volunteer scientists that provide their expertise and answers to traditional media journalists. Such a center is an impetus for the creation of a good relationship between the media and science.

The seventh discussant noted that Japan's Miraikan plays a role in public engagement with science. Also, further efforts are being made to increase the scientific literacy of public officials in Japan.

Concurrent Session 203: [ICT] Development of Nano-industry

[Session Chair]

Nelson, Donna J., President, American Chemical Society; Professor, Department of Chemistry and Biochemistry, University of Oklahoma, U.S.A.

[Speakers]

Chery, Jean-Marc, Chief Operating Officer (COO), STMicroelectronics, SWITZERLAND

Fujita, Hiroyuki, Professor, Institute of Industrial Science, The University of Tokyo, JAPAN

Iwatsuki, Masashi, Representative Director & Executive Vice President (CTO), JEOL Ltd., JAPAN

Kotrotsios, Georges, Member of the Executive Board, Corporate, CSEM, SWITZERLAND

Sargent, Edward H., Vice-President, International, Office of the Vice-President, International; University Professor and Canada Research Chair in Nanotechnology, Edward S. Rogers Sr. Department of Electrical and Computer Engineering, University of Toronto, CANADA

Strano, Michael S., Carbon P. Dubbs Professor of Chemical Engineering, Department of Chemical Engineering, Massachusetts Institute of Technology, U.S.A.

Opening Remarks

The chair began by going over the session overview of the future of evolving nanosystems and semiconductor technology, which are predicted to be the future core of the IoT and smarter driving technologies. However, there are numerous challenges associated with achieving the potential of these areas, including security, ethics, equipment service, and the size and geography of the development team. She noted that the session would focus on challenges and solutions for issues that included implementation concerns for the practical applications of nanomaterials, scale-up challenges in applications, and innovation in combining fabrication methods.

Chair: Nelson, Donna J.

The first speaker said that we are evolving in many directions as we drive innovation. The challenge is to recognize the key components of semiconductors, including having the building blocks to address different needs of systems. These needs include processing and security, which encompass different levels. There is also the issue of connectivity, with short ranges and long ranges. Finally, there are issues related to power management. Specifically for the IoT, the semiconductor industry needs to be able to support a wide customer base to help them develop applications at high speeds and affordable costs.

The second speaker described a project using thousands of sensors that addressed fire prevention for destruction of forests. Although it was decided that the project was not feasible, it was an eye-opening experience at looking at very small devices. He then related this to the future of nanosystems. Due to the fragmentation of market needs, the marriage of commodities (classical microelectronics), specialties (customized nanosensors and actuators) and packaging in miniaturized devices requires equipment, infrastructure, and skills, and this is becoming more complex and expensive. The question is how to optimize access to such equipment, infrastructure and skills for research or industry by replications or through coordination. Europe tried to coordinate this at the top level, with an example being the Nanotechnology Alliance between the Fraunhofer Gesellschaft-Microelectronics, VTT, CEA-LETI and CSEM. This is not easy, but it is certainly the way to follow.

The speaker said that many people think that bigger equipment is required to make smaller features, but there are efforts to make smaller machines that are more precise (for instance, desktop manufacturing). This is not a dream, and such devices should be brought to young entrepreneurs to create new fields and jobs. The next step is services beyond service/data economy in the installation and maintenance of nanosystems. Beyond this, in the case of nanosystems, we need organization to deploy, maintain, and develop sensors. The speaker concluded by giving his prediction for the future about neural dust, which has great potential benefits related to neural activity, however there are concerns about privacy.

Beginning by introducing his company that is deeply involved in the nano-industry, the third speaker gave an explanation of the diverse aspects of nanotechnology, looking at the fields such as materials science and life sciences that it encompasses. He introduced the electron microscopes and other scientific instruments, industrial equipment, and medical equipment used in nanotechnology. The speaker stressed the advanced device development that is already underway, and said he hoped to discuss these instruments and innovation during the session.

The fourth speaker said the previous speakers had outlined the history of nanotechnology, and he believed the next generation is soft nanotechnology and using chemical techniques to make nanotechnology ubiquitous. He spoke about ubiquitous sensing and described the creation of Envisage, a company that makes image sensors for smartphones that can sense colors that humans cannot see and allows you to take pictures. In the current world of augmented reality, it is important to be able to interact with the world even outside of human limits.

The speaker described the next area as big nano, which he sees as the next generation 10-30 years out. With soft nano in the midst of commercialization, the speaker said he wanted to find approaches as an academic and looked for problems that will not be solved soon. He became convinced that solar cell energy would be cheaper than that produced by fossil fuels, so he focused on making a contribution in the post-solar era. This led him to think about energy storage, and he worked on creating the next generation of carbon-neutral fuels, making energy that utilizes carbon. This led him to the field of big nano, and he believes this represents a great opportunity. The approach of his group is to do science and engineering at the same time. The other key element is that it is a global and open approach, and the group works with industry in an open access model, creating a global network called Bio-inspired Solar Energy that is bringing in many partners.

The fifth speaker spoke about combining soft nano and hard nano, and said that application-wise, nanotechnology should be connected to our microscopic world. To that end, many functionalities should be attached to electronics, and the IoT represents a good example. It should handle electronic signals in combination with bio and chemical signals. In addition, thinking about IoT for human beings necessitates interfacing with human bodies, and this requires soft, undetectable materials. There needs to be a wide variety of fabrication capabilities over materials and scale; this leads to the integration of heterogeneous processes.

Stating that he would focus on disruption, the sixth speaker titled his remarks Emerging Trends in Nanotechnology 2.0. He gave three attributes about nanotechnology that we could not have predicted in the past. These were the ability to cross biological membranes and barriers, synthetic molecular recognition, and the collapse of the chemical sensor detection limit. Nanotechnology 2.0 will combine these attributes in massively transformative ways.

Plant nanobionics will use nanoparticles to augment or impart new functions into living plants, manipulating their functions. The speaker's vision was to replace everyday objects we currently stamp out of plastic and circuit boards with equivalent functioning living plants. This would give advantages such as negative carbon footprints, self-repair, and adaption to harsh environments. One example would be a plant that could communicate with cellphones.

The speaker also spoke about Corona Phase Molecular Recognition, in which nanoparticle corona phases transform them into 'synthetic antibodies.' The human body has 1021 distinct chemical species and is thus more complex than the internet, and nanotechnology represents the opportunity to tap this information network in real time. This could be utilized to join humans inherently to the IoT through in-vivo methods. The speaker concluded by saying that these examples of plant nanobionics and sensors to plug humans into the IoT are examples of the transformative power of nanotechnology 2.0.

Discussion

The first discussant said his group spoke about nanoparticles and plants, and how interested they were in this aligned with sustainable development. There was a question on how to make plants more effective at what they do, versus just using plants as carriers. For instance, nanofertilizers could be used to help plants survive in rugged environments.

