The 11th Annual Meeting

STS *forum* 2014

Summary

October 5, 6 and 7, 2014
Kyoto, Japan

Science and Technology in Society *forum*

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Statement

1. The 11th Annual Meeting of the Science and Technology in Society *forum* took place from October 5 to 7, with the participation of about 1,000 global leaders in science and technology, policy, business and media from approximately 100 countries, regions and international organizations who met to reflect on how to strengthen the "lights" and control the "shadows" of science and technology.

2. We are highly honored that Japanese Prime Minister Shinzo Abe, who has attended the forum four times, has now accepted to serve as honorary chairman of this forum. His leadership, based on profound insights into humanity's future and the role of science and technology in society, will contribute greatly to our forum achieving its goals.

3. The STS *forum* has entered its second decade. It is with satisfaction that we see that the forum has grown from a mere conference into one of the most important movements for global leaders, and we will build on and broaden the network we have established to further address the problems facing humanity and seek solutions. As part of our mandate, at this year's meeting the forum fully instituted an "STS Young Leaders Program" inviting more active participation of younger leaders. We will also hold workshops in major cities of the world, including Beijing, Berlin and Kuala Lumpur, before the next Annual Meeting, to expand the forum's activities.

4. The STS *forum* will thus be reaching out to expand the communities with which it is involved. The quest for a sustainable future for humankind will require greater collaboration between science and society, to increase public trust and promote significant changes in individual and social behavior. Exchanges between scientists and society should be broadened and improved so that the public can make informed decisions, provided that the risks and benefits are clearly explained. In addition, the importance of STEM education should be highlighted and high-quality science programs should be developed to interest and inform the public about the role of science and technology in society. The arts, humanities, social and political sciences and social innovations are also key elements.

5. Out of that intensified interaction, we strive to develop a coalition that includes the public and private sectors, academia, government and industry as well as the civil society. This coalition will help develop inclusive frameworks that cover the entire global community, frameworks that will expand the role of women and give greater voice to academies of science, engineering and medicine. Chief Technology Officers will become bridges between business and the developers of science and technology in universities, private labs and the public sphere, to nurture innovation.

6. Industrial innovation driven by new manufacturing technologies, robotics, nanotechnology and new materials is playing a vital role in various areas including product development, healthcare and urban living. Agricultural innovation will also be needed as climate change will challenge the production patterns in many parts of the world and aridity makes itself felt in larger geographic zones.

7. It will be necessary to link the innovations in one part of the world to others that need them, thereby ensuring that sustainable solutions spread throughout the planet and that expanding populations, especially in the poorest countries, find the means for decent living standards by husbanding resources and working with new plant varieties of more drought tolerant and salinity resistant plants to ensure food security despite the vast and expanding aridity that will be spreading in large parts of the globe.

8. Science and technology diplomacy enhances relations across national boundaries. Supporting education, research and local entrepreneurship is essential for capacity-building in developing countries. Funding agencies should finance international science collaboration programs promoting multilateral arrangements, especially on global issues. Competition and cooperation among industries focusing on science and technology in the global economy today are increasingly important.

9. Global environmental problems are reaching a critical stage. The need for a consensus on specific measures to reduce CO_2 emissions is urgent. The adjunct session on Regional Action on Climate Change (RACC6) reviewed best practices to promote resilience, and to explore mechanisms that would enhance the incentives for communities and institutions to build up their resilience ahead of the likely severe weather phenomena which different parts of the world will witness; and encouraged initiatives through Knowledge Action Networks, for example, to prepare coastal cities and regions for sea level rise. RACC6 will cooperate closely with "Future Earth," a new 10-year international research initiative begun in 2013, and will organize a workshop in Alexandria before next year's meeting.

10. The environment we live in and the ecosystem we are part of are not just the land mass we inhabit and the atmosphere that envelops us. By far the greatest part of our planet is covered by water: the oceans and the glaciers and the surface waters that replenish the moisture in the earth, in a hydrological cycle that allows life to exist. The oceans and their deep currents are central to the climate and the management of GHG emissions and the improved understanding of the oceans and the fresh waters of the earth are at the core of developing effective sustainable development futures for humans, with adequate energy, good health and a rich social life.

11. The shale gas and oil revolution has opened a new phase in the world's energy supply. We must recognize that any future energy supply should include a wide range of options that adhere to the best standards of safety and environmental and social compatibility. Over the long term, continued burning of fossil fuels will exact an unacceptable environmental cost. We will need diverse energy sources, and nuclear power will remain an important option. Intensive enhancement of nuclear safety, security and non-proliferation are also vital.

12. In the area of global health issues, research into genomic and regenerative medicine has developed very rapidly. iPS cells have high potential to generate breakthrough technology for cures, and research into personalized and preemptive medicine should also be accelerated together with scientific knowledge on nutrition. Promoting brain science research will contribute to improving quality of life, especially among aging populations. There is more need than ever for a new international system to improve collaboration among industry, academia, the public sector and WHO for global health. It is also urgent to strengthen the global community's capacity for dealing with infectious diseases, including Ebola hemorrhagic fever.

13. ICT, especially with the emergence of "Big Data," is changing everything, from research to production, from education to entertainment, from discussion to discovery. A global-level consensus on universal ICT rules is needed, with particular emphasis on security and privacy. The merging of the internet with mobile telephony will transform society and also assist the increased empowerment of women, in advanced and developing countries alike, by encouraging more female participation in research and development, education and entrepreneurship.

14. More than half the world's population is already living in cities; rapidly growing urbanization raises a variety of challenges and opportunities. More livable, humane and safer urban environments must be developed using science and technology for urban planning to create "smart cities," to support the evolution of cities, peoples, values and cultures.

15. The world's population should not continue to expand indefinitely, as the earth is finite. We need to think of humanity's condition from the perspective of 100 or 500 years from now and promote global cooperation on the management of resources and waste. In this respect, living in harmony with nature is of the utmost importance and we will therefore continue to focus on sustainability for humankind and our planet. We are all committed to activities to pave the way for future generations.

16. We look forward to meeting here again next year. We agreed to hold the 12th Annual Meeting of the STS *forum* in Kyoto from Sunday, October 4 to Tuesday, October 6, 2015.

Day 1

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

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

Session Chair

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

Speakers

Shinzo Abe, Prime Minister of Japan
Laurent Fabius, Minister of Foreign Affairs and International Development, France
France A. Córdova, Director, National Science Foundation, U.S.A.
Sadayuki Sakakibara, Chairman, Toray Industries, Inc. and Keidanren, Japan
Pichet Durongkaveroj, Minister of Science and Technology, Thailand

The opening plenary session focused on the primary goal of the STS forum – controlling the shadows and increasing the lights of science and technology for society. New and key themes to emerge in recent years include ICT, regenerative medicine, and renewable energy. When discussing these or any other fields in the context of science and technology policy, we must ensure that research results impact society at large, understand that no country can operate alone, and take a truly long-term view, extending far beyond our lifetimes. The session kicked off three days of vigorous and fruitful discussions.

Mr. Koji Omi, Founder and Chairman, Science and Technology in Society (STS) *forum*, Japan, opened the 11th annual meeting of the STS *forum*. He began by expressing his gratitude to Prime Minister Shinzo Abe for agreeing to serve as Honorary Chairman of the STS *forum*. Mr. Omi also expressed his thanks to all the participants for their attendance.

STS *forum* was started 10 years ago to discuss the lights and shadows of science and technology, and acts as a venue for discussing future policies to control the shadows and increase the lights of science and technology for society. STS *forum* has grown from a conference to a worldwide movement. It is recognized as a venue for science and technology discussion by leaders around the world. Mr. Omi requested the further contribution of all participants, so that the STS *forum* can continue to act as a more fruitful forum for global leaders. One particular focus of the STS *forum* is ICT. While the spread of ICT has changed society and our lives, it has also raised a variety of issues, such as security risks. Another key theme for this year's forum is energy issues, including renewable energy and how to deal with nuclear energy. As for regenerative medicine, research in iPS cells has helped create new forms of drug delivery and medical treatment. Food, water, oceans, and other issues are also important matters for people and society, and were to be discussed at the *forum*.

Alongside this year's forum, an STS Young Leader's *forum* has also been established to encourage greater participation from younger members of society. In addition the STS *forum* also holds peer meetings for various participants.

Science and technology issues concern all members of society and should not be left up to the science professionals alone. Furthermore, this cannot be left up to just one or two countries, and requires a worldwide effort. That is why the STS *forum* has brought together leaders in diverse fields to discuss the issues of science and technology for society. Moreover there must be a truly long-term vision, not only 10-20 years in the future, but 100 years into the future as well. Mr. Omi asked that the participants take part not as national representatives, but as human beings concerned with the future of our planet and society. STS *forum* also serves as an opportunity to broaden the network of like-minded people. Finally, Mr. Omi hoped that the participants would engage in frank and open discussion that would help set new and appropriate policy directions to foster a sustainable future for humankind.

Mr. Omi then introduced Prime Minister Abe, the first speaker, who has sought to change Japan and foster growth through innovation driven by science and technology.

Prime Minister Abe expressed his great pleasure and honor to address the STS *forum*. He shared the fact that as Prime Minister he had never failed to attend the STS *forum* each year, believing it to be an important venue for tackling issues facing society.

Prime Minister Abe then quoted a passage from the Jules Verne novel, *The Mysterious Island*, which suggested that "water will one day be employed as fuel." Prime Minister Abe thought this was highly prescient, as sure enough, Japan has since developed fuel cells in 2009, which has subsequently been a key national strategy for Japan. However, it has been more difficult for fuel cell cars to become commercially viable. A major reason has been the number of regulations impeding progress. Prime Minister Abe promised to reduce the number of regulations from 25 to 0, and next year, fuel cell cars will be made commercially available for the first time. In addition, he pointed out that all government ministries would use fuel cell cars, and that all those who purchased a fuel cell car would be eligible for credit.

The Prime Minister spoke next about regenerative medicine and iPS cells. iPS cells have finally been put into practical application. The first experiment using iPS cells was conducted in Japan on an operation for retinal regeneration, a tremendous achievement.

Prime Minister Abe emphasized that innovation was at the heart of his administration's policies. Furthermore, he believed that Japan was at the forefront of issues that will be faced by countries around the world, such as the use of robotics in healthcare, disaster resilience, and creating a fuel-cell driven society, among others. The key to all these lies in innovation, which is also at the heart of the policies supported by the Abe administration, not only in Japan but around the world as well.

Next, Prime Minister Abe announced that the Innovation for Cool Earth Forum would be held the week following the STS *forum*. He hoped the event would generate large enough momentum to lead human society into the future.
Mr. Omi then introduced His Excellency Mr. Laurent Fabius, who as a policy maker, had addressed many pressing issues faced by society.

His Excellency Mr. Fabius first touched upon the Kyoto Protocol, and then discussed the 21st Conference of the Parties on Climate Change (COP 21) to be held in Paris in 2015. He believed the conference's objectives resonated well with the discussions of the STS *forum*. The conference aims to deliver a universal climate agreement for all countries, which would be common and binding, and to help them achieve the necessary transformations to achieve the target of limiting atmospheric temperature to 2 degrees Celsius, thereby mitigating catastrophic climate warming. This would represent a historical milestone after 20 years of discussion under the UN framework.

Science and technology plays a core part in this issue. Firstly, there is the impact of science and technology on combatting climate change. Secondly, science has also been paving the way for international cooperation in tackling climate change. Thanks to scientific data, there are also far fewer climate skeptics than before. Finally, science and technology will play a vital role in shaping the low carbon societies of tomorrow.

That being said, reaching an agreement between 195 countries will not be easy; but several countries have started transitioning to low carbon societies, including countries that were previously reluctant to do so. For example, President Obama of the United States has made the decision to cap emissions from power plants. China has also made ecological civilization its target, and represents the largest market for renewable energy in the world. Brazil too looks set to meet its deforestation reduction targets. Many countries have already agreed to cut their emissions. Japan, too, while set back by the tragedy of the 3.11 disaster, is nevertheless committed to combatting climate change.

Science and technology is a key area of collaboration between Japan and France as well, and the challenge of COP21 is to harness the achievements in science and technology and continue to move forward together.

His Excellency Mr. Fabius then quoted Ban Ki Moon, who said: "Gentlemen, ladies, there is no plan B, because there is no planet B." There is much that society can achieve towards combatting climate change. Permanent interaction between society, diplomacy, and business is

essential as well. It is up to all members to work together to achieve a low carbon future.
Dr. France A. Córdova addressed the STS *forum* next, mentioning that she had the honor of attending STS *forum* on many occasions. She also shared her experience attending the Nobel Prize ceremony for Ei-ichi Negishi and quoted him: "The final reward for any researcher is to see his or her lifetime of work extend beyond academia and laboratories into the mainstream of our society, where it can breathe hope into the world." STS *forum* is an exciting model for doing just that. Science can provide avenues for understanding and enlightenment, bringing together people from diverse countries and backgrounds. Dr. Córdova also believed that the ability to interact with colleagues from developing countries was particularly valuable.

STS *forum* is a rare initiative that started out as great idea that keeps getting better. The National Science Foundation (NSF) is proud to sponsor the Young Leader's *forum*. The NSF also supports progress in science across all fields, and has a long history of international collaboration in these areas. In fact, the first overseas office of the NSF was in Japan.

Dr. Córdova then highlighted one substantial project that was particularly important for her. The Atacama Large Millimeter Array (ALMA) in Chile has received investments from a broad range of fields, and will play a key part in addressing key questions related to the universe. ALMA is the result of the commitment of Japan and NSF to pursuing and supporting basic science.

At the same time, the NSF is devoted to promoting innovation, and has in place initiatives to support high risk R&D. Additionally, its Innovation Core program enables young graduate researchers to identify product opportunities from NSF research. This utilizes a public-private partnership eco-system for fast-tracking results from science into society. NSF's current priorities include broadening participation and widely communicating the impact of scientific achievements.

Dr. Córdova also urged participants to give all members of society the opportunity to participate in scientific enterprises. Despite recent gains, women remain underrepresented in science and engineering. Furthermore, she hoped that the next decade would be the decade of the citizen scientist. Additionally, Dr. Córdova believed that basic research offers keys to the questions that face mankind and looked forward to hearing discussions and opinions about how to achieve this goal.

Mr. Sakakibara expressed his delight at being given the opportunity to address the STS *forum*. Look back at history of mankind, every turning point had a basis in science and technology. He highlighted the coincidence of the development of the steam engine and the industrial revolution. Afterwards, ICT fostered the new paradigm of the knowledge co-economy. The world is facing a variety of urgent issues, and the solutions to these problems can only be found by harnessing the powers of science and technology.

Mr. Sakakibara expressed his strong belief that science and technology would pave the way for a better future, stating that Japanese enterprises were also committed to developing new technologies. He then mentioned the example of carbon fiber, which has a variety of uses in society such as for aircraft construction, which has led to 20% reduction in weight and 20% increase in fuel efficiency. Carbon fiber has also helped reduce the weight of automobiles by 30% contributing to greater fuel efficiency, less emissions, and greater resource conservation.