There was also a question about how little has come out of nanotechnology in the years it has existed, although of course there have been some developments. One reason is the widespread fear of GMOs that is linked to a fear of nanoparticles in Europe, and perhaps in other countries. Another problem is a lack of ambition, as well as insufficient sustained government policy for nanotechnology, and one solution could be private and academic parties getting together to work on this. The final point was that the progress of nanotechnology could be accelerated through the momentum created by COP21.

The second reporter jumped off a point by one of the speakers about biological barriers and nanoparticles, stating that there are a number of concerns accompanying this. For example, in building up a nano-industry, it is difficult for nanotechnology SMEs without extensive legal teams and research departments to tackle issues of nanotoxicity. This is also relevant for technology transfer departments at universities. Unfortunately, it is relatively easy for the public to suddenly turn against new forms of technology, and although this has not happened with nanotechnology, nanotoxicity represents a risk.

The third representative said his group talked about commercializing nanomaterials, with one route being to add nanomaterials to existing products, and the second to use them to create new industries. Another application is using them in pharmaceuticals to block reactions, which could be cheaper and easier to use. Issues include fears by the public blocking progress of nanomaterials, as well as the fact that R&D is very cost prohibitive. Nonetheless, the group concluded that this is a very busy and productive field and there are numerous opportunities.

The fourth discussant said that his group spoke about businesses that have been enabled by nanoelectronics. The big trend is having systems which support the service economy by providing automation and security. The crucial issue is that the demand of the market is fragmented, which creates issues in helping particular customers. Following this, one of the speakers made a point that people who study nanotoxicity should be the people who are also developing nanotechnology. The chair then declared the session closed.

Plenary Session 204: Delivering Health Care to the World

[Session Chair]

Agre, Peter, Director, Johns Hopkins Malaria Research Institute (JHMRI), Johns Hopkins Bloomberg School of Public Health, U.S.A. [Nobel Laureate 2003]

[Speakers]

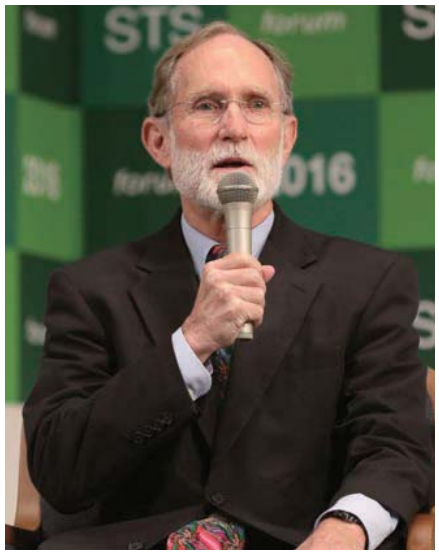
Hasegawa, Yasuchika, Director and Chairman of the Board, Takeda Pharmaceutical Company Limited, JAPAN

Meunier, Bernard, President, Academy of Sciences of France, FRANCE

Welham, Melanie, Chief Executive, Biotechnology and Biological Sciences Research Council (BBSRC), U.K.

Bréchot, Christian, President, Institut Pasteur, FRANCE

Yamanaka, Shinya, Director and Professor, Center for iPS Cell Research and Application (CiRA), Kyoto University, JAPAN [Nobel Laureate 2012]



Chair: Agre, Peter

Opening Remarks

Prof. Peter Agre discussed the U.N. Sustainable Goals to promote well-being for all ages. The delivery of healthcare is the primary cause for the increasing life expectancy of the human population. However, this improvement has not been consistent across countries. Infant mortality, while negligible in some countries, remains a major problem in other countries. In many cases, the cause of death is a communicable disease, which should be preventable. While efforts are being made and they are effective, more needs to be done. Overall, it is important to note that, when discussing delivery of healthcare to the world, there are extremes.

Mr. Yasuchika Hasegawa believed that healthcare was one of the best targets for both public and private investment. Investment in preventative healthcare is far more efficient than treating people after they fall ill. The focus of healthcare should be on the individual.

Healthcare investment has become globalized with global companies investing in healthcare around the world, and public bodies also devoting resources to promoting healthcare in developing countries. Public-private partnership can pool these efforts and promote healthcare worldwide. Innovation is also an important tool. In recent years, the U.S. eco-system has been particularly effective in generating biomedical innovation. The U.S. model should be embraced and recreated, and entrepreneurship should be promoted to improve healthcare worldwide.

Prof. Bernard Meunier spoke about drug discovery. The drug discovery and development process are getting more expensive each year. As a result, pharmaceutical companies tend to devote more resources to therapeutic fields considered as less risky, such as cancer therapy. This also opens the door for personal medicine. However, some domains end up being "orphaned" as a result. These include less well-known tropical diseases, neurodegenerative diseases, or drug-resistant bacterial diseases. To address these orphaned domains, more support is needed from public foundations that devote funds to drug discovery, which make it possible for promising compounds to overcome the Valley of Death, and produce effective drugs.

Prof. Melanie Welham discussed new research that may prevent chronic diseases and promote health throughout life. The microbiomes in the human gut have largely been ignored. However, recently researchers have studied their relationship with chronic diseases. Exciting discoveries have been made linking changes in these microbiomes to chronic diseases, such as cancer, cardiovascular diseases, and inflammatory bowel diseases. This suggests that we may be able to manipulate the composition of such microbiomes to both improve life-long health and combat chronic diseases. Research must now move beyond descriptive studies to functional studies. However, there are many gaps and questions that need to be addressed. New techniques and approaches, requiring interdisciplinary research and new models, are needed to better understand the function of these microbiomes and the impact on our health. It is also necessary to consider how best to coordinate and collaborate on these efforts, and ensure maximum impact. If successful, this research could create new fields of medical practice, which would in turn also yield new business opportunities.

Prof. Christian Bréchot stressed the necessary association between research, education and healthcare. The key question is how to communicate to the world the progress of medical science and build trust with the community. For example, onsite capacity and infrastructure are important for delivering medical advances to the community. The inadequacy

of these two aspects was revealed during the Ebola outbreak. Another urgent need is the sharing of data from different countries and organizations. In addition, an area of priority, which causes the majority of deaths in the world, is non-communicable diseases in low or medium-income countries. When thinking about delivering healthcare to the world, we must firstly act globally and not in silos. Furthermore, education and training must be at the forefront of such efforts.

Prof. Shinya Yamanaka spoke about iPS cells. The advantages of human iPS cells are that they can be expanded limitlessly, and their function can be differentiated into any type of cell. The medical applications of this are therapy and drug discovery. Kyoto University patented its iPS technology and has licensed this out to many companies around the world, with whom it is partnering to further such research. In addition, the first clinical trial using iPS cells to treat macular degeneration has been successful. This has promoted other researchers to pursue similar research, for example for the treatment of Parkinson's disease. CiRA has also proceeded from autologous iPS cell generation to the cultivation of iPS cells from healthy volunteers. CiRA is working on identifying donors of iPS cells that cause little immune rejection. To simplify the process for developing novel therapies, thereby reducing

the costs of these therapies, it would be beneficial for university researchers to work directly with pharmaceutical companies. CiRA has done exactly this with Takeda Pharmaceutical Co., Ltd., launching the T-CiRA program.

Discussion

Prof. Agre asked how the Nobel Prize had changed Prof. Yamanaka's life.

Prof. Yamanaka explained that rather than the Nobel Prize, it was the discovery of human iPS cells that changed his life. Prior to the discovery, he was a pure scientist, working on his own. Now, however, he devotes more time to building a team and working with patent rights experts and other non-researchers to maximize the impact of his research.

A member of the audience highlighted the emerging role of scientists in the developing countries and the need for greater collaboration between developed and developing countries and researchers. He asked if an open innovation model might be applicable.

Prof. Bréchot concurred. Closer interaction and collaboration is increasingly needed, not only between developed and developing countries, but also between research institutes and industry.

Mr. Hasegawa agreed on the importance of public-private partnerships, sharing an example of a joint effort between Japanese businesses, the Bill and Melinda Gates Foundation, and the Japanese government. He also suggested that private companies could be more proactive about launching initiatives.

Prof. Meunier pointed out that as the role of developing countries in drug discovery grew, these countries needed to think carefully about implementing the necessary regulations to avoid the mistakes that developed countries had made previously.

Prof. Agre asked which areas of microbiome research were most promising.

Prof. Welham thought it was too early to give a definitive answer but suggested that perhaps work on inflammatory bowel disease had been most promising to date.

A member of the audience then commented that delivery of healthcare throughout the world must start with underdeveloped countries. This can reduce the spread of transnational infectious diseases from underdeveloped countries to developed countries, and also reduce healthcare costs in developed counties. There are also many neglected diseases in underdeveloped countries that need to be addressed. Collaboration and the sharing of experiences among underdeveloped countries would also be worthwhile.

Prof. Welham reported that the U.K. had launched the Global Challenges Research Fund for funding new research and social innovations expected to improve the lives of those in poverty, a portion of which was dedicated to health.

Next a question was raised regarding research on antibiotic resistance.

Prof. Bréchot agreed that if this was not addressed it could be disastrous. Research is advancing, but there is still not enough known.

Day 3

Plenary Session 300
Closing Plenary Session 301

Plenary Session 300: Key Messages from Concurrent Sessions

[Session Chair]

Carty, Arthur J., Executive Director, Waterloo Institute for Nanotechnology, Mike & Ophelia Lazaridis Quantum-Nano Centre, University of Waterloo, CANADA

[Speakers]

Koanantakool, Thaweesak, Advisor; former President, National Science and Technology Development Agency (NSTDA), THAILAND

Steen, Tomoko Y., Professor, Department of Microbiology and Immunology, School of Medicine, Georgetown University, U.S.A.

Abé, Hiroyuki, President, The Engineering Academy of Japan; Special Counselor to the President, Principal Fellow, Japan Science and Technology Agency (JST), JAPAN

Blanco Mendoza, Herminio, Founder and Chief Executive Officer, Soluciones Estrategicas S.C., MEXICO

Johnson, Ray O., Executive Director, QxBranch; Senior Vice President and Chief Technology Officer (ret), Lockheed Martin Corporation, U.S.A.

Gutfreund, Hanoch, Executive Committee Chairperson, Israel Science Foundation; former President, The Hebrew University of Jerusalem, ISRAEL

Saito, William H., Special Advisor, Cabinet Office, Government of Japan; Vice Chairman, Palo Alto Networks, JAPAN

Rubinstein, Ellis, President and Chief Executive Officer, The New York Academy of Sciences (NYAS), U.S.A.

[Future Leaders]

Falk, Anna, Associate Professor, Neuroscience, Karolinska Institutet, SWEDEN

Hagan, Julius Kofi, Senior Lecturer, Department of Animal Science, School of Agriculture, University of Cape Coast, GHANA

Opening Remarks

Prof. Arthur J. Carty explained that STS *forum* was created to provide an opportunity for engineers, scientists, social scientists, political leaders, and members of industry to discuss the issues facing the world. The number of concurrent sessions demonstrates the diversity of participants and interests at STS *forum*.

Dr. Hugh Thaweesak Koanantakool presented the key messages from the energy and environment concurrent sessions. Each country faces different challenges in terms of balancing affordable energy and impact on the environment. In addition, the falling petroleum prices and the development of shale gas have affected the prices in energy markets.

Chair: Carty, Arthur J.

There are a number of policy and scientific issues affecting energy issues. Policymakers are responsible for putting in place incentives, such as a carbon tax and pricing, to encourage the promotion of cleaner energies. Demand-side measures are also needed. As for science, better transport systems, the Internet of Things (IoT), remote conferencing and other technologies can reduce the amount of energy consumed.

Renewable energies, such as solar or wind energies, are gaining attraction as they become increasingly economically viable. Of course, they are also subject to fluctuations, whereas consumers expect continuous energy supply. Mass energy storage systems are therefore needed to stabilize renewable energy and make it sustainable. The scientific community should do more in this area. A large carbon capture and storage (CCS) solution would also enable the continued use of fossil fuels while reducing carbon emissions. Geothermal and hydropower are other forms of renewable energy but they still have limitations that mean they are not widespread.

Nuclear power is also an important source of energy with the lowest emissions. However, there are still concerns about nuclear reactor safety. While Japan has shut down almost all of its nuclear reactors, many other reactors are being constructed around the world. Members of the science and technology community need to ensure that nuclear power is safe, affordable, and reliable. Each country will have different mixes of energy. Renewable energies should make up an increasingly large part of the energy mix. However, they are not steady sources of power and must be combined with other power sources and energy storage systems. Nuclear power will also be an important option, but its promotion must be based on safety, security and non-proliferation.

Prof. Tomoko Y. Steen presented the key messages from the life sciences concurrent sessions. First of all, the culture of life sciences has changed. Big data and other developments have promoted international and interdisciplinary collaboration.

Koanantakool, Thaweesak

Steen, Tomoko Y.

Abé, Hiroyuki

With regard to genetically modified organisms, communication with the public will be essential for public acceptance. CRISPR is a very promising technology in the field of genome engineering. However, it also raises important ethical and regulatory questions. In this area as well, scientists must learn to communicate better to explain this technology to the public and gain their acceptance.

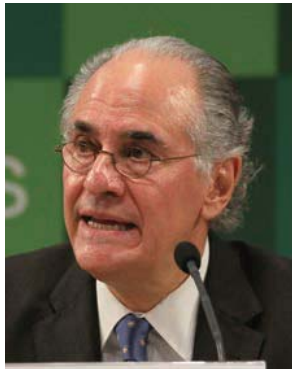
In terms of environmental factors affecting health, one development is the rise in allergies among children due to air population. Societies need to be educated to raise awareness about this.

The concept of one health must be embraced, whereby veterinarians and physicians work together to tackle animal-borne diseases. The outbreak of Zika recently captured global headlines. The reason that the science and technology for tackling Zika has developed so rapidly is due to high public awareness, spurred by exposure in the news, which has helped direct resources to the field.