Next Mr. Sakakibara discussed policy developments regarding science and technology. Under Prime Minister Abe, Japan seeks to promote innovation in science and technology. The Government has formulated a number of specific measures including the establishment of the Council for Science Technology and Innovation. In addition to SIP cross-ministerial initiatives, there is also a new initiative called ImPACT aimed at encouraging high-risk research and development. The latter is the successor to the FIRST program, which provided non-traditional and friendly support to researchers. Keidanren also strongly supports these initiatives, and many of its members have backgrounds in science and technology.

Finally Mr. Sakakibara asked that industry redouble efforts to revitalize Japan and foster innovation. He called for the creations of a national innovation system, and sought greater collaboration between government, business and academia. Innovation and technology could give rise to new industries and Mr. Sakakibara urged Japan to return to its roots as a country driven by technology.

His Excellency Dr. Pichet Durongkaveroj offered his appreciation to Mr. Omi and the STS organizing committee for inviting him to speak. The holding of the STS *forum* for the 11th year reaffirmed His Excellency Dr. Durongkaveroj's belief in the importance of science and technology.

His Excellency Dr. Durongkaveroj highlighted the need to foster international partnerships, share what we have, and work together to solve global challenges. Thailand has been successful in promoting science and innovation for the betterment of society. Examples include the development of a drug for combatting multi-drug-resistant malaria, or systems for water management in rural areas.

Researchers and innovators can share and collaborate with each other in openness and complete transparency. Science and technology cannot stay idle as the world undergoes dramatic transformations. A rational society needs scientific thinking, and its administration needs transparency which can be delivered by science and technology. Science and technology should not be confined to individuals or even individual ministries. Collaboration should be conducted across ministries, countries, and throughout society.

The current Thai government is promoting science and technology and transparency in their implementation, in the belief that science and technology will lift the economy of Thailand higher and pave the way for a better future. The government has provided support for small and medium economies, transformation of education, and technology transfer in support of mega-infrastructure projects. It has also facilitated and established incentives to prioritize research, while also investing in modern science and technology infrastructure. Finally, His Excellency Dr. Durongkaveroj expressed his belief that the future of mankind rested upon science and technology and policymakers.

Mr. Omi thanked all the members for their opening remarks, and said he looked forward to frank and fruitful discussions over the next two and a half days.

Plenary Session 101: Energy and Environment

Session Chair

Gordon McBean, Professor and Research Chair of Institute for Catastrophic Loss Reduction, Departments of Geography & Political Science, University of Western Ontario; President, International Council for Science, Canada

Speakers

Nizar M. Al-Adsani, Chief Executive Officer, Kuwait Petroleum Corporation, Kuwait
Norihiko Ishiguro, Vice-Minister for International Affairs, Ministry of Economy, Trade and Industry (METI), Japan
Andreas Kramvis, Vice Chairman, Honeywell International Inc., U.S.A.
Atsutoshi Nishida, Adviser to the Board, Toshiba Corporation, Japan

Energy and environmental policy are intimately linked. How can we secure a stable and low-cost energy supply, while also controlling greenhouse gas reductions and ensuring sustainable consumption of the earth's resources? Renewable energy sources are certainly important, but there are questions about their economic feasibility. Shale gas has also emerged as a new and viable energy source, but this too comes with environmental risks. Moreover, the situation is being exacerbated by the urbanization of developing countries at an unprecedented rate, accompanied by accelerating rates of consumption. This session sought to find a way to tie together these different pieces of the puzzle.

Opening Remarks

Prof. Gordon McBean opened the first plenary session as its Chair, explaining that the session would address themes related to the economy, environmental issues, technology and a variety of other topics. Prof. McBean stressed the importance of collaboration between government, business, and academia. He also discussed the role of the International Council for Science in fostering progress in science and technology for the benefit of society.

The Council for Science also recognizes the need to integrate all the fields of science to address issues such as climate change, biodiversity, and so forth. In line with this, the Council established and launched Future Earth: Research for Global Sustainability. Traditionally, science proceeds with research and reports results only afterwards. Instead, for this Program, the Council for Science will engage business and government from the very start, and together will co-design, co-produce and co-deliver the scientific findings for society.

Mr. Nizar M. Al-Adsani spoke next. He believed that energy was the lifeblood of the economy, and provided comfort and convenience in everyday living. However, to meet future demand, more efficient use of energy is required. Energy must become increasingly clean as we become a high energy planet. We must innovate and enhance productivity and develop technologies. Kuwait recognizes the urgency of the climate change issue, and will seek cooperation to address this issue, with each country adopting nationally-appropriate mitigation plans.

Developing countries are urbanizing at unprecedented rates. Urbanization means both higher standards of living, but also greater resource consumption. New ideas are needed for tackling this, such as cleaner modes of transport. Moreover, the global goal of limiting the rise in atmospheric temperature to two degrees Celsius is a permanent global issue, and no country acting on its own can solve this issue. The Kuwait Petroleum Corporation is determined to play a role to tackle this issue faced by its society, and is proud of its emissions control systems. Kuwait is devoting intensive efforts to accelerate strategic projects within and outside Kuwait. Mr. Al-Adsani also believed that energy industry is adept at producing innovative solutions to tackling problems faced by society.

Vice-Minister Norihiko Ishiguro spoke next. He began by outlining Japan's policies. Following the 3.11 disaster, Japan has been faced with many restrictions in terms of energy. Japan has reviewed its energy policies and created a new Strategic Energy Plan. Vice-Minister Ishiguro highlighted four key points from the plan, including the realization of advanced energy saving society, acceleration of the introduction of renewable energy, reestablishment of nuclear energy policy, and securing a stable supply and efficient utilization of natural resources. In terms of climate change issues, Japan aims to submit its intended nationally determined contribution (INDC) as early as possible, taking into consideration Japan's energy mix. He highlighted the important role of innovation and technology to reduce global greenhouse gas emissions, as well as the need to diffuse this technology throughout the world. Finally, Vice-Minister Ishiguro expressed his hope that he would also see the participants at the Innovation for Cool Earth Forum (ICEF).

Mr. Andreas Kramvis opened by explaining that Honeywell International is a company with key diverse technologies that drive energy efficiency and tackle climate change. There are significant obstacles in the world from achieving greater greenhouse gas emissions reductions. There is broad consensus that emissions will continue to grow throughout this century, and will have significant impact on the planet and society. At the same time there is growing demand for energy.

In terms of obstacles, there are some who believe that climate change is simply too big to address. However, this is no reason to do nothing. There has also been reluctance to bear short-term costs for significant long term benefits. In the absence of coherent policies, this remains unchecked. Incentives are necessary to counter this issue. Indeed, measures in fields such as the automobile sector have already begun to bear fruit. Legislation also needs to be decisive and technology-neutral.

Governments must encourage technology development in a competitive manner, and can play a role in fostering markets for promising new technologies. For example, Honeywell has a technology that can process plants and algae into real biofuels, as well as a range of next generation products that promote energy efficiency and have very low emissions. Governments can play a role fostering markets for such promising new technologies and must do so in a predictable and transparent manner. There is, therefore, every reason to set about the task of combating climate change now.

Mr. Atsutoshi Nishida addressed the audience next. He pointed out that the population would continue to grow to 9 billion by 2050. In turn, economic activity will increase, as will energy demand. This makes it increasingly important to secure energy sources. At the same time, climate change is a growing source of concern. In 2050 we must reduce greenhouse gases by 74% to half of the emissions in 2010. If efforts to reduce greenhouse gases are delayed to 2030, it will be difficult to limit the increase in atmospheric temperature to two degrees Celsius. COP21 will establish a framework for greenhouse gas reductions from 2020. Mr. Nishida hoped that all countries would accept climate change as the critical issue it is, and take 2010 levels as the base year for reducing climate change, not 1990.

Mr. Nishida advocated two means of tackling climate change which were to reduce greenhouse gas emissions and raise energy efficiency. Future expectations for renewable energy are high, and renewable energy must make up a part of the energy mix. However, difficulties are faced in terms of their economic viability. Japan has introduced a feed-in tariff for renewable energy, for example. Nuclear power will also be one of the base load energies for Japan. Fossil fuels will continue to have an important role to play as a key energy source, especially in developing countries. Therefore, it is key to continue technologies to raise energy generation efficiency. Toshiba has been producing technology that seeks to achieve this goal. At the same time, demand-side initiatives are needed, such as the installation of energy efficient technologies in homes and households, and the development of smart cities. Toshiba has also been contributing to developing smart grids and smart societies.

Next Mr. Nishida pointed out the importance of awareness-raising to save energy. He hoped the STS *forum* would continue to play a major role in combating climate change by bringing together leaders from government, business, and academia, and contribute to future of humankind.

Discussion

A member of the audience pointed out that studies show that reduction in energy consumption and emissions can be achieved through the reorganization of cities and transport. Renewable energies are important, but not enough discussion has been given to reduction in energy consumption. It was therefore encouraging to hear it raised by the panelists, and the participant asked for more information in this regard.

Mr. Kramvis agreed with the comments. He believed coordination was required between government and business and was particularly pleased with the efforts of the Japanese government.

Mr. Nishida highlighted Yokohama as a smart city which has achieved a maximum of 22.8% cut in peak power use. In Lyon, smart devices have also been introduced to demonstrate home-monitoring systems and energy management systems. In addition, it is very important to construct and develop the smart grid itself. ICT could also be used more efficiently for various systems, such as the healthcare system.

Vice-Minister Ishiguro introduced that a variety of experimental projects have been conducted in Japan, and that Japan also promotes feasibility studies for smart communities in foreign countries.

Next there was a comment from a scientist. He believed that while progress had been made in renewable energies, this was not enough. He also noted that while nuclear power would reduce carbon emissions, by 2050 world energy consumption would be 30,000 gigawatts. Given that nuclear power currently account for only 3% of world's energy production and the fact that more plants will be decommissioned, by 2050 they would only account for 1% of global energy production. Therefore, nuclear power needs a new paradigm if it is really going to significantly mitigate greenhouse gas emissions.

Vice-Minister Ishiguro believed it was important to think not only about CO_2 emissions, but also the need for stable energy supply. Both nuclear power energy and renewable energy are important. The key is to find the right balance and come up with an appropriate energy mix in accordance with the progress of technology from time to time, because new technologies might be created 50 years later.

Mr. Nishida believed the time was now to calculate the energy cost and identify the target to be achieved by the end of 2050. If no countermeasures are taken, 30 billion tons of CO_2 in 2010 will rise to 57 billion tons by 2050. Therefore, there is a need to reduce emissions by 74% overall and by 80% in developed countries. This is very difficult to achieve, and more serious efforts are required. Mr. Al-Adsani advocated that each country have its own mix for energy, but believed there was room to develop efficiency in power generation.

A participant asked the panelists whether they believed hydrogen or electric cars were more promising. Mr. Kramvis thought that hydrogen was the more promising technology, but noted the importance of an evolutionary not revolutionary approach to shifting the energy mix, to bring products more smoothly to market.

Prof. McBean summed up the discussions, noting that the participants had agreed on the importance of COP21. He also reiterated the significance of holding discussions on reducing greenhouse gas emissions and energy efficiency. Prof. McBean also supported the idea of bringing together technology in ways to make innovative changes to society. He also highlighted the remarks by Mr. Kramvis that there was a reluctance to share short-term costs for long-term advantages, and urged all parties to work together.

Prof. McBean turned next to smart cities. He believed in the importance of a multidisciplinary approach, not only in terms of different scientific disciplines but also different approaches, spanning policies, systems, and more. Smart cities should also be more resilient cities that are less vulnerable to disaster.

Finally, Prof. McBean thanked the panelists for their efforts and the audience for their participation. He then brought the session to a close.

Plenary Session 102A: The Role of Universities for the 21st Century

Session Chair

Eric Mazur, Area Dean of Applied Physics; Balkanski Professor, Harvard University, U.S.A.

Speakers

Joseph E. Aoun, President, Office of the President, Northeastern University, U.S.A.
Michinari Hamaguchi, President, Nagoya University, Japan
Hakubun Shimomura, Minister, Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan
Thomas Rachel, Parliamentary State Secretary, Federal Ministry of Education and Research, Germany

This session explored how universities will change to meet the demands of a new globalized economy. Universities must teach students how to use and apply information creatively, rather than rely on simple memorization or rote procedures. With the amount of information now available, and the most advanced technology in our hands, we simply cannot limit ourselves to teaching the same way we did in the Middle Ages. We must embrace non-traditional students and new methods of teaching a classroom, such as MOOCs, and shift to learner-centric education with individualized content and a focus on entrepreneurship to help support the society of the future.

Opening Remarks

Prof. Eric Mazur welcomed everyone to the session and introduced the panel of distinguished speakers; including His Excellency Mr. Hakubun Shimomura, Mr. Thomas Rachel, Dr. Joseph Aoun, and Dr. Michinari Hamaguchi.

A few years ago, his daughter was an undergraduate at Harvard University, and noticed she was studying with flash cards. "I have to know all these amino acids," she said, and though he asserted there was an application for that, she replied she couldn't use it on the test. That got him thinking: why do we force students to learn information that we know they will never need? Why don't we embrace IT in education the same way we use it in the workplace?

IT is seen as a groundbreaking tool in academia, but it was not being used in the right way, he felt. Everywhere in the world we can see the effects of technology, even giving the notion to massive open online courses rather than regular lectures at a brick and mortar institution. Prof. Mazur thought we should reflect on what the greatest contribution to education was: the book. He quoted, "Lectures were once useful, but now with books, lectures are unnecessary." This only stood to prove that only "chemistry and the making of shoes" would be best served with lectures, but we see that the quote does not hold. Education is a two-step process: information transfer and for the learner to make sense with the information and do something with it; to extract the mental knowledge and skills that will make them successful in future careers. However, conventional education only values the first step. Just as robots have replaced certain jobs, so will computers replace any jobs that involve memorization or rote procedural problem solving. Many jobs can now be automated, and so university education in the future will have to adapt to that. Universities have to prepare students for jobs that do not yet exist, now teaching global perspectives, resilience, and creativity.

For some universities—typically leading institutions—another mission is research and scholarship. There, professors do not simply teach current knowledge, but also advance the knowledge taught around the world. But this is all done with practices that have barely advanced since the Middle Ages. How do we foster the critical thinking skills needed for the 21st century? How to prepare graduates for an unknown feature? How to prepare universities for that? If we do not, we will only be teaching the students of yesterday.

His Excellency Mr. Shimomura thanked the STS *forum* for giving him the chance to speak. Science and technology drive economic growth, making society dynamic. Since becoming the minister of MEXT, he has done everything possible to foster innovation in science and technology, knowing that it is the key to the future. Universities that make great contributions to science, technology, and the future of humankind will be the root of their philosophy.