As for healthy aging, an important question is what to do about the retirement age and how to help the transition from the workforce into retirement. Additionally, when treating health issues, the age of the patient should be taken into account, and training on this should be provided to physicians.

Prof. Hiroyuki Abé presented the key messages from three of the engineering and innovation concurrent sessions. Industrial innovation is a major topic of interest for many countries. One example is Germany's Industrie 4.0, a fourth industrial revolution combining manufacturing and ICT. In this area, collaboration between academia and industry that is based on mutual respect will be essential. Fostering common understanding on the importance of open innovation is needed.

Nanomaterials are playing a major role in many fields. While there have been many developments in recent years, resulting in nanomaterials with a wide range of functions, there are still many fundamental scientific questions that need to be understood. In addition to the science, attention needs to be paid to the concerns of the people and the role of the government. When introducing new nanomaterials, it is necessary to balance academic understanding of the benefits and risks, and industrial use, to gain the understanding of the public. To this end new modes of research based on public-private partnerships, attention to safety, and public outreach will be important.



Blanco Mendoza, Herminio

New manufacturing technologies, such as 3D printing and introduction of big data, are changing the manufacturing landscape. These technologies have made it possible to produce structural materials with functionality. While new technologies emerge, issues relating to intellectual property rights must be carefully considered. Furthermore, education of the public and future members of the manufacturing industry will be essential to realize the transformation of the manufacturing sector based on these new technologies, which will surely produce many business opportunities in turn.

Johnson, Ray O.

Dr. Herminio Blanco Mendoza presented the key messages from the earth science concurrent sessions. The field of Earth observation is of great relevance to the world. The information gathered by satellites has played an important role in shaping the Paris Agreement. At the same time, more sophisticated satellites are needed to produce more robust databases. Such satellites can be used to promote disaster-preparedness, destroy harmful space debris, or predict the future evolution of the Earth based on observations of Mars and Venus. However, the engagement of high-level government leaders with such satellites is low. Public-private

Gutfreund, Hanoch

Saito, William H.

Rubinstein, Ellis

partnerships, which include insurance companies, could be a viable model for providing funding for satellite research.

The relevance of oceans has finally been recognized by the international community. The lack of knowledge on the ocean is outstanding. Only 13% of the ocean floor has been mapped, despite the fact that the ocean covers 70% of the Earth's surface. Better understanding of ocean ecosystems is needed and this can be advanced by new technologies such as remote sensing systems or genetic techniques.

Water remains a major issue for the world. Only 1% of water in the world is consumable. One key challenge is minimizing wasteful use, the leading source of which is leakage. Technologies for correcting this are promising, but there are other political and regulatory aspects that must be dealt with. Water pollution is another important challenge. One of the main sources of such pollution is micro-plastics dumped in rivers. The provision of water to arid regions is also an important challenge. Fortunately technologies, such as new filtration systems, are emerging, which could help.
With regard to climate change, while NGOs have been reluctant to discuss adaptation techniques in the past, it is now recognized that mitigation and adaptation techniques are key. An example of an area needing adaptation measures is widespread wild forest fires, exacerbated by drought caused by global warming.

Dr. Ray O. Johnson presented the key messages from the cooperation in science and technology concurrent sessions. There is a thin line between competition and collaboration that businesses understand well. The issues faced by the world are increasingly global and interdisciplinary, which requires collaboration across countries and disciplines. More can be gained from cooperation than from competition, provided that such cooperation is carefully managed. Startups play an important role in innovation as well, but need to be supported by government and larger companies.

Falk, Anna

Hagan, Julius Kofi

Government-industry-academia collaboration is a marriage made in heaven. Each of the three sectors plays a vital role in innovation. Governments can pursue a high risk and high reward strategy not possible in the business models of companies. Industry promotes innovation and helps achieve scale. Academia provides the talent and the basic research. STS *forum* also leads efforts to promote such collaboration.

Science and technology diplomacy has been instrumental in promoting international collaboration, even during adverse international situations. Open innovation also supports collaboration. Furthermore, technical talent knows no boundaries. Universities also desire global interactions. In addition, diversity is essential for innovation.

Science and technology is essential for addressing the issues that are emerging in developing countries undergoing rapid growth. At the same time, education is needed to spread the benefits of science and technology as widely as possible in these countries. This cannot be achieved by governments or donations alone, and a sustainable and long-term model is needed.

Prof. Hanoch Gutfreund presented the key messages from the science, technology, and society concurrent sessions. The key global issue that linked the various sessions together was how to feed, cure, and protect the rapidly growing population of the world, while also meeting global climate change targets. Science and technology alone cannot achieve this. This goal cannot be achieved without a change in individual consumption patterns, in behavior of the business community and in national and international conduct. Social science has not been adequately utilized in helping promote such change. There is room for innovation in social science for better understanding of incentives for social change.

Governments need scientific advice on what is feasible and at what cost. But scientific advice should be responsible, reliable and understanding of the worldview and the constraints of policy makers. It should not be authoritative, and should include a range of options. There

is room for developing and improving effective mechanisms of this interaction between the executive and legislative bodies and the scientific community. It would be worthwhile holding deeper discussions on this matter at STS *forum*.

The public awareness and understanding of science and technology is essential and should be improved. Science museums play an important role in this regard. However, there are also strong anti-scientific elements in society, such as fundamental religious beliefs or financial interests of industrial corporations. Confronting these is a multi-dimensional challenge.

Education at all levels, formal and informal, is a major part in achieving the goal defined at the outset. Formal education should attempt to produce flexible graduates that can adjust to rapidly changing technologies. Finally, the overall goal of sustainability requires a broader incorporation of science, mathematics and engineering into basic education. This is essential to form a better informed society in the future.

Dr. William H. Saito presented the key messages from the ICT concurrent sessions. The subject of ICT has continued to gain interest. Innovations in ICT also have implications for other fields, such as life sciences, the environment, cities.

ICT is a broad field, and discussion focused largely on the three main fields of big data, IoT, and artificial intelligence and machine learning. It is not the technical aspects of ICT but the social implications that deserve the most attention. ICT obviously has risks and benefits, but there is no doubt the benefits to society have been extraordinary. The measurement of such risks needs to be improved, so that they can be better managed. The progress of digitalization has also produced challenges such as digital theft, privacy theft, and physical disruption.

ICT technology has transformed markets and societies. It is here to stay. Those who cannot adapt to this will be left behind. Data has also become the new oil, in terms of its value as a resource. There are massive amounts of data in circulation, tied to huge amounts of money. While big data and artificial intelligence may lead to the loss of jobs in the short-term, it has the potential to promote growth and job creation in the long-term. To promote public acceptance, education, not only for schoolchildren but also politicians, is needed.