The Abe administration has three basic strategies, called the three arrows, for reviving the Japanese economy. They are currently in the middle of implementing the third arrow, to make sure the economy comes back and continues to grow. As part of that, innovation in science and technology is essential for creating breakthroughs. It is clear that universities will play a key role in both aims, producing the thinkers and leaders who will be the wellspring of innovation. It is said that society in the 21st century is intelligence-based. What is the function of a university in such societies? They cannot be an extension of what has come before. The question is if universities can evolve from a new standpoint. How can universities respond to the community, the mission, and indeed the world? They have to maximize their educational resources and create innovation. To do that, university presidents must exercise strong leadership in Japan. Reforming university governance was conducted in June 2014 for that purpose. The next year, all universities would be subject to reform. National universities will build systems that can respond flexibly to change in society. They will develop research capabilities that reach the highest global standards, and they will put into place the systems to attract the best possible researchers. Universities must also ask those with a sense of mission to foster them, and instill in them the need to contribute back to society with their identity as Japanese citizens. That has to be fostered at the high school and university stage. The university admission system must be changed so that there is a stronger link between high school and universities.

Regarding high school education, schools will move away from education that puts too much emphasis on soaking up information for entrance exams. They will switch to peer-based, diversity education. Education will also veer away from traditional one-way lectures, where only the lecturer speaks. Each student will engage in a give-and-take where they can learn independently. Universities will now consider many factors in selecting applicants. They will ask if the applicant can study, if they want to study, and if university education is truly the best option for them. In all these ways, they will take innovative action so that students can become well-rounded. In Japan, society and economy are becoming increasingly globalized. Companies and others are venturing out into the world. They urgently need individuals with strong personal abilities who can play active roles overseas. In order to foster those global individuals, MEXT is sponsoring efforts to send more students abroad and to gather more researchers. They aim to double the amount of study abroad students from 60,000 and double the number of foreign students from 140,000 to 300,000 by 2020. He also discussed MEXT campaigns for sending students abroad with scholarships from private companies, in addition to financial aid. Human resources development and innovation creation at universities will help ensure that Japan can compete globally and continue to grow into the future.

Last, he expected that there will be candid discussion at the STS *forum* regarding these issues, and that they will contribute to the betterment of humankind.

Next, Mr. Thomas Rachel gave his deepest empathy for the victims of the eruption on Mt. Ontake. Germany's centuries-old tradition in science and research laid the groundwork on which the country can build. Important reforms and investment in the last ten years, the financial crisis notwithstanding, have propelled Germany into one of the world's most successful countries. Germany rates 5th in the so-called "Excellence Rate" after the UK, US, Netherlands, and Switzerland. But all of it pointed to the success of a science system that helps us to solve problems of the present and for the future. Despite the diversity of scientific institutions, higher institutions play the key role because they unite research, teaching, and the training of younger scientists.

What is the philosophy of higher education policy? Higher education institutions have to provide training for various students from numerous economic backgrounds. Furthermore, they have to be attractive and competitive for potential international students, have to provide an excellent training of young scientists, and conduct research which is competitive at an international level. No one institution would be able to fulfill those tasks completely. But in Germany they want a system that can meet all of their goals. Universities respond exceptionally well to opportunities and demands if they are granted a great deal of autonomy, but they must use that autonomy responsibly. Germany is spending, in the frame of the Excellence Initiative, about 4.6 billion Euros to remain competitive in that area. The German federal government is spending 2 billion Euros on teacher training to improve study conditions and the quality of teaching and mentoring for students at institutions of higher education.

They also want to have international universities. An efficient higher education system will not and cannot be an isolated German system, but rather one which establishes contacts around the world and remains open. Internationalization and mobility were crucial for university reform in Germany, fostering cultural exchange and knowledge exchange. There were more than 300,000 foreign students at German universities last year, one of the highest numbers in the world, and they want to be further attractive in the future. Foreign students and scientists enrich us with their ideas, and thus their institutions will not only be scientific, but also societal and cultural centers working on an international level. He looked forward to following discussions.

After that, Dr. Joseph Aoun spoke on the subjects of academic leadership and the role of universities in the 21st century. He noted that demographics are an important factor to consider.

In the United States, 85% of learners are now non-traditional, meaning they don't attend four-year college on a fulltime basis, and may not be aged 18-22. Since the majority of universities around the world focus on the 15% of students who are traditional, they fail to address the different needs of the majority. Even as learners are changing, however, so are the skills they require to succeed in today's market. Nowadays, students want customization and personalized higher education. To deliver this, universities can shift to a learner-centric perspective instead of a teacher-centric one, offering individualized content—MOOCs alone are no panacea. Learners also want value and outcomes. They want jobs. Universities can better serve their students by fully integrating classroom experience and work experience. While they're still enrolled in college, they need to develop relationships and skills that will serve them in their careers. Students cannot afford to wait until graduation before they enter the workplace.

In some circles within higher education, theoretical research can be regarded more highly than applied research. Thankfully this is changing, since the problems faced by society are too complex to be solved if we limit our approaches. Use-inspired research that melds theory with practicality is necessary if we wish to address the global challenges ahead. We can learn an important lesson from developing countries like India, where the practice of reverse innovation yields results through research at a marginal cost. This example is a wake-up call for universities, as this form of research is performed with limited resources and translated into valuable products. Universities can learn from such entrepreneurship, embracing it within their institutional cultures. But we also need a new model of entrepreneurship—one that doesn't punish failure or view it as standing in the way of advancement. Failure should be used to learn and to build future successes. At New England Biolabs, for example, an entrepreneurial approach opens researchers to conducting fundamental and applied research, to bringing solutions to market, and to making progress that we cannot afford to ignore.

We change the world through our scholarship and research, but we are extremely conservative when it comes to personal models. This is an impediment that we have to change.

Last up was Dr. Hamaguchi of Nagoya University. Nagoya University had just launched unique doctor programs, called the Asian Campus. That will be started in various Asian countries, and is a hybrid program because it is carried out at the home Nagoya campus and the local branch campuses. This program is a first among Japanese universities.

Why do such a thing? Sustainability. The Asian countries are facing both great growth, but also problems like poverty, global warming, and so on. None of the problems are easy to solve. He believed one of the main missions for universities is to find human solutions for sustainability. For that reason the campuses focus on rule of law, health care, food supply, and reduction of poverty. Second, diversity is a huge initiative. It is not the strongest, nor the most intelligent; it is those who best adapt to change. Universities must reform to survive. Japan appears relatively homogenous, but in contrast other countries are quite rich in it.

Last, based on their history, over two decades Nagoya University has had many of its graduates now playing active roles in their hometown as incentives. Most wish to continue their students as they only have master's degrees, but they cannot suspend their work for long. Their new programs enable those in other countries to obtain degrees in English without having to come right to Japan. They have also dispatched representative skilled in academic writing to each campus. Nagoya aims to make further contributions to the Asian knowledge network with Asia at is core.

Prof. Mazur opened the floor for discussion.

Discussion

The first audience member to speak asked Dr. Aoun about research initiatives, particularly with keeping a balance with foreign researchers who have to balance seeking tenure and receiving enough support to do the research they want to do. Dr. Aoun responded that they are in flux, where the system is forcing people to play very conservatively when they are trying to seek tenure. The only thing they are doing by that is cloning themselves and they cannot afford to do that forever.

One audience member pointed out that they were all discussing training students for the future. He saw a greater threat if universities did not adapt to a composition of students that they need for the future: that the costs of universities were growing absurd and qualified students, exactly the kind they need, were cut off from the system. He asked what they would do, and complimented the German system which offered apprentices, but still sought out a clear answer. He also stressed that they had to reduce the price of education, as well as reduce a bias of sexism when families are forced to make a choice to send their son or daughter. Prof. Mazur responded that he agreed that diversity was incredibly important, and they had a moral responsibility to educate those with talent, not just the money. A number of universities in the US actually did have need-based admission, and he commented that 80% of students at Harvard were indeed receiving financial aid. However, there were few universities who could afford such initiatives. Dr. Aoun also added that the number of students going on to university had dropped to 38% in the US, with South Korea the highest. In order to do that however, they had to adapt to different models. The four year model was terrific, but even things like MOOCs were seen by universities as cheapening their brand, thus the dilemma that schools faced. But destructive innovation was a core of this revolution. Mr. Rachel commented that they were able to raise their percentage of students from 32% to about 50%, given their system where if a student's family didn't have enough money, they could receive a stipend that would allow their student to study. He thought that was necessary because the population of Germany had fundamentally changed—and now tuition was even free.

There was a comment from the audience about how the traditional model was not going away anytime soon, but asked what they thought about the idea of the flex classroom. For instance, he had students follow the MOOC and then do the hands-on work at the university. Prof. Mazur stated that he did exactly that: using the information and showing the students what they can do with it.

The next question came from an audience member from Lithuania, where they were hotly debating the balance of public accountability and university autonomy. He wished to hear opinions from other panelists, about that balance, if they wanted it; and if yes, what mechanisms should apply. Dr. Aoun replied that they had to promote diversity of models, and promote competition and collaboration; that cannot be built. If all decisions are being made by the government, the beauty of competition and collaboration is lost.

One member of the audience was concerned about the role of universities in society and their lessening impact. He thought the role of universities were to contribute to the spread of knowledge of society, but had the feeling that the more they advance technology, more that mass ignorance expands; with the sense that knowledge suddenly becomes concentrated to the elite. He believed that the direction of universities seeking out technological solutions might be dangerous, and that they had to find an equilibrium. Exaggerating the technological side might not be the best choice. In response, His Excellency Mr. Shimomura replied that in any mature nation, it was necessary to place more emphasis on higher engagement. This is related to the session theme; so far, education has placed more emphasis on input, but they had to focus more on the output of education—how to be able to elicit and draw out the potential of each student. So, he thought that mundane work could be replaced by robots or IT, and to meet the needs of jobs of the future, current universities do not respond well to it. They need to enrich creativity in students, and universities must foster that; a path which all mature nations eventually end up at.

The last question was concerned with childhood brain development. The audience member was excited to learn that the process would be starting from high school and instilling the idea that failures are not the end. She was concerned more about early childhood development, such as bilingualism proven to support more creativity; and asked what policies were in place to encourage students to be more creative. His Excellency Mr. Shimomura responded that the question really is what Japan is facing now. As a homogenous nation, how to transform itself into a diverse nation is the main problem they are really trying to solve. So, how to develop talent from an early age and diversifying education itself, especially with school as the main battleground for that, they had to find ways to develop early talent from childhood.

Prof. Mazur closed the session, concluding that they needed many more sessions to fully discuss the issue. But everyone surely was in agreement that fundamental shifts in education were coming, such as from academic to peer-based learning, and from rote memorization to applied lessons. Regardless of what will happen, we all face an exciting future. To quote Dr. Aoun, "We changed the world. Now it's time to change ourselves."

Plenary Session 102B: Research and Innovation

Session Chair

Ryoji Noyori, President, Riken, Japan [Nobel Laureate for Chemistry, 2001]

Speakers

Edward F. Crawley, President, Skolkovo Institute of Science and Technology, U.S.A.
Yoshimitsu Kobayashi, Representative Director; Member of the Board; President and Chief Executive Officer, Mitsubishi Chemical Holdings Corporation, Japan
Lim Chuan Poh, Chairman, Agency for Science, Technology and Research (A*STAR), Singapore
Robert-Jan Smits, Director General, DG Research and Innovation, European Commission, Netherlands
Takeshi Uchiyamada, Chairman of the Board, Toyota Motor Corporation, Japan

Policymakers and business leaders around the world wholeheartedly champion research and innovation, but what do these interlinked processes specifically entail and how do they differ? More importantly, how can we ensure that their fruits are enjoyed by society? This session presented examples of how research and innovation can change our lives for the better, such as the ICT revolution or commercially-viable fuel cell cars. At the same, it also touched upon the difficulty of achieving innovation and highlighted the importance of collaboration between governments, academia, and industry.

Opening Remarks

Prof. Ryoji Noyori opened the session by expressing his excitement at the opportunity to hear opinions from eminent speakers on the topic of research innovation. He also mentioned the fact that Prime Minister Shinzo Abe would make Japan one of the easiest countries in the world in which to pursue innovation. Prof. Noyori emphasized the importance of applying knowledge and taking action. Furthermore, scientific achievement must be in line with the needs of society. The reason for Japan's lack of success in this regard is not for a lack of scientific achievement. Rather, it comes down to the fact that in Japan, there do not exist frameworks for cross fertilization and integration of those achievements. The key is for diverse sectors of society to work together to foster an innovation ecosystem.

Moreover, conventional modifications are no longer sufficient. With the ICT revolution currently taking place, thought must be given to how to change the world. Publically funded scientific research is expected to be open and fair, while the private sector must focus on competitiveness and issues such as preventing information leaks. Significant technological achievements originating in Japan, such as the Shinkansen and the hybrid cars of Toyota, reflect the motivation of Japanese companies to link research and society.

However, looking abroad, the drive for innovation comes not only from industry, but also from basic research. At the same time, corporations must also play a greater role in education, as few educators have experiences in industry in applying scientific achievements.

Finally, Prof. Noyori raised the need for science and technology to address issues faced by society, such as efforts to lift developing countries out of poverty, combat climate change, and contribute to the sustainability of human society. This is also something that Japan actively supports, he stated.

Prof. Edward F. Crawley offered remarks on behalf of Mr. Victor F. Vekselberg, who was unable to attend. Prof. Crawley spoke about the contribution of the Skolkovo Institute of Science and Technology to innovation and research. The goal of the institution is specifically to join research and innovation, and to prepare the way for innovators and entrepreneurs in a Russian context, while building an international university. Universities usually believe that what industry most desires from universities is research results; but actually, more frequently the answer is actually great talent.

When creating an institution from scratch, thought must be given to where the priorities must lie. From a government perspective, when discussing science and technology, industrial growth is the clear goal. The new institute seeks to act as a bridge to connect academia on one side, and industry on the other; accelerate the transfer of knowledge; and educate students who take ideas across the bridge. Producing talented individuals is extremely important. For example, a study showed that companies created by graduates of Stanford and MIT had each contributed 1.5 trillion US dollars to the US economy, whereas the economic effects achieved by technology and patenting produced by universities was an order of magnitude less.

In terms of structure, the institute has no schools and no faculties. There are simply 200 professors who are free to operate as they please. There are no boundaries and no academic programs. The focus is intensely on developing knowledge, skills, and attitudes to be an innovator. Most faculty at universities would not be comfortable with this, but fortunately, as the institute was started from scratch it was possible to recruit faculty who were amenable to this.

Mr. Takeshi Uchiyamada spoke about the FCV. Looking back at history, Mr. Uchiyamada highlighted the production of the Toyota Prius, the first mass-produced hybrid car, in 1997. He considered this to be a historical necessity, and sales of hybrid cars have grown continuously to this day, taking them from a niche to the mainstream. Mr. Uchiyamada was proud that the Prius sparked this change. At the same time, the Prius was innovative for other reasons as well. The technology of hybrid vehicles has also stimulated research into EV, PHV and FCV technology.

Now Toyota has created the first mass-produced fuel cell car. It is expected to go on sale before April 2015 at a suggested retail price of about 7 million yen. The reason the hydrogen technology behind this car is so revolutionary is because it emits water, it is user friendly, and it can be used as a power source in emergencies.

Currently, there are many initiatives to reduce carbon emissions. These often involve the use of renewable energies or smart grid technologies. However, solar and wind power depend on weather and are therefore unstable. Toyota believes that a combination of hydrogen and electricity would be optimal and envisions the creation of hydrogen society. FCVs could help make such societies a reality. They represent an innovative way of addressing environmental and energy challenges. Toyota hopes to change the world by spreading the use of FCVs and the use of hydrogen as a major store of energy.

Under the Abe administration, the Council for Science, Technology and Innovation has been very active in making Japan an even more innovative country. It guides ministries and agencies in allocating research budgets and establishing programs for fostering research. Industry hopes that the projects introduced by the government can change society through industry-academia collaboration. As a resource-poor nation, Japan must make a nationwide effort to promote research and innovation, and work with industry to find applications for this innovation.

The Honourable Mr. Chuan Poh Lim began by pointing out that all governments would position innovation as a number one priority, and would hope to apply research and innovation society. However, it is a very challenging process with many obstacles. Careful coordination is required, as the stakeholders have diverse interests and priorities. In fact, this gap may be growing. Universities continue to seek greater research results with a focus on university rankings, whereas companies are punished by markets and are constantly seeking to push innovations downstream.

The Honourable Mr. Lim highlighted various programs conducted by governments around the world to expedite the translation of research outcomes in society. In particular, the Honourable Mr. Lim highlighted the fact that New York was near the top in the world in terms of acquiring research funding, but ranked far lower in terms of research impact. To address this, a new center, Cornell New York City Tech, was established. These programs all act as intermediaries for bridging research and application with the ultimate goal of generating economic growth.

The Honourable Mr. Lim then spoke about his own organization, the Agency for Science, Technology and Research (A*STAR) in Singapore, which seeks to transform Singapore into an innovation country, and leverage innovation to impact the economy and change lives. Finally, the Honourable Mr. Lim said he would be happy to share the experiences of A*STAR and also learn from the experiences of the other participants in attendance.

Dr. Yoshimitsu Kobayashi discussed the important role of innovation and the movement towards a more sustainable society. Historically the chemical industry has generated innovations for sustainable society, such as renewable energy, membranes for finding water, products to improve health and wellbeing, and so forth.

A pressing issue for Japan is that the Japanese population will see significant decline in its workforce. Unless something changes, Japan will not be able to sustain its current level of prosperity. Game-changing technologies and products are required. While, "Open Innovation" is now seen as the most prevalent model, "value chain collaboration" or "Open Shared Business" is also crucial to the successful scale-up of business innovation. In "Open Shared Business," business processes from procurement to sales are examined for external collaboration.

At the same time, there must be national policies for fostering research and encouraging industry-academia-government collaboration. Furthermore, other policies should include a national program put into place to develop a creative and experienced workforce with an innovation-oriented mind-set, and a more transparent and effective process to assess applied research programs of government.

As most innovation today occurs at the boundaries of different disciplines, we must find mechanisms for bringing people in these disciplines together. For example, the organic chemist can be invited to venues such as workshops with biologists, politicians, industrialists and environmentalists, where innovation can easily occur. In closing, Dr. Kobayashi expressed his belief that there was nothing that human beings could not achieve, and that our futures were only limited by our imagination.

Mr. Robert-Jan Smits spoke next. To begin, he noted that governments around the world are increasingly aware of the importance and impact of science and technology, as exhibited by growing government expenditure in these areas. The European Union has a 7-year program called Horizon 2020, which promotes and supports research targeting challenges faced by society with particular emphasis on impact and output. The program also gives special attention to high growth small and medium enterprises. Furthermore, Horizon 2020 has committed to doubling the budget of frontier research (through the European Research Council). Finally, a unique characteristic of the program is that it is open to all researchers, regardless of country or organization.

In closing, Mr. Smits emphasized the growing need to work closely together to address pressing issues faced by society such as aging population, energy security and food safety. To this end, there is a need to develop common appropriate framework conditions for researchers and other stakeholders to work together effectively across the world.

Discussion

A representative from industry congratulated Toyota on its innovations in developing hybrid vehicles and the fuel cell vehicle. However, he pointed out that these innovations ultimately rely on having clean energy. The participant informed that in all but two states in the US, it was cleaner to drive a hybrid car than a Tesla electric car, because electricity production in the United States is so dirty. While the hydrogen society is an interesting concept, if the production of hydrogen requires burning fuel, then this is not the right way forward. Mr. Uchiyamada commented that when developing the FCV, he was presented with two goals. The first was to develop a 21st century vehicle, and the second was to change Toyota's automobile development process. Mr. Uchiyamada decided to focus on energy and environmental issues for the expanding population and demand from developing countries. He also highlighted the importance of setting a high target to motivate the development team.

Next a member of the audience asked for more details about the Skolkovo Institute for Science and Technology.

Prof. Crawley said that the center only educated graduate students. The faculty size will eventually be around the same size as Caltech, which is roughly 200 professors and 16,000 students. In terms of attracting professors and students, the institute worked very hard to emphasize culture of center as being centered on innovation. Secondly, in terms of strategy, the institute has worked with strategy consultants and MIT to develop a strategy based around research considering use. As for power, the organization has a very clear incentive structure whereby each faculty member is expected to contribute to education, research, and innovation.

A participant from the public sector asked about the role of technology transfer agencies and how sometimes the agencies themselves inhibited this. The Honourable Mr. Lim emphasized that universities were motivated differently from industry. Unless an organization is set up with the mission of closing this gap, it is working closely with both sides, and it has a deep understanding of the wonderful research being produced, it cannot succeed.

Mr. Smits disagreed with the traditional method of knowledge transfers. Instead, he believed that researchers should be informing and working with society and industry from day one of their projects.

Next, a member of the audience asked for advice for policymakers on novel award systems for research and innovation. Mr. Smits argued that the current award systems did not reward multidisciplinary work or collaboration with industry. This needs to change. However, there are many vested interests that would be affected and therefore offer resistance.

The final question concerned how industry could change to better facilitate collaboration with smaller companies. Mr. Uchiyamada believed that to date, there have been many opportunities to collaborate with smaller companies, such as suppliers or systems providers. That being said collaboration is growing increasingly diverse. A more open innovation style is needed.

Dr. Kobayashi believed that the transformation of companies depended on the policy of top management. He also argued that collaboration was better facilitated through human transfer than through any schemes.

Plenary Session 103: Population and Resources

Session Chair

Yuan Tseh Lee, President Emeritus, Institute of Atomic and Molecular Sciences, Academia Sinica, Chinese Taipei
[Nobel Laureate, 1986]

Speakers

Lino Salvador Barañao, Minister of Science, Technology and Productive Innovation, Ministry of Science, Technology and Productive Innovation, Argentina
Alain Fuchs, President, French National Centre for Scientific Research (CNRS), France
Matthias Kleiner, President, Leibniz Association, Germany
Hiroshi Kamiyama, Chairman, Mitsubishi Research Institute Inc.; President Emeritus, The University of Tokyo, Japan
Sorena Sattari Khavas, Vice President for Science and Technology Affairs, Islamic Republic of Iran
Alexander Nikolaevich Shokhin, President, Russian Union of Industrialists and Entrepreneurs (RSPP), Russia

There is no denying the impact of humans on the planet. As the human population grows, so too will our consumption of the planet's resources. The question now is how we can limit this. There is a need for both developed countries to set an example and curb their own consumption, and for developing countries to seek alternative and more sustainable paths to growth. The topics explored in this session included transitioning to knowledge-based economies, sustainable food and energy, and lifelong education.

Prof. Yuan Tseh Lee opened the session, stressing that population and resources are the two biggest factors affecting human impact on the planet. The science is clear. Humanity's impact comes down to human population. While discussions and education about fertility and contraception have helped slow population growth, the impact of such efforts is nonetheless limited, and the outlook is not good. It is currently forecast that the population of the earth will reach 12 billion people by 2100. Furthermore, emerging countries are not only consuming more and more resources, they are doing so less and less efficiently. As such, the problems of population and resource consumption must be urgently addressed. In fact, population and resources was an issue tackled at STS *forum* in 2013. It is critical that we limit both population and consumption in our finite earth. Developed countries should take the lead in shrinking their consumption and impact. Meanwhile, developing countries should seek alternative pathways for growth that are less impactful on the globe and less wasteful.

Dr. Sorena Sattari Khavas spoke of the transition from resource-based value-added economies to economies built on knowledge, as well as the transition from a production base to an efficiency base. The key question is how to accelerate this transition. Understanding the solutions and problems is required. A knowledge economy focuses on human capital, innovation, ICT infrastructure, and so forth. To aid the transition, the development of knowledge-based SMEs and SME networks are essential. However, this will also cause challenges, including the need to provide specialized training for knowledge-based careers, and a shift in literacy from reading and writing to idea and technology literacy. There is also a need for greater recognition of the importance of knowledge utilization.

Governments can create supporting rules and regulations to promote this transition towards a knowledge-based economy. The utilization of knowledge can contribute to growth and increasing knowledge-based assets. These should be harnessed as drivers towards fostering a knowledge-based economy. Prof. Khavas also advocated engaging a greater part of society, including younger people. This can help generate collective action for creating a knowledge-based economy, while simultaneously combatting unemployment.

His Excellency Dr. Lino Salvador Barañao offered remarks next. He believed it was likely impossible to limit consumption and population growth. Instead, he outlined a variety of measures that Argentina has focused on, aimed at solving the problems posed by these issues. First, Argentina aims to end poverty and provide support to this end. The second goal is to end hunger and promote food sustainability. Regarding this second goal, a researcher in Argentina was able to isolate a gene from sunflowers that was able to raise the disease resistance of a variety of agricultural crops. The third goal is lifelong education for all. The next goal is the provision of affordable and sustainable energy for all. In addition, Argentina is seeking to make sustainable use of ocean resources and protect biodiversity. Furthermore, Argentina is strengthening efforts to promote international collaboration to address globally relevant issues. Finally, His Excellency Dr. Barañao expressed his belief that the problems posed by population and limited resources could only be solved by science and technology, and was sure the STS *forum* was a great venue for addressing this.

Dr. Alain Fuchs touched upon a report by MIT entitled *The Limits to Growth*, which addressed the conflict between continued economic and population growth with finite resource supplies. It appears that there still remains no convincing solution to solve this problem. People will surely have to alter their consumption habits. However, there is a risk that people will associate this with a step backwards or a decline in their standards of living. Government policy should make it clear that science and technology and the future of people and society are in fact convergent, rather than divergent goals; and greater efforts are needed to integrate the public into the world of science. Finally, Dr. Fuchs emphasized the urgent need of closing the gap between science and society.

Mr. Alexander Nikolaevich Shokhin spoke about the fact that the Russian economy was faced with a decline in the working population due to the overall shrinking of the Russian population. In light of this, sustainability policy in Russia includes aspects such as job creation. Two years ago, the Russian government set a target of achieving 20 million high-efficiency jobs. One obstacle is the lack of qualified workers, which is a particularly sensitive problem for the Russian government, as well as Russian industry. Therefore efforts are being made to enhance the education system, including qualifications and vocational training. Business in Russia is already engaged in operating vocational training, as well as the assessment of such efforts. Finally, Mr. Shokhin expressed his belief that joint activities between government, business, and civil society would lead to overall sustainability and mutual benefits for all stakeholders.

Prof. Dr.-Ing. Matthias Kleiner believed the identification and discussion of the 17 Sustainable Development Goals (SDG) proposed by the STS *forum* Population and Resources panel was an impressive accomplishment in itself. Prof. Dr.-Ing. Kleiner then outlined the efforts of the Leibniz Association in fostering science and technology collaboration among not only its member institutions, but also in collaboration with industry, as well as bringing the results of science research to society. Prof. Dr.-Ing. Kleiner then shared examples of research conducted by the Leibniz Association that addressed some of these SDGs. For example, in the context of sustainable development and poverty, the Association is pursuing bio-crop research to achieve sustainable food supply. In addition, various Leibniz partners analyze various facets of education, meeting the goal of inclusive and lifelong education opportunities for all. Finally Prof. Dr.-Ing. Kleiner invited all the participants to take part in such cooperative research efforts.

Prof. Hiroshi Komiyama spoke next. He began by stating that man-made artefacts for humans would become saturated. The quantity of artefacts under saturation are correlated with human population. At some point, if energy efficiency is improved significantly, it will become possible to achieve resource sustainability. As for the stabilization of population, combatting poverty is considered the most effective means of doing so. In turn, economic growth is required for generating job opportunities and wealth. Prof. Komiyama said that he had long argued that energy efficiency could be increased by a factor of three on average and believed this was key for countries with saturated populations. Developed countries have to change their consumption patterns while developing countries must also pursue alternative paths to growth. Growth is their right, but they must achieve greater efficiency. Innovation is required to achieve this goal, and developed and developing countries should work cooperatively and synergistically to achieve such innovation. The role of the STS *forum* should be to disseminate throughout society the hope offered by science and technology for addressing the issues we face.

To close out the session, Prof. Lee reemphasized a few points, including the need for global cooperation, for developing countries to seek alternative means of growth to existing developed countries that do not overload the planet, and the need to develop new technologies for better storing energy.

Concurrent Sessions 104 (A-H)

Session Chair

Masakazu Toyoda, Chairman and Chief Executive Officer, The Institute of Energy Economics Japan (IEEJ), Japan

Speakers

Mark K. Boling, Executive Vice President, Southwestern Energy Company, U.S.A.

Guy Caruso, Senior Adviser, Energy and National Security Program, Center for Strategic and International Studies (CSIS), U.S.A.

Shigeru Muraki, Director, Vice Chairman of the Board, Tokyo Gas Co., Ltd., Japan

David Sandalow, Inaugural Fellow, Center on Global Energy Policy, Columbia University, U.S.A.

Phillippe Tanguy, Vice President, International Scientific Development, Total S.A., France

Barend van der Meulen, Head of Department, Science System Assessment, Rathenau Instituut, Netherlands

Anthony Yuen, Director and Global Energy Strategist, Global Strategy and Macro Group, Citi Research, U.S.A.

Concurrent Session 104 A-1: Shale Gas/Shale Oil Revolution

Opening Remarks

The chair opened the session, remarking that the future energy landscape was potentially stormy due to many issues, both positive and negative, including geopolitical developments, addressing climate change, and the great potential as well as the uncertain future of shale gas. Therefore it was suggested that the discussion for the groups was intended to consider how to maximize the benefits while minimizing the negative aspects related to shale gas development.

The first speaker pointed out that a discussion of shale gas and unconventional oil is very appropriate for a conference about innovation, as the technologies involved are in fact a combination of innovative uses of existing technologies. This is helping to replace coal in the US, which is therefore improving GHG emissions, and also allows the US to be a net energy exporter. At the same time, there are a variety of views concerning the future of US oil production. He concluded that the story surrounding shale gas is mostly positive, but the technology is still in its early days.