If IoT is not carefully managed it will become the “Insecurity of Things” or the “Internet of Threats.” Security of data and ownership of data are key topics in this area. Security should be incorporated at the design stage. Furthermore, since no security system is perfect, resilience is also important. ICT is no longer just a technical issue. It has become a driver of economic growth and is therefore a board-level issue.

Mr. Ellis Rubinstein presented the key messages from the cities concurrent sessions and one engineering and innovation session. The world is rapidly urbanizing. There are 30 megacities in the world, with 10 in Asia. Cities are systems of systems, shaped by their people and institutions. At their best they can provide good quality of life for their inhabitants and promote innovation and growth. At their worst they can perpetuate vulnerabilities. Cities need smart governance that integrates science and technology and social science. Transparency of city data to the citizens is also essential.

Cities must also be resilient to disaster. Past disasters, such as the earthquake in Kobe in 1995 and the floods in New Orleans in 2005 and in New York in 2012, were predicted but not enough was done to prepare for them. We must ensure that these mistakes are not repeated. For example, Asia is particularly vulnerable to water disasters.

Finally, 60% of cities have yet to be built. When will smart cities no longer be defined solely as IT-based solutions to efficient energy, transportation and waste systems but also include personalized health care, personalized education, and sustainable food systems?
To build better cities, we must (1) better identify, understand and quantify the elements of the urban system in order to help city managers; (2) stimulate public buy-in to improved systems approaches; and (3) foster interdisciplinary research and integrative planning and implementation.

With regard to artificial intelligence and robotics, the lights and shadows of technological advances are clear: they can relieve humans of repetitive, dirty and hazardous work but put people out of work. But they can also create new, higher-order jobs and create transformational new services such as automated driverless cars, automated warfare removing humans from harm's way, and robots for personalized companions. Moreover, AI is bringing enormous advances in diagnosing disease, educating children, and transforming industries. In addition, we can now envision extraordinary potential in nano-robots, hybrid human-robotic systems and AI-based smart robots. However, public policy and legal and regulatory frameworks have fallen far behind the pace of technological development and government, industry, and academia must come together to address this.

Dr. Anna Falk reported on the future leaders' dialogue with Nobel Laureates. The importance of diversity, bridging different disciplines, and engaging the public were highlighted. In addition the high ratio of women to men among the future leaders is highly encouraging.

Dr. Julius Kofi Hagan shared his thoughts on the future leaders' program. Development of future leaders is essential for the future of the world. The future leaders' program at STS *forum* has provided the opportunity for leaders of the next generation to meet and interact with current leaders in government, academia and industry. This has given them the knowledge and inspiration to make a difference in their own countries and fields of endeavor. He also expressed the possibility of getting the future leaders mentored by the Nobel Laureates so as to follow the progress of the latter.

Discussion

A member of the audience expressed her agreement with the importance of discussing scientific advice. She also pointed out that it was important for scientists to give advice not only to those who shared their views, but even more so to give advice to those who disagreed with them.

Another member of the audience cited the importance of the role of social scientists and requested their greater representation at STS *forum*.

Next, a comment was raised regarding public resistance against the latest ICT developments, such as artificial intelligence. Societies need to think about how to accommodate older workers whose jobs are replaced by technology. In addition, greater discussion on ethical matters is needed. To that end, social scientists have a vital role to play.

Finally, a point was made on the importance not only of social innovation but also social fundamentals, so that the impact of such social innovations can be maximized.

Closing Plenary Session 301: Development and Sustainability for the Future of Humankind

[Session Chair]

McKinnell, Henry A., Chairman, Moody's Corporation, U.S.A.

[Speakers]

Plangsangmas, Luxsamee, Governor, Thailand Institute of Scientific and Technological Research (TISTR), THAILAND

Hunt, Tim, Emeritus Group Leader, Francis Crick Institute, U.K. [Nobel Laureate 2001]

Yamada, Keiji, Governor, Kyoto Prefectural Government, JAPAN

Omi, Koji, Founder and Chairman, Science and Technology in Society *forum* (STS *forum*), JAPAN

Opening Remarks

Chair: McKinnell, Henry A.

Dr. Henry A. McKinnell expressed his hope that the discussions on science and technology in society would not start and end at STS *forum*. He urged the participants to continue discussions and follow up on the connections that they had built.

Dr. McKinnell also spoke about the future. Most of the participants at STS *forum* are part of the first generation to leave a less attractive future than they inherited to the next generation. However, there is reason for optimism. In particular, autonomous driverless vehicles are an exciting development that have the potential to contribute to many different fields, such as more attractive and efficient urban planning, increasing the number areas in the world that can be inhabited, and reducing the impact of economic activity on the environment.

The world is undergoing great change as the result of science and technology. This change needs to be carefully managed to ensure that the lights of such change outweigh the shadows. To achieve that, we need more science in politics, and less politics in science.

Dr. Luxsamee Plangsangmas first spoke about the importance of collaboration. Collaboration across sectors is necessary for tackling the issues faced by the world. STS *forum* is an important venue for promoting such collaboration among government, industry, and academia. Its outreach activities, for example by holding a workshop in Bangkok, are also very valuable for promoting dialogue and collaboration.

In addition, tackling environmental issues is essential for achieving sustainable development. Science and technology is contributing a great deal in this regard. Nevertheless, more needs to be done.

Another crucial subject is human resource development. Knowledge and skills in science, technology, engineering, and mathematics should be promoted to encourage lifelong learning and innovation-based societies.

Sir Tim Hunt began by discussing oceans and the nature of science. There is very little known about oceans, despite how much of the world's surface they cover. There are many issues that researchers are already aware of, and many more that have yet to be discovered. This ties in to the culture clash between politicians and scientists. On the one hand, politicians, who have to answer to taxpayers, want to be able to quantify the benefits of a piece of funded research, but on the other, scientists explore their respective fields without knowing what they might find.

Sir Tim also described the efforts of Chairman Omi to establish Okinawa Institute of Science and Technology (OIST). The center is international, interdisciplinary, and a departure from traditional universities. Given its location, it is expected to conduct valuable research on

the sea and marine life, both in basic and applied areas, which has the potential to also further our understanding of life on land.

Governor Keiji Yamada expressed his appreciation for the participants of STS *forum* to promote dialogue on science and technology issues and their impact on society. He then discussed the issues facing Japan and local governments in particular. The two main challenges for local governments are the aging of society and sustainable development.

The aging of society is a good example of the lights and shadows of science and technology. While Japan can be proud of its long life expectancy, this also creates an older society. This places a burden on society in terms of providing the necessary care, which is exacerbated by the fact that there are not enough members of the younger generation to cope with this burden. Science and technology, such as artificial intelligence, can help the elderly remain in the workforce for longer. It is also hoped that science and technology can find a way to help improve Japan's low birthrate.

With regard to sustainable development, cities cannot afford to ignore their surroundings and the impact they have on them. Moreover, there are no boundaries when it comes to the global environment and the environmental impact of one country cannot be separated from that of another. As such, it is only by working together and doing our respective parts that we can achieve the goal of global sustainability.

Mr. Koji Omi, Founder and Chairman, Science and Technology in Society *forum* (STS *forum*), began by thanking the participants for their active contributions and expressing his hope that the discussions at the Annual Meeting had yielded valuable insights. He then outlined the major points of discussion over the course of the annual meeting.

Sustainability in all aspects of human life is an ever present challenge. The world needs to develop effective energy sources, while also paying attention to the impact on the environment. Nuclear energy should remain an important option, provided that safety, security, and non-proliferation are ensured.

Better use of resources from the natural world is essential. Food production must be maximized through science and technology. This includes use of genetically modified organisms.

Life sciences have advanced human health around the world and breakthroughs in personalized and preventative medicine are emerging. At the same time all scientists in the life science field must understand the ethical issues associated with these developments.

Advances to ICT have greatly improved our quality of life. However, they also raise concerns related to security and privacy issues. It is also necessary to consider the great potential for ICT to contribute to a variety of other fields as well.

Issues of science and technology, and their impact on society cannot be addressed by scientists alone. STS *forum* is bringing together leaders from policymaking, academia, and industry to jointly tackle these issues. STS *forum* is also promoting greater participation by members of the younger generation and women. Furthermore, STS *forum* will expand on its existing networks to contribute more than ever before to addressing the issues facing mankind.

STS *forum* 2016 - 13th Annual Meeting: Statement

1. The 13th Annual Meeting of the Science and Technology in Society *forum* took place from October 2 to 4, with the participation of nearly 1,200 global leaders in science and technology, policy-making, business, and media from nearly 100 countries, regions, and international organizations.

2. In 2015, the world adopted three major agreements: the Sendai Framework for Disaster Risk Reduction, the UN Sustainable Development Goals (SDGs) to promote a balanced growth that leaves no one behind; and the Paris accords to limit the emissions of greenhouse gases. In that context, our STS meetings here in Kyoto and the events that we organize elsewhere in the world, must focus on ensuring that the good intentions in these agreements are implemented.

Energy, the Environment and Resources

3. For the targets set by the 2015 Paris Agreement to be met, all countries must strive to create sustainable socioeconomic systems while balancing energy needs and care for the environment. More emphasis needs to be placed on finding scientific and technological solutions to achieve a low-carbon society. While new and renewable energies will be an essential part of the solution, nuclear energy as a low-carbon energy source should also remain an important option under the conditions of safety, security and non-proliferation.

Life Sciences and Global Health

4. The rapid transformation of the life sciences opens very promising avenues of therapeutic treatment. But these technologies also raise some ethical concerns especially with potential impacts on germline or hereditary changes. Further progress in personalized and preemptive medicine should be encouraged, with due attention given to safety and ethical issues.

5. The rapid development of diagnostics, vaccines, and therapeutics to combat emerging infectious diseases presents scientific, manufacturing, and regulatory challenges. Novel approaches are needed for developing a response to the emergence of antibiotic resistant strains of bacteria that will bring back lethal diseases of the past, and which threaten literally millions of people worldwide. A new international system is required to improve regional and international collaboration led by the WHO.

ICT and Smart Cities

6. As it connects the world, ICT is also drastically changing economic activities and our lives, and thus a global-level consensus is needed on universal ICT rules for improved security and privacy. Personalized hand-held devices and access to the "cloud" are making possible innovative new services that can serve the needs of populations in developing countries, especially including women. The "Internet of Things" and use of "Big Data," as well as the emergence of "AI" and "robotics," will create new opportunities for society, but they raise challenges in our understanding of the social benefits and disruptions that machines bring. More active use of ICT in urban planning and management would make human habitats in the new smart cities more livable, humane, disaster-resilient, and energy-efficient.

7. Increasingly, we need to reflect on the relationships between people and the virtual world of ICT. We must think about how ICT will impact on social solidarity and the sense of responsible citizenship that we assume are the pillars for creating an inclusive and sustainable society, a society concerned with the future of employment and retirement, as well as inequality and poverty, and intergenerational connections and equity.

Population and Food

8. Beyond energy, we must provide more food for a growing global population, who will also demand more balanced diets. Producing food under changing climate conditions will require mobilization of science and technology to better manage the available land and water sustainably, while we deploy the best science, including GMOs, to develop new plant varieties with greater drought and salt tolerance and shorter growing seasons.

Science, Technology and Education

9. Scientists should give the public correct information on all topics from climate change to GMOs, so that they can better understand the issues and compare benefits and risks, and support innovative and potentially useful applications of science and technology.

10. STEM education should be emphasized and high-quality science programs developed to interest and inform the public about the role of science and technology in society, and how it helps with sustainability. Emphasis on fostering younger generations and empowering women in all societies would bring forth their talent and would also help enhance sustainable development.

Cooperation in Science and Technology

11. Nurturing Science, Technology and Innovation (STI) requires collaboration between academia and business in addition to the central role of government in funding basic research and providing the regulatory framework within which the private sector brings forth new products, services and business models.

12. International cooperation between the scientific communities of the various countries is essential. Collaborative efforts through open innovation should be continued while at the same time, issues related to intellectual property and technology transfer are addressed.

13. This year, the STS *forum* held workshops in major cities Brussels, Delhi, Bangkok, and Nairobi. We have also established an "STS *forum* Future Leaders Program" involving more than 100 active young leaders. We will build on and expand the network we have established to further address the opportunities and challenges facing humanity.

14. We look forward to meeting here again next year. We agreed to hold the 14th Annual Meeting of the STS *forum* in Kyoto from Sunday, October 1 to Tuesday, October 3, 2017.

Council Members

In alphabetical order of individual names

* Board Members / ** Auditor

ABDUL HAMID, Zakri, Science Advisor to the Prime Minister of Malaysia, Malaysian Government, MY

AHO, Esko, Executive Chairman of the Board, East Office of Finnish Industries; former Prime Minister, FI

ALBERTS, Bruce M., Professor Emeritus, Biochemistry and Biophysics Department, University of California, San Francisco (UCSF), US

ANZAI, Yuichiro, President, Japan Society for the Promotion of Science (JSPS), JP

ARIMA, Akito, Chancellor, Musashi Academy of the Nezu Foundation; former Minister of Education, Culture, Sports, Science and Technology; former President of University of Tokyo, JP

BAI, Chunli, President, Chinese Academy of Sciences (CAS), President, The World Academy of Sciences (TWAS),CN

BLANCO, Herminio, Founder and Chief Executive Officer, Soluciones Estratégicas, MX

CAMPBELL, Donald W., Senior Strategy Advisor, Davis LLP, CA

CARTY, Arthur J., Research Professor and Executive Director, University of Waterloo Institute for Nanotechnology, CA

CHUBACHI, Ryoji, President, The National Institute of Advanced Industrial Science and Technology (AIST), JP

CHUBAYS, Anatoly B., Chairman and Chief Executive Officer, OJSC "RUSNANO", RU

CHUCHOTTAWORN, Pailin, Chairperson, Board of Vidyasirimedhi Institute of Science and Technology (VISTEC); Chairperson, Kamnoetvidya Science Academy (KVIS), TH