The second speaker stated that US LNG exports are expected to start in 2016, with total volume exported to the Asian market expected to reach 35 million tons per year by 2020, having a significant impact on Asian LNG trade, and making it more competitive in the energy mix. There are also other new supply sources coming on-stream, and based on these new energy hubs are expected to develop in Asia. Increased trade is expected to make the Asian Premium disappear. The future development of methane hydrate in Japan is also expected to have a large impact.

The third speaker stated that gaining public acceptance for fracturing operations has been a challenge for the industry, despite the benefits brought in terms of reduced fuel prices and lower emissions compared to coal. He explained that when surveyed a majority of people believe that oil and gas companies make too much profit and should be more highly regulated, while only four percent said that oil and gas companies are generally trustworthy. However, when states were surveyed, most agreed that shale gas is important to the economy of the state, and around half felt that the economic benefits exceeded the risks, but a majority still wanted a temporary moratorium to be placed on shale gas development. In order to gain public trust and acceptance, he suggested we need to acknowledge that there are issues to the development of the resources, and move forward with risk management.

The fourth speaker stated that the debate on shale gas is broadened by local actors, including residents, companies and local governments. He noted that we must accept that there are issues that go beyond the immediate impacts of shale gas development, and we must address the differences in strategy between different government departments. There is also a need for a long-term strategy to gain acceptance, and opinions of outside independent experts, which can be a new role for universities.

The fifth speaker highlighted that natural gas, including shale gas, has many advantages: a good geographical spread, large resources, and reduced CO_2 emissions during power generation as compared to coal. One difficulty to convince the population of the importance of gas vs. coal is that CO_2 cannot be seen when burning coal, making it not an immediate concern. At the same time, the oil and gas industry has not communicated well on fracking technology and the impact of shale gas exploitation, which has exacerbated negative reaction and misinformation. Mild earthquake events and the contamination of tap water were attributed to gas shelves, whereas in many cases, the origin was different. The acceptance of risks has a strong societal dimension: human response to risk is largely irrational, with risks such as smoking being acceptable, while lower risks from technologies are not accepted. So far, the shale gas revolution has only occurred in the USA, although some early progress is being made in several countries around the world.

The sixth speaker explained that if US oil production continues to grow at current rates, it will continue to push down oil prices; and with the US becoming a net exporter it will start to generate large income from fuels. This will have an enormous impact. There are questions about whether this is sustainable in the future, and the effects on the Middle East and Russia of depressed oil prices. There is also a risk that lower prices may stifle new development projects.

The seventh speaker sought to answer the question of why the shale gas revolution happened in the US, explaining that it was largely due to a large and high quality resource - although not the largest in the world, the free market system, transferable property rights for mineral resources, tax credits, availability of data through public disclosure requirements, an established natural gas pipeline network, and entrepreneurial spirit. He also noted that greenhouse gas emissions had fallen sharply due to displacement from coal to natural gas, to a level lower than at the time of the Kyoto Protocol discussions 17 years previously, which was something that would have been hard to imagine at that time.

Discussion

The session was divided into groups, who discussed issues including the disclosure of estimates of gas resources for long-term planning related to sustainability; the potential for evidence to turn public opinion with regard to opposition to fracking, given time when compared to other energy sources; the importance of ongoing development of technologies to reduce the impacts of resource development and extraction; and how good science and technology innovations could diminish negative public opinions.

There were also discussions on how to bridge the gaps between perception and reality. In contrast, there was a discussion on the investment in shale gas in the US which is expected to be in the trillions of dollars. It was noted that the case against shale had not been made, and that the opportunity cost to transition to solar, wind and ocean power had not been considered, and that the amount of investment to be made in shale gas would certainly allow other solutions to be made. However, it was noted that shale was geopolitically important for the US, and it was a political decision to continue with development.

It was suggested that in Europe, shale gas was unlikely to be successful due to the desire to protect the landscapes, and with consideration of the opposition to and shortcomings of other energy sources, it could be concluded that Europe could end up becoming more coal intensive.

There was a question raised about how much energy is used in the production of shale gas, and the CO_2 emissions generated during the production process. It was suggested that only a few percent of the energy generated was used in the process of production, but that the data regarding emissions and leakage were less clear, with many studies still ongoing. There were also questions about what the next event would be that would cause a major shift in the preferred energy source. It was noted that while newly developed nuclear would not be competitive, existing nuclear power could be competitive.

It was noted that among the speakers there should have been a counterargument against shale included, and it was highlighted that the risks of methane leakage would need to be better understood and investigated to evaluate the potential offset of any improvements in emissions.

There was a question about why the shale technologies which had succeeded in the US had not spread beyond the US. In response, it was suggested that there were various factors in the short term, but that over a longer timeframe shale gas development should be expected to be seen in other countries around the world following changes in policies.

In conclusion, the chair noted that while the shale gas revolution can be considered as good news, there are also many challenges, including the question of long-term consideration of climate change risks.

Fruitful discussions taking place during the Concurrent Sessions.

Session Chair

Ursula M. Staudinger, Vice President, German Academy of Sciences Leopoldina, Germany

Speakers

Yu-Zhen Liu, Diagnostic Expert, Personalised Healthcare and Biomarkers, AstraZeneca, U.K.

Osamu Nagayama, Chairman and CEO, Chugai Pharmaceutical Co., Ltd., Japan

David Sourdive, Executive Vice President, Corporate Development, Cellectis, France

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

Robert Willenbucher, Head of Cell Therapy, Janssen Research & Development LLC, Johnson & Johnson Group, U.S.A.

Concurrent Session 104 B-1: Regenerative Medicine

Opening Remarks

The chair opened the session by pointing out that regenerative medicine was an important component of medical science. We are living in an exciting time, where the average life expectancy has expanded by more than 30 years over the last 100 years. The pivotal question is how to bring quality to our longer lives. Evolution has not necessarily optimized our bodies for these longer lives. Since its early days focusing on organ transplants, regenerative medicine has taken on a major role in preventive medicine. Exciting examples include tissue replacement or first steps in stem cell work. If we continue to transform the therapeutic to become a preventive approach, it will contribute to containing health care costs.

A number of issues stood as interesting discussion points. First, as the experiments by Wyss and colleagues have shown, connecting the vessel system of a young and an old mouse rejuvenates the cells of the old mouse. Is this still to be called regenerative medicine? Second, considering the multimorbidity of an older organism, it seems necessary to consider the systemic effects of regeneration in one area of the body, unless regenerative medicine is always targeting basic mechanisms; that would then have effects generalizing across the original target of intervention.

The first speaker pointed out that so far there has been no cure for heart problems. The only solution is heart transplantation. However, regenerative medicine gives us hope. Ms. Liu continued to say that it was once believed that the heart was not capable of regenerating cells. However, now there is a new technology where half of the heart's cells are replaced by new cells. A key area in regenerative medicine is how to enhance this process. By 2016 it will be ready to test on humans. Hopefully it will also be possible to develop personalized medicine for each individual.

The second speaker pointed out that regenerative medicine covered broad issues and scientific points. There are four major points. Firstly, by 2050 the population will be at 9 billion and 22% of this will be people over 60 years old. A proper balance is critical to retain human health. Functional health is expected to contribute for elder people.

Second is the importance of clinical application, where it is necessary to discuss how new innovation can be implemented. Industrialization is another vital area, as well as iPS portal and regulatory science. There needs to be cooperation between countries in order to establish this.

The third point is about social implications. Finally, fourth, there is the issue of the economy developing a cross function among companies in different fields for creating new jobs. Regenerative medicine includes a wider range of aspects, such as returning to work after hospitalization, and so on. There is no doubt that regenerative medicine will have a dramatic impact in the future and on social implications.

The third speaker pointed out the main challenges and reasons for optimism on our capacity to tackle the consequences of ageing on health, in light of recent scientific findings and technological breakthroughs. The four challenges in addressing age-related diseases are to predict, to prevent, to personalize and to produce. Predicting is about knowing ahead of time what will go wrong in a body or how that body will react to compounds.

There is now a growing understanding of both the molecular mechanisms (e.g. gradual accumulation of dysfunctional proteins in cells), and the underlying genetic bases (e.g. gene polymorphisms making proteins more susceptible to carbonylation) leading, in the long run, to biological disorders. Moreover, functional tools, such as iPS-derived functional cells and tissues, allow direct detection of the early stages of ageing in an individual, and predicting which biological functions may become fragile over time. Likewise, iPS-derived cells made from individual panels allow in vitro testing of pharmacological compounds against the human genetic diversity that makes us respond differently to the same medicines. Most drugs do not fail in clinical development because they are not good, but because they are not suited for a large enough population. Not every molecule will work on every person.

Preventing age-related disorders is now a plausible perspective for a not too distant future. Since it is now possible to identify which of an individual's proteins are more susceptible to dysfunctional accumulation over time, a new class of drugs can be designed to increase their stability and delay the accumulation of these susceptible proteins. A precedent for pharmacological compound acting by restoring the normal structure of a protein actually already exists.

Personalizing is about optimizing treatment for each individual. The historical model of the pharmaceutical industry has been to make highly pure compounds acting very selectively on individual receptors or targets and aiming at treating all the patients. That model suffers strong limitations. But it is now possible to better understand and even test, and therefore predict how combinations of drugs may be used on different individuals. Targeted medicine is already a reality in some areas of oncology. It is just one step away from personalized medicine.

Finally, production is a major issue for regenerative medicine and cell therapy, especially when addressing age-related disorders. A few decades ago, therapeutic proteins injected into patients transitioned from being extracted from donors to being manufactured from recombinant cells. This major change allowed the development of a new segment of the biopharmaceutical industry. Likewise, cells are about to undergo the same transition. They are powerful biological objects, but are now becoming industrial objects, robust, reproducible, and can be turned into clinical objects. They can now be manufactured from sources external to the body. Industrialization allows mass production, cost reduction, and wide access to these new therapeutics. There is thus room for optimism in addressing the consequences of ageing on health.

The fourth speaker explained the start of the first iPS cell sheet transplantation for eyes. Autologous cell sheet transplantation is the best method; however it is very expensive. One major problem in regenerative medicine is that the expectation of patients is enormous. This will become a significant field in the future. In the future, patients can be told that they will no longer be blind after surgery. However, this technology cannot heal the person all the way to how they were before.

The fifth speaker opened his speech by pointing out that cell therapy and regenerative medicine have tremendous potential to provide meaningful treatment outcomes for patients. Currently within Janssen Cell Therapy, there are two clinical programs. One is the cell based- treatment for age-related macular degeneration, and the other is the program for heart failure. Many technological advances have been made in the last 10 years in the field of regenerative medicine. At present, many countries are investing significant sums in regenerative medicine, as they deem it important for the health of their populations and for their country's economic growth. The manufacture of cell and tissue-based products presents unique challenges owing to the fact that these products are composed of living cells. Convergence of health authority regulations will facilitate the global development of these important products.

Discussion

The first point of discussion was on prioritizing different approaches, such as traditional approaches around tissues. The question is, are we underinvesting in regenerative medicine? Europe, for example, has a human brain project. Prioritization is on money and talent.

Furthermore, there is the importance of maintaining trust with the issue of risk. In addition, there is the need to adjust expectations of the public around the field. The question is how to maintain public trust. Furthermore, there should be proactive steps to develop global shared infrastructure. However, there are also issues of trust about the establishment of cell banks in different countries. Another topic was the challenges of purification of stem cells in terms of biomarker research.

Next, intensive discussion was held on the question how regenerated cells integrate in the body. There are concerns that regenerative cells may have different functions compared to the original cells. Because it is new technology, no one yet knows if safety can be evaluated after a transplantation. Therefore more discussion is needed. Potential carcinogenic effects of stem cell therapy need to be investigated with a long-term perspective.

Participants also pointed out that regenerative medicine was effective depending on different social backgrounds. The aging of society is progressing rapidly. Use of regenerative medicine elderly members of society would help keep them healthy. However, cost is a key concern, especially in developed countries, which are facing an aging society with declining birthrates.

Another very crucial point raised was media responsibility, and managing expectations. There are expectations for a rapid timeline for development of the technology, but in reality it will take at least 15 years.

Echoing an earlier point about risk, it was pointed out that basic scientists look at their own specific area of research, but do not consider the operational risks. The Japanese government has also adopted a very challenging framework. It aims to expand into a broad range of areas in the future, but this will take time.

Finally, discussion turned to cellular therapy and RNA molecules. Currently there are many great success stories in drug screening of a promising new technology. The major problems are dose scaling and the formulation of the liver, and the associated costs.

Listening closely to a speaker's presentation.

Session Chair

Eric Grimson, Chancellor, Massachusetts Institute of Technology (MIT), U.S.A.

Speakers

Yasuhiko Arakawa, Director of the Institute for Nano Quantum Information Electronics, The University of Tokyo, Japan

Jaime Parada Avila, President, Institute of Innovation and Technology Transfer of the State of Nuevo Leon; Monterrey International City of Knowledge (MTYCIC), Mexico

Robert Parkin, Pro Vice Chancellor (Research & Knowledge Transfer), Office of the Vice Chancellor, University of Bradford, U.K.

Alexey K. Ponomarev, Vice President, Industrial Cooperation and Public Programs, Skolkovo Institute of Science and Technology, Russia

Kan Trakulhoon, President and Chief Executive Officer, Siam Cement PLC, Thailand

Mitsuhiko Yamashita, Member of the Board, Nissan Motor Corporation, Japan

Concurrent Session 104 C-1: Industrial Innovation

Opening Remarks

The session chair spoke on the topic of co-location. He began by noting that there was a large concentration of technology, IT, and pharmaceutical businesses, venture capital firms, research facilities, startups, and other related businesses facilities in close proximity to the Massachusetts Institute of Technology (MIT) campus. The chair stated that the proximity of these businesses and research facilities to MIT was mutually beneficial for both the school and various industries. Continuing on, the chair stated that MIT would continue looking toward the future by creating various spaces on campus to promote further co-location to encourage innovation.

The first speaker introduced Nuevo Leon's Innovation Ecosystem. He explained that the ecosystem model consisted of multiple components: a favorable environment for a knowledge based economy and society to be viable; reference frameworks as the structural component supporting the model and providing viability in the long term; legal frameworks; strategic frameworks defining the short and long term priorities based on the government plan; institutional frameworks consisting of government offices, advising, design, and support of the implementation of programs and projects; and a budget framework for the fiscal funding and support of the ecosystem. He emphasized that the next component of the model was to focus on strategic areas and the establishment of strategic clusters, namely in IT & software, automotive, home appliances, biotechnology, health sciences, agribusiness, nanotechnology, aeronautics and aerospace, creative industries and media, sustainable housing, and transport and logistics.