CICERONE, Ralph J., President Emeritus, National Academy of Sciences (NAS), US

CLARK, Megan, Advisory Board Member, Bank of America Merrill Lynch, AU

COLOMBANI, Pascal, Director and honorary Chairman, VALEO; Vice-chairman, French National Research Strategy Council, FR

COLWELL, Rita R., US Science Envoy; Distinguished University Professor, Center for Bioinformatics and Computational Biology, University of Maryland and Johns Hopkins University, US

CONNELLY, Jr., Thomas M., Executive Vice President and Chief Innovation Officer, DuPont, US

DIJKGRAAF, Robbert, Director and Leon Levy Professor, Institute for Advanced Study (IAS), Princeton, NL

DURONGKAVEROJ, Pichet, Minister, Ministry of Science and Technology, TH

FRIEDMAN*, Jerome I., Institute Professor and Professor of Physics Emeritus, Massachusetts Institute of Technology (MIT); Nobel Laureate, US

FUCHS, Alain, President, French National Centre for Scientific Research (CNRS), FR

FURSENKO, Andrei A., Presidential Aide, Presidential Office; former Minister of Education and Science, RU

GOLDIN, Daniel S., Chairman and Chief Executive Officer, The Intellisis Corporation; former NASA Administrator, US

GREGORIAN, Vartan, President, Carnegie Corporation of New York, US

GROS, François, Honorary Permanent Secretary, French Academy of Sciences, FR

GUTFREUND, Hanoch, Executive Committee Chairperson, Israel Science Foundation, IL

HACKER, Jörg, President, German Academy of Sciences Leopoldina, DE

HAMAGUCHI, Michinari, President, Japan Science and Technology Agency (JST); former President, Nagoya University, JP

HARA, George, Chairman of the Board, The Alliance Forum Foundation/Cabinet Office of Japan, JP

HASSAN, Mohamed, Co-Chair, iap, SD

HOFFMANN, Jules Alphonse, Member, French Academy of Sciences; Nobel Laureate, FR

HOLLIDAY*, Jr., Charles O., Chairman, Royal Dutch Shell plc.; Chair, Council of the National Academy of Engineering; Chairman Emeritus, Council on Competitiveness; former Chairman and Chief Executive Officer, DuPont, US

HOLT, Jr., Rush D., Chief Executive Officer, American Association for the Advancement of Science (AAAS); former Member of U.S. House of Representatives, US

HÜTTL, Reinhard, President, acatech (National Academy of Science and Engineering); Scientific Executive Director, German Research Centre for Geosciences (GFZ) , DE

IGLESIAS, Enrique V., former Secretary-General, Ibero-American General Secretariat (SEGIB), UY

ISHIGE*, Hiroyuki, Chairman and Chief Executive Officer, Japan External Trade Organization (JETRO), JP

ISKANDAR, Marzan A., former Chairman, Agency for the Assessment and Application of Technology (BPPT), ID

JOHNSON, Ray O., Executive Director, QxBranch; former Senior Vice President and Chief Technology Officer, Lockheed Martin Corporation, US

JUMA, Calestous, Professor of the Practice of International Development, Belfer Center for Science and International Affairs, Harvard University, KE

KAGERMANN, Henning, President, acatech (National Academy of Science and Engineering), DE

KING, David, Special Representative for Climate Change, Foreign & Commonwealth Office, UK Government, UK

KLEIBER, Michał, Vice-president, European Academy of Sciences and Arts; former President, Polish Academy of Sciences (PAN); former Minister of Science and Technology, PL

KLEINER*, Matthias, President, Leibniz Association, DE

KOANANTAKOOL, Thaweesak, President, National Science and Technology Development Agency (NSTDA), TH

KOMIYAMA*, Hiroshi, Chairman of the Institute, Mitsubishi Research Institute, Inc.; President Emeritus, The University of Tokyo, JP

KUMAR*, Ashwani, Member of Parliament of India, Rajya Sabha (India); former Minister of Science and Technology, IN

KUROKAWA, Kiyoshi, Adjunct Professor, National Graduate Institute for Policy Studies (GRIPS); Chairman, Health and Global Policy Institute, Japan, JP

LEE*, Yuan Tseh, former President, International Council for Science (ICSU); President Emeritus; Distinguished Research Fellow, Institute of Atomic and Molecular Sciences, Academia Sinica; Nobel Laureate, CHINESE TAIPEI

LIM*, Chuan Poh, Chairman, Agency for Science, Technology and Research (A * STAR), SG

LIU, Peng, Managing Director, Sinocity Investment Limited, CN

MATSUMOTO, Hiroshi, President, RIKEN, JP

McBEAN, Gordon, President, International Council for Science (ICSU); Professor Emeritus, University of Western Ontario, CA

McKINNELL*, Henry A., Chairman, Moody's Corporation; Chairman, Emmaus Life Sciences, US

McNUTT*, Marcia, President, National Academy of Sciences, US

MEUNIER, Bernard, President, French Academy of Sciences, FR

MUROMACHI*, Masashi, Executive Advisor, Toshiba Corporation, JP

NAKANISHI*, Hiroaki, Chairman and Chief Executive Officer, Hitachi Ltd., JP

NOYORI, Ryoji, Director-General, Center for Research and Development Strategy (CRDS), Japan Science and Technology Agency (JST); Nobel Laureate, JP

NURSE*, Paul, Director and Chief Executive, The Francis Crick Institute; former President, The Royal Society; Nobel Laureate, UK

OKIMURA**, Kazuki, Chairman, Japan Foundation of Public Communication on Science and Technology (PCOST), JP

OMI*, Koji, Founder and Chairman, Science and Technology in Society *forum* (STS *forum*), JP

ONISHI, Takashi, President, Science Council of Japan (SCJ), JP

PALIS, Jr., Jacob, President, Brazilian Academy of Sciences (ABC), BR

PRIYANTO, Unggul, Chairman, Agency for the Assessment and Application of Technology (BPPT), ID

RAMAKRISHNAN, Venkatraman, President, Royal Society; Nobel Laureate, UK

RIETSCHEL, Ernst Th., European Affairs Representative, acatech (National Academy of Science and Engineering), DE

ROBERTS, Richard J., Chief Scientific Officer, New England Biolabs Incorporated; Nobel Laureate, UK

RUBBIA, Carlo, Scientific Director, Institute for Advanced Sustainability Studies e.V. (IASS); Nobel Laureate, IT

RÜBIG, Paul, Chairman, Science and Technology Options Assessment (STOA); Member, European Parliament, AT

RUBINSTEIN, Ellis, President and Chief Executive Officer, The New York Academy of Sciences (NYAS), US

SAKAKIBARA*, Sadayuki, Chairman, Keidanren (Japan Business Federation); Chief Senior Advisor, Chief Senior Counselor, Toray Industries, Inc., JP