The second speaker began by noting that SCG was continuing to invest in R&D and encourage further public and private collaboration. He emphasized that while the private sector would continue to play an important role in promoting industry innovation, the role of the public sector in providing supportive schemes and promoting collaboration between universities and industry would be crucial. Next, he pointed out that there was strong evidence that as private sector markets grow, the nation would benefit and become wealthier due to the relationship between net profit and tax paid to the government. In conclusion of his remarks, He introduced the "Talent Mobility Program," which the Thai government had recently initiated in order to help facilitate knowledge sharing between the public and private sectors.

The third speaker spoke on how university/industry collaboration could be encouraged. He stated that there was technical innovation, in which companies would work in tandem with universities to encourage the more rapid development of technologies; co-location innovation, in which the proximity of major industries and research facilities to universities would prove to be mutually beneficial; and the development of common goals, by which universities and industry could work with one another from the very beginning on certain projects. He concluded his statements by emphasizing that international collaboration was also vital.

The fourth speaker spoke on the topic of the need for industrial innovation. He began by noting that a UK government study had showed that innovative businesses responded better to change, saw higher returns on their investments, and were overall substantially more successful than those businesses which were not considered innovative. He stated that a key barrier to industrial innovation was the fact that the technology readiness level standards between universities and industry were not consistent and compatible with one another. In conclusion of his opening remarks, he remarked that the UK was developing and supporting the creation of multiple technology and research centers and facilities across the country, which would help form the backbone of industry/university collaboration through the dissemination of the research and findings of academic institutions.

The fifth speaker spoke on the topic of the government's role in innovation promotion. He emphasized that world governments should first recognize that there were many accumulated technologies in specific sectors and industries, and then focus on those sectors in terms of budget allocation and sponsorship. In conclusion, he stated it was also vital for the CEO and leaders of business and industry to be innovators themselves, and that creating and maintaining healthy markets for those businesses would be essential.

The sixth speaker spoke on the topic of government support of innovation. He stated that the Russian government had implemented many programs to support science, technology, and innovation in the last several decades, but that the line between indirect and direct support between government and industry should be tread carefully. Continuing on, he explained that if there was too much government involvement in certain projects, it could potentially scare away private partners. In conclusion of his remarks, he stated that achieving this delicate balance would be a challenge going forward for all countries and industries.

Discussion

The first group summarized their discussion by stating that they discussed achieving a series of balances in innovation undergrowth (pure and applied research); the difference and balance between open and closed innovation (traditional model not good enough to respond to rapid innovation); the importance of co-location; the importance of government intervention in industry support, particularly in third-world countries; achieving a balance in how to disseminate research to the public; and the balance between industry and university R&D to achieve a successful innovative schedule.

The second group summarized their discussion by stating that they discussed the facilitation of collaboration; the positive and negative effects of national cultures on co-location; the importance of understanding how market and industry benefits from academic research; what the right model is for intellectual property both for academia and industry; and the challenge of government to reduce bureaucracy in supporting industry.

The third group summarized their discussion by stating that they discussed co-location and how companies can be innovative within their organization. They explained that they talked about the dual definition of co-location; namely how it could be defined as bringing individuals together from different companies and sectors, and bringing a diverse group of people together within an organization. Entrepreneurship was also discussed, and the various monetary incentives that could be used to encourage employees to take independent action and conduct research that would ultimately benefit the organization.

The fourth group summarized their discussion by stating that they discussed market driven innovation and collaboration between large companies and venture groups; the need for CEOs and leaders to be devoted to innovation; the need to differentiate between innovation from long-term R&D and innovation by entrepreneurship; and the importance of integration, speed, and diversity in industry/government/academic collaboration.

The fifth group summarized their discussion by stating that they discussed the difficulty in achieving real innovation; the importance of rapidly progressing innovation and information transfer; conflicting national missions for industry and the need to centralize that vision; and finally, various monetary and other incentives to encourage employees to become entrepreneurs.

Session Chair

Hanoch Gutfreund, Executive Committee Chairperson, Israel Science Foundation, Israel

Speakers

Masatoshi Ishikawa, Professor, Department of Creative Informatics, The University of Tokyo, Japan

Kenji Kurata, President, New Energy and Industrial Technology Development Organization (NEDO), Japan

Bruno Revellin-Falcoz, Executive Committee Member, European Institute of Innovation and Technology (EIT), Honorary President and Delegate for Foreign Affairs, National Academy of Technologies of France (NATF), France

Yongvut Saovapruk, Governor, Thailand Institute of Scientific and Technological Research (TISTR), Thailand

Concurrent Session 104 D-1: Collaboration among Academia, Industries and Government

Opening Remarks

The chair opened the session by saying the triangle of academia, government and industry is a topic which is of the utmost importance today. Whether we speak of knowledge-based economics, consumption of resources, population growth, or protecting mankind against environmental hazards, it is achieved with knowledge gleaned from study and research at university. Collaboration with industry, taking research, and building results is of the utmost importance.

He said that it is understood today that one of the missions of universities is sharing the knowledge produced today with society. There was a time when we believed that the industry and academia relationship was not required, that there are deep incompatibilities between the cultures and compatibilities of success between academia, industry, and government.

He admitted that there are differences in roles of these institutions; for example, in terms of producing and distributing funding, tax exemptions and philanthropy. The role of legislation is also important. A significant boost of technology development was allowed by the government relaxing restrictive legislation. Also, there are changing definitions of IP – it will be important going forward to internationally standardize IP systems.

Although many of the countries that participate in STS Forum are very different, they have certain aspirations in common. New initiatives are created and tested all the time, such as fast-track initiatives from innovation to industry.

The first speaker started by explaining what Thailand is doing for research, with his position at Thailand Institute of Scientific and Technological Research (TISTR). The guiding principle for his research is OZONE, where O means opportunity for new business, Z means zero waste management, O means occupation creation, N means natural resources-based, and E means energy efficiency.

He said that in Thailand, SMEs play major roles as economical driving engines. He expects this will create increased opportunity for the Thai people and Thai industry. Each year, he said, TISTR conducts over 100 projects using its own technology in diverse industries and areas in Thailand, to improve and develop over 3,000 beneficial societies. There are two interdisciplinary models that TISTR has applied to combine contribution from academia, industries, and governments: a large-scale industry model, and the SME sector model/provincial model. He then presented a case study of a specific project from conception to completion, and its impact on Thai economy.

The second speaker has worked for collaboration between universities and industries – and for privation. He has designed collaboration schemes at The University of Tokyo, discussing issues such as copyright, patents, and so on. He said that each individual piece of the system is not very important by itself, not until it is put together as a final system. Requirements for these systems have changed greatly in the past ten years. One example he discussed is that The University of Tokyo has created an indirectly-managed venture capital organization.

Scientific structure has changed in terms of collaboration between academia and industry. He believes that approach schemes need to be reevaluated, and that we have to question the social value of science and technology. However, these ideas are difficult to evaluate, as is developing perfect answers. He wants to ask the participants about how to evaluate social value in this context – are there any neutral metrics? All users have to evaluate social value – not just certain users, or the creators themselves.

Another issue that the speaker discussed is technology finance programs. In the past, the government has paid a lot of research funds to the University. However, in the 21st Century, there are corporate considerations as well. Sometimes, process fees are prohibitively expensive, and they are very risky in terms of financing. He believes that we need to not only talk about industry, the government, and academia, but also the bridge between the three. What will it look like?

The third speaker suggested, in terms of collaboration, an answer which involves improving competitiveness between countries. EIT (European Institute of Innovation and Technology) is a European institution created the by knowledge innovation community. The European Parliament put some seed money forward to establish this institution. It is interested in examining how to put people together from a "knowledge triangle." In order to have it clearly defined, three themes were selected: ICT, climate change, and alternate energy.

In the past, it was decided to put 320 million Euros into these initiatives, and it was predicted that this would represent one quarter of the overall investment. These initiatives helped catalyze partnerships, and now there are over 500. One of the keys to this growth has been entrepreneurship. At the beginning, he expected to take people from science research, and train them to be entrepreneurs. However, today he has the impression that these programs are successful more because of increased funding. Recently, it was decided that by 2020, there will be dozens of billions of Euros invested in addition of the initial investment.

Cooperation is ongoing, fostered by exchange of individuals from academia, industry and government. He said that success will be achieved by creating new cases – new themes – food, aging, raw materials, and so on. In the coming years, he believes that we should inform and train more people in this model. Today, we are at a turning point.

The final speaker said that collaboration is very important, and actively explored all over the world. The goal of collaboration is creating innovation that can benefit society. Innovation also be expected to strengthen the international competitiveness of companies, industries and nations. Based on the above understanding, as an example, he showed the Japanese government's activities related to PV cell development, which began in 1974. These activities allowed new industries to emerge, and Japanese industries became world leaders in this field. However, now the industries are losing traction. In contrast, neighboring countries in Asia are beginning to gain a lead in the world market. The innovation process in which academia, industry, and national research institutes work together and share knowledge and then move on to the development of specific target worked once; however, it does not seem to work any longer in the present day. Digitalization in technologies will play a large role in this changing situation, he believes.

Technology must diffuse and spread, and its nature makes this easy and fast. Entry barriers are falling, which means more parties will begin to participate in the market. R&D comes first, commercialization for the market next, and finally value is converted to profit and gained by investors. Some profit may be reinvested in new R&D. He called this cycle a linear model of innovation, and assumes that this model does not work anymore.

He concluded that the question now we are facing is how to make the innovation model work, and if there would be a new form of collaboration required among academia, industries, and government, under the circumstances of rapid change in technology such as digitization.

Discussion

To begin the discussion, a participant asked what a career path would be like for somebody interested in the dialogue between the academia-government-industry "triangle." The difference between the transfer of technology IP from university to university, and university to industry, was described. The point was made that there are different possibilities for people interested in doing research or entering into industry after their studies are completed. He said that it is important to foster entrepreneurs regardless of whether they come from academia of industry.

Next, a participant commented about additional funding schemes in the UK, stating that they are successful in their aims to bring academia and industries together to develop products. Funders can make a big difference in not only developing technology, but also in fostering entrepreneurship.

Another participant commented that it is very important to think about mechanisms which address the overarching issues, and themes when creating teams who will define a strategic roadmap to tackle a problem. It is important to align the research goals or ideas of a researcher with the technology being developed by industries.

The distinction between TTOs and TTCs was explained. TTCs are Technology Transferred Companies, while TTOs are Technology Transfer Offices. TTOs are based in academia, and they are important because they can be used to develop strategies to benefit students and create opportunities for all students and entrepreneurs.

Next, a participant asked to clarify the difference between collaboration between nations and collaboration between academia and industries within single countries, noting that borders between nations are beginning to break down because of the Internet, and asking what people's opinions were about funding research and projects beyond country borders. One participant commented that this was tried in his country, and it did not work. Another participant mentioned that in Europe, collaboration is trans-border. Competitive clusters can be created not only within Europe, but with Europe and, for example, Japan. A participant mentioned that the lines between universities and industry are beginning to blur, creating networks and a type of synergy that did not previously exist.

Next, a participant commented on the ideas of career path and career transfer. He mentioned that in order to influence entrepreneurs and transfer technology, it is important to be involved with students from early in their academic careers, and guide them through the process of navigating an academic or industrial career path.

Another participant then stated that one of the issues with technology transfer is networking, and believed that one of the important factors that will encourage technology transfer is sharing results and creating a network.

Next, a participant praised the system where universities have a technology transfer office. He said he thinks that universities must have better approaches for developing technology that reaches the public and has some element of public good. Because governments fund some universities with public taxpayer money, it is important to reach these standards, and have these lofty goals. A government should be prepared to invest in transfer technology with regard to universities. The participant concluded by saying that profit is good because it creates incentive, but universities should not be profit-oriented.

Next, a question was asked how much innovation should be on the side of enterprises, believing industry can be quite conservative when compared with universities.

A participant then commented on cross-country investment. He said that the needs of technology are also applicable in developing nations. Thinking of technology transfer in academia and industry in terms of developing nations, and introducing this technology into real situations in developing nations, is of crucial importance. Another participant commented further on this issue, stating that great minds that exist not only in developed nations, but also in developing nations, and that their perspectives and ideas could create important technologies. Having a collaborative element and fostering entrepreneurship within developing countries will be of great social value.

Next, a participant said that while many sophisticated programs have developed bridges between industry and academia, he is curious about the overall impact they have on the economy. A participant mentioned that when working at an aircraft manufacturer in France, there had been continual connections with universities, and that the connections and technology transfer they allowed for were very beneficial.

A comment came about the importance of sustainable development of linkage between the corners of this triangle in developing countries. He said that it is important to couple technology transfer with development in this way.

Another participant said that it is important for universities to actively seek potential partnerships with an active program – to look for new IPs – and also to help grow technologies. Another comment came that this is indeed the core purpose or goal of a university. He said that one of the problems was to get new technologies and materials accepted. He admitted it is a tedious process, that there is a lot of loss in process; but that universities should be willing to undertake research and take some of this loss.

To wrap up the session, the chair summarized by saying that he believes universities should develop a Mission Statement, and that profit should be low on the list. For example, he mentioned that at MIT conducts a lot of technology transfer, and that while they do not gain much income directly from it, they benefit indirectly. He said that one of the issues is that there are different models in different countries and at different universities. For example, some universities have industrial parks on or near their campuses. He also made one last cultural point, stating that one should never forget that there is one mission at every university: basic sciences, basic humanities, and so on. The problem is that we do not know what is "basic" in terms of science and humanities anymore. The bottom line of "basic" is continually changing, and technology is continuously evolving and developing.

Discussions taking place during Concurrent Session 104 D-1.

Session Chair

Margaret Leinen, Director/Scripps Institution of Oceanography, University of California, San Diego (UCSD), U.S.A.

Speakers

David Johnson, Coordinator, Global Ocean Biodiversity Initiative (GOBI) / Director, Seascape Consultants Ltd., U.K.

Anne McDonald, Professor, Graduate School of Global Environmental Studies, Sophia University, Canada

Mamoru Mohri, Chief Executive Director/Astronaut, National Museum of Emerging Science and Innovation (Miraikan), Japan

Yoshihisa Shirayama, Executive Director of Research, Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Japan

Concurrent Session 104 E-1: Ocean

Opening Remarks

The chair welcomed the participants, and invited them to engage in fruitful discussion. She explained that one of the focuses of the concurrent session would be on conservation and biodiversity. Oceans are extremely important for economies, for life, for the hydrologic cycle, and have a profound impact on human life. However, failure to address issues such as CO_2 emissions or overfishing has had very severe implications on oceans. Therefore, the question is what science and technology can do to address these issues and long-term changes, and what it can contribute to biodiversity. Furthermore, adaptation, and how well biological ecosystems will be able to adapt to the changes that are occurring, is another important issue to consider. Finally, it is important to discuss whether it is possible for science and technology to contribute to the development of oceans in harmony with conservation of the environment, and if so, how. She then asked each of the speakers to offer introductory remarks.