SERAGELDIN*, Ismail, Director, Library of Alexandria; Advisor to the Prime Minister for Cultural, Scientific and Museum Affairs, EG

SHIRAO*, Takayuki, Executive Director, Science and Technology in Society *forum* (STS *forum*), JP

TAHA, Elzubair B., Governor, Gezira State; former Minister of Science and Technology, SD

TANIGUCHI, Tomihiro, Senior Adviser, Science and Technology in Society *forum* (STS *forum*), JP

UCHIYAMADA*, Takeshi, Chairman of the Board, Toyota Motor Corporation, JP

WALLBERG*, Harriet, University Chancellor, Swedish Higher Education Authority; Professor of Physiology, former-President, Karolinska Institutet, SE

WALPORT, Mark, UK Government Chief Scientific Adviser, Government Office for Science, UK

WAMBUGU, Florence M., Chief Executive Officer, Africa Harvest Biotech Foundation International (AHBFI), KE

WINCE-SMITH, Deborah L., President and Chief Executive Officer, Council on Competitiveness, US

YEO, Philip, Chairman, Economic Development Innovations Singapore (EDIS); Chairman, SPRING Singapore, SG

YONEKURA, Hiromasa, Counselor, Sumitomo Chemical Co., Ltd. JP

YOSHIKAWA*, Hiroyuki, Special Counselor to the President, Japan Science and Technology Agency (JST), JP

ZEHNDER, Alexander J.B., President and Founder, Triple Z Ltd.; former President of the ETH Board, Swiss Federal Institute of Technology (ETH), CH

ZERHOUNI, Elias A., U.S. Science Envoy; President of Global Research & Development, Sanofi SA, US

ZULKARNAIN, Iskandar, Chairman, Indonesian Institute of Sciences (LIPI), ID

(86 Council Members from 28 countries and regions, 1 international organization including 20 Board Members and 1 Auditor)

As of November 1, 2016

Members

BELGIUM
- EUREKA
- Solvay S.A.

CHINA
- Huawei Technologies Co., Ltd.
- New China Gathering (Beijing) Investment and Consulting Co., Ltd.

DENMARK
- Novo Nordisk A/S

FRANCE
- Électricité de France (EDF) SA
- Gemalto NV (The Netherlands)
- Sanofi SA
- Total S.A.

GERMANY
- German Academy of Sciences Leopoldina
- Robert Bosch Stiftung GmbH
- German Research Foundation (DFG)

INDIA
- Biotechnology Industry Research Assistance Council (BIRAC)
- Escorts Limited
- Indosolar Limited
- Reliance Industries Limited
- Tata Consultancy Services Limited
- Technology Information, Forecasting and Assessment Council (TIFAC)
- Toyota Kirloskar Motor Pvt. Ltd.

ITALY
- National Research Council (CNR)

JAPAN
- Ajinomoto Co., Inc.
- ANA Holdings Inc.
- Astellas Pharma Inc.
- Chiyoda Corporation
- Chugai Pharmaceutical Co., Ltd.
- Daiichi Sankyo Company Ltd.
- Daikin Industries, Ltd.
- Denso Corporation
- East Japan Railway Company
- Fujitsu Limited
- Hitachi, Ltd.
- Honda Motor Co., Ltd.
- Horiba, Ltd.
- Idemitsu Kosan Co. Ltd.
- IHI Corporation
- Japan Tobacco Inc.
- JEOL Ltd.
- JX Nippon Oil & Energy Corporation
- KDDI Corporation
- Kobe Steel, Ltd.
- Konishi Decorative Arts and Crafts Co., Ltd.
- Mitsubishi Chemical Holdings Corporation
- Mitsubishi Corporation
- Mitsubishi Electric Corporation
- Mitsubishi Heavy Industries, Ltd.
- Mizuho Financial Group, Inc.
- Murata Machinery, Ltd.
- Nichicon Corporation
- Nippon Steel & Sumitomo Metal Corporation
- Nippon Telegraph and Telephone Corp. (NTT)
- Nissan Motor Co., Ltd.
- Nomura Holdings, Inc.
- Omron Corporation
- Osaki Electric Co., Ltd.
- Shimadzu Corporation
- Sumitomo Chemical Co., Ltd.
- Sumitomo Mitsui Banking Corporation
- Takeda Pharmaceutical Co., Ltd.
- Takenaka Corporation
- The Bank of Tokyo-Mitsubishi UFJ, Ltd.
- The Okinawa Electric Power Co., Inc.
- Tokyo Electron, Ltd.
- Tokyo Gas Co., Ltd.
- Toray Industries, Inc.
- Toshiba Corporation
- Toyota Motor Corporation

KOREA
- Lotte Chemical

LUXEMBOURG
- International Technology Solutions

MALAYSIA
- Malaysian Industry-Government Group for High Technology (MIGHT)

NETHERLANDS
- Royal Dutch Shell

OMAN
- Saud Bahwan Group

QATAR
- Qatar Foundation

RUSSIA
- Fund for Infrastructure and Educational Programs (Rusnano)
- R-Pharm

SAUDI ARABIA
- King Abdulaziz City for Science and Technology (KACST)
- Saudi Aramco

SWITZERLAND
- Novartis International AG
- Philip Morris International Management S.A.

THAILAND
- PTT Public Company Limited

TURKEY
- Arçelik A.Ş.

U.K.
- Anglo American plc
- British American Tobacco Plc.

U.S.A.
- World Resources Company

American Associates of the STS *forum* (AA-STS)
- Carnegie Corporation of New York
- Gordon and Betty Moore Foundation
- Honeywell International
- Lockheed Martin Corporation
- Thermo Fisher Scientific
- UL LLC

Associated Members
- Osaka Gas Co., Ltd. (Japan)
- Resona Bank Ltd. (Japan)
- Saitama Resona Bank Ltd. (Japan)

As of November 1, 2016

STS *forum* 2016 Summary – 13th Annual Meeting
Issued by Koji Omi
Edited by Science and Technology in Society *forum* (STS *forum*)
Sanno Grand Building 419, 2-14-2 Nagatacho, Chiyoda-ku, Tokyo 100-0014, Japan
Tel: +81-3-3519-3351

Lead Sponsors

HUAWEI

مدينة الملك عبدالعزيز للعلوم والتقنية KACST

مؤسسة قطر Qatar Foundation
Unlocking human potential لإطلاق قدرات الإنسان

TOYOTA

Regular Sponsors

HITACHI
Inspire the Next

MITSUBISHI ELECTRIC
Changes for the Better

NTT Group

NOVARTIS

SAUD BAHWAN Group

أرامكو السعودية saudi aramco

TEL
TOKYO ELECTRON

"TORAY"
Innovation by Chemistry

TOSHIBA
Leading Innovation

UL

STS *forum* (NPO)
Sanno Grand Building 419, 2-14-2 Nagatacho, Chiyoda-ku, Tokyo 100-0014, Japan
Tel: +81-3-3519-3351 Fax: +81-3-3519-3352
http://www.stsforum.org