The first speaker offered a few key points that he wished to stress. First, marine surveys need better coordination globally to fill gaps and ensure better use of marine data, and monitoring to inform the policy agenda and link different data sources. He also called for better biogeographic classifications at the regional level, as well as comprehensive baselines and monitoring to assess environmental impacts of deep sea mining and other forms of investment. To establish effective networks of marine protected areas, better indicators for ecological coherence are necessary, which not only involve spatial representativeness, but also understanding the viability and interconnectedness of biological populations in different areas. He also highlighted the importance of involving social scientists to assemble evidence of socio-economic benefits of sustainable ocean management linked to monitoring and surveillance. Finally, he emphasized the need for better recognition of the extensive possibilities that oceans can provide, especially when combined with science and technology to address issues faced by human society: for example, financial mechanisms acknowledging the ability of marine and coastal ecosystems to sequester carbon emissions.

The second speaker explained her background as an ethnologist studying Japanese folklore and living among rural agricultural and fishing communities in Japan, before eventually working for the Ministry of Agriculture, Forestry and Fisheries. More recently, she has been working with the Japanese government to deal with issues such as the Intergovernmental Panel on Climate Change and the Conference on Biodiversity. She emphasized the importance of communicating the ideas of policymakers and leaders to all stakeholders, and acquiring buy-in from them. She then turned to the subject of the Sustainable Ocean Initiative which looked to bring together the fisheries interest and conservationists in tackling marine biodiversity. Overall, she advocated an integrative approach, together with a multitude of partners to achieve international biodiversity targets.

In addition, she highlighted the fact that capacity building was currently one pressing issue, as well as the problem of communicating the relevant science in an accessible and relevant way. She also shared her experiences and learning from working with the Ama divers in Japan, gauging their opinions on the ocean and marine biodiversity, and trying to communicate the local needs to the policymakers. Ultimately, she succeeded by tailoring her message to policymakers' interests, and rather than focusing on the science, she focused on the importance of preserving the ocean to preserving the culture of the Ama divers. She believed that this experience highlighted the importance of bringing in collaborators from different disciplines.

The third speaker shared his experience exploring space and the deep ocean. From experiencing microgravity, he was left with the impression that it would be difficult for future generations of humans to survive in space. On the other hand, the ocean on earth is the source of all forms of life. Furthermore, rather than focusing on the dreams of space travel, he believed that human society should focus on the Earth and sustainability. In addition, he made the point that while scientists were collecting tremendous amounts of data, there should be much greater collaboration among scientists. That being said, science and technology alone is not enough, and only represents one part of society. Communication and engagement with the general public is essential for tackling any problem, which is the work of the National Museum of Emerging Science and Innovation (Miraikan), where he serves as Chief Executive Director. In light of this, he concluded his remarks by calling for greater public engagement in relation to ocean conservation and biodiversity.

The fourth speaker believed that conservation of marine biodiversity was a must for humankind. However, the biodiversity of oceans is declining. Among the reasons is firstly the existence of very local issues, as well as global issues. The second reason is the existence of direct and indirect impact on biodiversity. All of these problems must be addressed, but they each require their own individual solutions. He hoped the accumulation of individual experiences and success stories would build momentum towards greater success in the future. At the same time, he believed there was low interest among the general public for maritime biodiversity, as the issue seemed removed from the people. Therefore, better efforts to communicate the impacts on society are needed to gain public awareness and support.

Discussion

The participants were invited to engage in open and free dialogue. The first points were raised regarding the importance of ongoing global cooperation to fill gaps in data, underpin monitoring and management, and other purposes. Additionally, finding a balance between science and resource management can play an important role in raising awareness, as well as in helping share success stories.

Furthermore, science and technology plays an important role in influencing policymakers. However, there are many levels of decision-making and policymakers, so rather than more science, what is more urgently needed is to establish frameworks and provide training to help scientists and policymakers communicate closer and more effectively with one another.

There was also discussion of scientific collaboration and data sharing in the Arctic. Specifically, while collaboration is easy on the surface, given the various countries involved, there are also many political factors in the background, including national interests surrounding resources.

The role of education was also highlighted. This applies not only to education for the general public, but also education for scientists, to teach them how to better communicate their research as well as their views to society.

Additionally, maritime biodiversity was looked at from the perspective of capital. When trying to justify investment in conservation, one means of doing so is to look at the value of the ecosystem and view the destruction of biodiversity as a risk.

In addition, the issue of the Fukushima nuclear disaster was discussed. Specifically, there was discussion of how science can contribute to problems faced by local communities. Furthermore, effective communication in disaster areas is very critical especially in terms of ensuring

transparency. It is up to scientists to contribute to this, not only to help politicians, but also local communities.

A point was then made that alongside warnings about risks and so forth, success stories can also be very effective. These not only demonstrate the science, but also present a concrete picture of how success can be achieved at a local level.

It was also posited that there was a need for change in the calibration of the value systems of human society. The point was also made that there seemed to be somewhat of a disconnect between the land and sea, where communities would value ecosystems on land, but not the ocean.

Another topic that was discussed was governance gaps. There seem to be gaps in communicating the urgency of particular issues, such as the impact of deep sea geoengineering, particularly between different scales, such as the local, the regional, and the global scale.

Marine-protected areas were then deliberated. While marine-protected areas are a useful tool, these are often rendered useless when the original rules behind their implementation are not maintained.

Participants also made the point that large companies have to be convinced to change their ways. Otherwise it will not be possible for marine biodiversity to be maintained.

Finally, the issue of aquaculture was also raised. In particular there seems to be a contradiction between trying to preserve ecosystems, while carrying out other activities that may be detrimental, such as taking samples for aquacultures. While aquacultures can play a role in addressing problems of overfishing, perhaps new and less impactful techniques of aquaculture development need to be found.

Session Chair

Denis Thérien, Vice-President, Research and Partnerships, Canadian Institute for Advanced Research (CIFAR), Canada

Speakers

Karlheinz Brandenburg, Director, Fraunhofer Institute for Digital Media Technology (IDMT), Germany

Phillip Morris, Head of Solution Engineering, BT-Asia, Middle East and Africa, U.S.A.

Yasuo Sakamoto, Vice-Minister for Policy Coordination, Ministry of Internal Affairs and Communications, Japan

Phil Venables, Chief Information Risk Officer, Goldman Sachs, U.S.A.

Concurrent Session 104 F-1: Security for ICT

Opening Remarks

The chair welcomed everyone to the concurrent session on Security for ICT; introduced common issues including the advance of technology and growth of economy; and highlighted areas such as privacy, accessibility, and the integrity of systems as fascinating problems that arise due to conflicting goals.

The first speaker stated that things do not currently look good in the state of global Internet security, the reason being because of three factors. The first is due to the threat landscape continuing to increase, especially in their sophistication. The second being a much larger attack surface as our lives are continuously becoming more connected online, thus giving rise to greater consequences of these attacks. And the third is ever-present vulnerabilities, specifically with new technologies constantly being launched and a lack of education and knowledge in security engineering. For the way forward, organizations need to hire a head of cyber security, to have someone accountable for the organization's security; to build more defensible and resilient architectures; and to share threat and vulnerability information across sectors.

The second speaker emphasized that it was important to stick to the fundamental principle to ensure free flow of information across borders, and stated that it was our mission to encourage all parties concerned to share the common goal. He pointed out that ensuring information security and protecting privacy were means to ensure the free flow of information. In this regard, he listed PPP schemes, international cooperation, the cultivation of human resources, and R&D as important pillars. He also stated that the advance of technology such as wearable devices and IoT would promote an inter-connected world and give rise to new challenges in the future, and therefore it was necessary for us to make continuous effort to overcome them.

The third speaker started his presentation by emphasizing that vulnerabilities will always be present and that it would be a constant race to stay ahead of the opposition, emphasizing that understanding the motivation of criminal organizations would be a key issue to stay ahead and that our biggest challenge and weakness right now is "Insecurity by Design." Because of the constant race to introduce the first product in the market, things are rushed, particularly for security. Politicians and regulatory bodies should push for at least minimum acceptable levels of security in order to be allowed to introduce products into the market. This is especially important for conformance from standards writing organizations, since many products will be developed with that as a minimum reference architecture.

The fourth speaker provided an overview of issues in his experience in the music industry, noting new technology to detect tampering of media. He highlighted that the tools for greater authentication security were there, but that there needs to be more work in this area and a greater focus on taking an initiative to tackle these issues, as well as the need to protect our individual data, as well as their customers' data.

Discussion

One participant discussed the risk of biometrics for authentication, rushing products to market, strength of passwords, evaluating the value of information especially when it is lost – noting that in India there is unlimited liability – and the idea of security as a burden for end users, emphasizing that the average individual user would only be compromised once every 30 years.

Another participant highlighted topics of people and areas of attack in supply chains, nationalism, and countries having distrust around each other, leading to a huge amount of problems. He also noted the issue of social media, Facebook, Google, public data; and mentioned the possibility of personal certificates assigned to users online, the possibility of adding biometrics on top of that, and training people on a regular basis as well as ethical testing such as in nuclear sites.

Next, a participant noted the use of applications on smartphones, giving information to companies, and that information being sold to third parties; changes in society in terms of speed and magnitude; the issue of threats being dynamic as opposed to static; the possibility of international collaboration or agreements at the United Nations level; and R&D for state of the art technologies.

There was discussion about training people to think about both offense as well as defense, the demand and burden of security and the balance between the two, what people want out of security and what they are willing to tolerate, embedding security engineering training in computer science courses, and the risks from the manipulation of data and media, and the trust of that information resulting in various consequences.

Another discussion covered procedures to regain operation from security attacks, the idea and implementation of simple and complicated security procedures, the potential threat of attacks in sectors such as with water utilities, as well as the strengthening of security measures to build up their current situation.

A participant brought up the issue of physical security and 24-hour E-services, understanding who the attackers are, as well as organizations selling user information and the application of big data. Another participant responded that some companies are trying to differentiate themselves by emphasizing that they do not sell user data and that it is actually becoming a competitive aspect. The cloud may actually be a better security model because individual companies many times cannot secure data on their own.

Another member commented on awareness raising between countries.

A contributor commented on the upcoming Global Cyberspace Conference in The Hague next year, topics including capacity building, PPP, and sharing sensitive information between countries so it forms a circle of trust.

Another participant questioned industry insiders about attacks on companies and how they share the information on those attacks due to reputation concerns. One reply was that they can share the attack information anonymously, the use of STIX and TAXII, and the use of real time machine to machine protocols. A follow-up question included the management of this sharing of information, to which a comment was made regarding ISACs, CPNI, and the differences between sharing with government and academia as opposed to sharing among companies. They also emphasized the formation of the finance ISACs came down to the trusted personal relationships between the high level members of the top 20 banks and that it did not begin as a government regulation.

Another comment was made that there were also subscription services that monitor a large amount of the raw Internet traffic in the world, and that these security centers could be of benefit to organizations as well.

The chair then thanked everyone for their input, and concluded the concurrent session on ICT security.

Session Chair

Herminio Blanco Mendoza, Founder and Chief Executive Officer, Soluciones Estrategicas S.C., Mexico

Speakers

Edward F. Crawley, President, Skolkovo Institute of Science and Technology, U.S.A.

Yasushi Horikawa, Technical Counselor, Japan Aerospace Exploration Agency (JAXA), Japan

Makoto Katsura, Ambassador for Science and Technology Cooperation, Ministry of Foreign Affairs, Japan

Michał Klieber, President, Polish Academy of Sciences (PAN), Poland

Eduardo Moacyr Krieger, Vice President, Presidency, State of São Paulo Research Foundation (FAPESP), Brazil

Baldev Raj, President, Indian National Academy of Engineering (INAE), India

Concurrent Session 104 G-1: S&T Diplomacy and International Collaboration

Opening Remarks

The chair stated that it is a great challenge to continue to bring value added after meetings in the past of the STS, on the subject of S&T diplomacy and international collaboration. He looked forward to hearing about India's recent achievements in space, and noted the success of the degree of recent Russian-American cooperation in science and technology.

The first speaker stated that his personal experience, as an American academic serving as the founding president of a new Russian technological institute, was concrete proof of the potential, even during difficult international political periods, of S&T diplomacy and international collaboration.

The second speaker stated that space development for sustainable development on the Earth is not well understood by policymakers around the world. He believed that international cooperation for the peaceful development of space is of the highest priority.

The third speaker pointed out the many areas where Japanese diplomacy has been active in S&T diplomacy and international collaboration. Japan has been active in the areas of tackling global issues for developing countries in particular, and elimination of weapons of mass destruction.

The fourth speaker stated (as a former short-term politician) that he experienced, during meetings with politicians of non-scientific backgrounds, how much science could contribute to good politics and good international relations. He believed that scientists can promote good governance because of the universal principles of science. Politicians should have the trust of scientists, and scientists should win the public trust.

On his initiative, an Agreement between the Polish Academy of Sciences and Ministry of Foreign Affairs concerning the cooperation between the Poland's missions abroad and foreign scientific centers of the Polish Academy of Sciences in the area of promoting of Poland was signed on March 26, 2014. This agreement created a formal basis for cooperation between the above mentioned institutions, and aims to facilitate joint efforts to strengthen the international prestige of Polish achievements in science.

The fifth speaker stated that the internationalization of his organization, the State of Sao Paulo Research Foundation (FAPESP), is of the highest priority. Promoting young Brazilian scientists is also an important goal. Cooperation, he stated, is also being extended to private companies.

The sixth speaker stated that the daunting challenges facing the Earth are best addressed through S&T diplomacy and international collaboration. When there are scientific or ecological problems internationally, it is not always the fault of the scientists or the diplomats, but sometimes a problem of innovation. He believed that scientists must learn the language of diplomats to increase their effectiveness. Proper baby steps realized with success can build credibility and bring support of bureaucrats and politicians for achieving mega success. Examples are Indian programs in atomic energy and space.

Discussion

One group stated that there is a view that there is a spectrum, spanning the pursuit of national interests to pure collaboration. Something in between, the group added, was the pursuit of mutual interest. They concluded that five things could be done. There are networks of scientists and true scientific collaboration, in the middle ground are economic development and global issues, and then the making of policy. Scientists have different responsibilities in these different regimes, the group stated. Sometimes scientists act as scientists. Scientists offer options based on scientific information to policymakers. International collaboration establishes trust, which is one of the essential features of being able to cooperate, the group concluded.

Another group stated that embassies must attach more importance to science, and that more science attachés should be attached to embassies. Even though science should be international, it can be said that scientists are subsidized and some taxpayers object to the use of their money in international cooperation on occasion. Mobility is essential, and the group stated that scientists should be able to get visas more easily to do their research and teaching.

Another group stated that there are examples where scientific cooperation has improved diplomatic relations between countries, such as in Europe. The group added that a book should be written on the successes and failures of S&T diplomacy. The group stated that some world leaders have chief scientific advisers, such as in the UK, and even in the European Commission. The group supports the idea that all world leaders should have a scientific counsel supporting the leader in a permanent position. The group stated that a differentiation should be made between advising the national government and international organizations which are more into global issues. A code of conduct should be created for scientists, and science should be made non-political. Lastly, the group concluded, there is a need to give scientific advice from private industry researchers to the government, and not only from public or government scientists, as governments listen carefully to private industry.

Another group stated that political problems can reduce opportunities for international scientific cooperation. The group identified a problem that governments sometimes want to cooperate with some governments and not with others, whereas scientists want cooperation in order to benefit internationally.

Another group stated the centrality of young leaders, both of scientists and diplomats, will become important for scientific cooperation. They believed that there should be international challenges to meet and that the best in the world should be able to participate in solving the challenge, regardless of where in the world they live. Also, resource rich countries and scientific-based countries should be able to gain from international cooperation.

A participant supported the idea mentioned by another group, of writing a book of the history of international collaboration of scientists and diplomats in S&T diplomacy efforts. Another participant replied that there is actually a journal on science diplomacy created by the American Association for the Advancement of Science.

Another participant stated that track II diplomacy has been used with scholars as the go-betweens to improve relations between states in the area of science and technology diplomacy. Such efforts by scholars led to the establishment of diplomatic relations between Canada and North Korea. He added that scholars have also been used to advance political reform where it was too sensitive to use diplomats and politicians.

Session Chair

Phillip Yeo, Chairman, Economic Development Innovations Singapore (EDIS) and SPRING Singapore, Singapore

Speakers

Hajime Asama, Professor, Department of Precision Engineering, The University of Tokyo; Chairman, Kashiwanoha Campus-city Information Technology Consortium, Japan

Nathan Fletcher, Senior Director Strategic Initiatives, Qualcomm, Incorporated, U.S.A.

Ronald Raffensperger, CTO, Data Center Solutions, Huawei Technologies Co., Ltd., U.S.A.

Guilherme Sales Melo, Director of Engineering, Humanites, Social and Exact Sciences, National Council for Scientific and Technological Development (CNPq), Brazil

Gerhard Schmitt, Senior Vice-President, International Institutional Affairs, Swiss Federal Institute of Technology (ETH), Germany

Concurrent Session 104 H-1: Smart Cities

Opening Remarks

The chair introduced the session, asking everyone to think about two key issues: how to create dynamic opportunities, and how to create livable, smart homes for people to live in.

Next, he passed the mic to the first speaker, who noted that at the previous smart city meeting, they discussed government fears that data collected by smart applications would be used against them; a fear that was prevalent in Brazil. This year, he highlighted the need to address the complications between business sectors and how to reconcile them; city size, and the feasibility of smart solutions when dealing with millions of people; if the technology must always be on the cutting-edge; and of course, what a smart city is. It is not just the quality of IT infrastructure, and is not just a marketing technique. He suggested that it was about quality, and the quality of solutions facing cities. A list of indicators might be necessary to indicate how far a city has gone to become 'smart'. Transportation, health care, safety, and stability are all part of that rubric; as are democracy and integrity. He finished by saying 'no jobs, no life'; stressing that the innovations should not come at the cost of human resources.

The second speaker discussed big data and design of future cities. The Future Cities Laboratory in Singapore saw the supplement of the technical aspects of data and people in big cities, and any city can be made smart through the activities of people. On the last page of his presentation was their conclusions, and their hope that they would lead to a new field of study called 'citizen design science'. That did not mean that citizens did not simply vote for representatives, but actually actively contribute to city design. This also allows for Cognitive Design Computing, which combines the advantages of sensor-derived big data and human cognitive capabilities; and finally the spread of MOOCs to bring informed design to citizens. An example of this in practice is the mobility of transport systems, with data from citizens not only being used, but citizens contributing to the actual improvement. He also noted that they could develop apps for understanding air quality and happiness of citizens, with low CO_2 emissions, which can all contribute to raising the quality of a city.

The third speaker next discussed various viewpoints of creating smart cities in Japan. Foremost was considering Japanese society's rapid aging, which smart cities had to take advantage of; lots of business chances await. The issue of natural disasters in such a disaster-prone country also had to be addressed, which they were currently attempting to do in Fukushima Prefecture. He discussed the need to delineate stages and life cycles of smart cities. There were so many incredibly 'old' cities in Japan that they had to manage. His suggestion was degradable cities, and also a reduction phase. He also discussed the Kashiwanoha City, planned by Mitsubishi, which aims to implement smart technology for problem solving. Naturally, ICT and robotic technologies can provide services for less cost as well.

Another example he brought up was Tama New Town, an example of an 'aged' city. There are many examples of such 'new' towns that claim to be new, but were actually developed in the 1970s. He brought up research by Tomomi Nonaka of Aoyama Gakuin, who examined Tama New Town and discovered it has the highest increase in populations of old age in Japan. Tama New Town also has implemented action plans for raising the birth rate in response. Last, he brought up the Fukushima Innovation Coast Vision, which aims to renovate the area which was irrevocably damaged by tsunami and nuclear disaster, and attract residents back. To summarize, he sought out city design based on needs of society and residents, implementing these required capacities by applying ICT and robotics, job creation based on local needs, and involvement of residents and local industries.

After that, the fourth speaker began by saying that they cover undeveloped and developed cities, and smart city applications were different among these. However, they can agree on the need for communication infrastructure, which allows for smart applications in the first place. Many places he worked in simply did not have any infrastructure capable of smart applications. Second was the platform: someone had to be willing to put together all of that information, and it has to be secure enough that people are willing to contribute their information to it. There has to be enough ICT infrastructure that gives you the ability to be smart, and there has to be a common platform that can help you build successful applications. There are too many point applications, like for traffic monitoring or environmental control; and many people being seduced by the availability of broadband, thinking it contributes to GDP growth. One thing he found was that building the infrastructure itself contributes to jobs itself, but then people can be trained, either through apprenticeships or on the job, for raising up the learning curve. Those same skills can empower them to start up new businesses, thus becoming a virtuous cycle. They had to ask what the best returns for society are, but also try to figure out how to build the platform for the information that people are willing to contribute to.

Finally, the fifth speaker echoed the comments about infrastructure, and also said that when examining such infrastructures, it is almost always, especially in the US, about cities. Municipal governments are particularly skillful at embracing innovative economies and knowledge-based structures, and are able and willing to build the infrastructure to support it. For instance, on a tour of Apple, they realized that a single iPhone has the entire computing power of the entire Apollo space program, and that more of those phones were sold than there were people being born. However, there are examples where it was implemented poorly, such as in Los Angeles when the city spent a fortune to give tablets to every child without realizing that in poor households, there was no broadband to take advantage of. Thus cities needed to concentrate on infrastructure.

With that, the discussion began.

Discussion

The first comment was that the problems they faced were largely with people, and guaranteeing privacy for people. Figuring out how to turn that information is difficult. The city itself was also an issue, as many avenues are stove-piped and everyone seems to be hoarding data for themselves. The disruption caused by data, such as embarrassing numbers and exposing difficulties, also prevented action. Another agreed fully, saying that the people who produce this data will eventually grant access to it. It is more about supplementing things with real data from real people, and not just focusing on one thing like crime data. Universities are the same way, focusing on company data rather than data generated by people.

Next came a comment from a representative from Switzerland, who commented on the need to deal with the waste that naturally results from smart cities that come along with progress. One participant commented on empowering the citizens, and asked how they ought to incentivize those who are stove-piping data to spread it, and how to spur users to travel efficiently and be mobile efficient? One comment was made regarding New York City, where Mayor de Blasio hired a CTO to deal with those issues specifically. The technical issues are solved easily, but the top must force the human factor to work with this. He also commented on the issue of waste, such as noting that 32% of perishable produce in the US perishes before it gets to its destination. That was one example of where transportation and mobility could improve. As for work within cities, MIT had calculated ways to see how walkable a city is, and governments could use that to plan ways to

bring city design in line with walkability. That would then incentivize real estate agents to relinquish their data, to measure walkability and add another metric.

A participant from the Netherlands asked if there was a policy concept of smart cities which organizes science and policy in a city, or if it was just a loose concept with everyone throwing in ideas—was it coherent? The reply was that it was basically a catalogue at this point and not so clear. This was made clear by cities having to decide what applications make a city more livable, which necessitates collecting data. Openness was crucial, as we had to use the data of today for the future of tomorrow. From there, infrastructure could be built.

They discussed the idea of getting an ISO for the concept of smart cities itself. One participant wanted to raise an issue related to the role of city government: in terms of smart cities, it had to be an integration of various kinds of 'smartnesses'. There were many fields which support smart cities, such as transportation, waste, water, ICT, electricity; and each field has smart applications which can benefit it greatly. Each provider or certain parts of the government can make use of those. How to advance integrated infrastructure is still the problem to solve, however. One participant recalled the how the policy idea was taken up in New York City, by discussing a congestion charge. If there was any hope of implementing policy, you had to understand the people part; how various factors influence the decisions they make rather than the infrastructure. Others responded to the people part, which itself could relate to other things; such as greater walkability ensuring better health, and Singapore's initiatives to reduce carbon emissions. People, from the bottom-up, use technology to improve their lives already; why not use it from top-down to improve on a large scale?

One participant asked what it is that a smart city can bring, and what benefits it has among a wide range of sectors. He suggested collecting some case studies to see what kind of intelligence and benefits can arise from integrated examples, instead of isolated cases; like traffic as it related to energy consumption in vehicles. Another participant agreed that just because technology is available, it doesn't mean people will use it. He mentioned the uncertainty and harshness of dealing with change, such as the switch from agrarian society to white collar. Disruptiveness seems to be largely generational in how it is accepted. Part of it is an educational process, and there will also be a mandate where industries are utterly disrupted and forced to change.

There was a question concerning technology islands. The first part of the question was about the strengths and weaknesses of such an environment, and if leap-frogging is feasible for a country to respond. Someone with experience in the area replied that in India, they were given a plot of land away from the city, where he created 3 million feet of IT space where there is work available, but no homes; thus forcing a community to build up around it. In that situation they leap-frogged, and did similarly in Suzhou, China and Ho Chi Minh City, Vietnam.

Another comment came regarding robotics and the influence it will have on labor. That implied changes for education and a knowledge-based economy, which they could not reconcile with the need for labor. The answer was that a new kind of labor would form: as we saw with the US agrarian society largely disrupted bringing forth a new labor, so would this. Another participant addressed how the government would be involved, and he replied that it would be the tax services, where they would seek out the impact of intelligent systems and how those needed to be addressed. Next came someone wondering about 'levels' of smartness, and what that scale was as regarding smart cities. The reply was that they meant integration, as regarding the ISO; which means they had to create metrics to judge each field of infrastructure.

There was another comment about policy maintenance, asking if they should let a city be degradable or aim to have the young take more responsibility. A response was that the greatest cities in the West were teeming with youth, which brought vitality to cities that was essential. A city made up of, and governed by elderly, seemed boring. In response was a comment about how the Netherlands had denationalized the welfare state, and the response was pushing national programs onto cities. The smart city concept had not yet reached that point. But cities were increasingly taking over the role that national governments used to play, and linking technology to social and policy forces would be crucial in supporting the needs of each generation.

One participant agreed, and thought there should be indicators to see how far a city has come in its 'smartness'. They should also probably compare cities of similar levels, and also should not forget about the people—as they will work and vote in the future, although they are scared of giving data. The problem with that discussion was that there was no one from the government who would respond to that effectively. One response was that that you could bring large numbers of people to consensus through facilitated dialogue, and with a lot of input this could be done. A smart city may well be a whole series of initiatives centered on people itself. Many 'successes' of a city were really simply successes in citizen engagement, such as discussing needs with actual welfare recipients and revamping the system once they understood their actual needs. They posited that a government collects enough data that if it finds enough ways to be transparent, that you can begin to carve paths forward and identify what the metrics of a smart city might be. They suggested they start with small things and then graduate onto larger initiatives. The participant also mentioned initiatives like Code for America, where people come in voluntarily and volunteer their time to work on technology initiatives for cities. Many things can be achieved by simply bringing together people who want to make things better.

That led to discussion of where cities should go when they want to become smarter. There were increasing examples of university-industry consortia, and he wondered if that was a productive way of doing things. One comment was that helping each other in the community was another kind of smartness. He also commented on changing family demographics, and how to integrate increasingly diverse paths for fragmented demographics to come together. They agreed that helping people was very smart, and that telecom advancements had properly facilitated that. It didn't matter how big a city was, any city could implement those initiatives.

There was a comment on metrics, about how to design cities that adjust to new and changing conditions. They have to figure out how those metrics would change with new conditions. Another comment was that humans have a tendency to resist change and need to adapt, which was a major part of the discussion; and they asked how we could make these changes more organic and bring back people who are disengaged with technology, making it more inclusive. The response was that if you don't like change, you're going to love irrelevancy even less. When you speak of smart cities, you have to emphasize that you are offering the same things a city always did, just in smart and more intelligent ways. Bring change to people through ways that make them feel more positive and in ways they expect.

Returning to the question about universities, industries and citizens working together, if you do not involve citizens, you won't be successful. Many new concepts and policies are resisted because they do not agree with the needs of the people and they feel like they lose input into their own cities. Hearkening back to the plenary sessions, one participant thought problems could be avoided by simply not doing what we have done in the past, such as by limiting the number of cars. He thought one of the challenges of a smart city was balancing citizen expectations at the same time as building the infrastructure. Citizen engagement is clearly key to this, but many governments don't want citizen engagement and force its people into a paradigm. They had to address the issue about getting governments on board, and allowing people to participate in ways that are not 'threatening' to governments, in essence collecting information in a way that people can participate without threatening the status quo.

A comment from Singapore stated that it all boils down to giving citizens what they want. The services had to be innovative, sustainable, cost-effective and one that serves the system effectively. In terms of behavior and engaging citizenry, whether a smart or 'dumb' city. A final comment came about Denmark, where civil society took the lead in transforming a city into a 'smart' city. Civil society kept politics on track, and provided a long-term perspective for industry.

The chair brought the session to a close, commenting on the points about constructing cities for the people.

Day 2

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

Plenary Session 200: Dialogue among Political Leaders, Scientists and Industrialists (Society Changed by ICT: Security and Privacy)

Session Chair

Ismail Serageldin, Director, Library of Alexandria, Egypt

Speakers

Takuya Hirai, Chairman, Special Mission Committee on IT Strategy, Liberal Democratic Party; Member of the House of Representatives, Japan
Joichi Ito, Director of MIT Media Laboratory, MIT Media Lab, Japan
Olivier Piou, Chief Executive Officer, Gemalto, France
Edward Screven, Chief Corporate Architect, Oracle Corporation, U.S.A.

In recent years, no form of science and technology has had more of a visible impact on society than ICT. Indeed, the ICT revolution has transformed the world we live in, offering seemingly infinite possibilities. At the same time, there are concerns that as our data usage grows, our security and privacy will become increasingly compromised. How do we resolve this apparent conflict? Is it even in fact a conflict? These are some of the questions that this session sought to address.

Opening Remarks

Dr. Ismail Serageldin opened the first plenary session of the second day of the STS *forum*. He began by describing the dual nature of ICT, which is both part of the everyday, and at the same time almost a dream world in a sense. Mobile phones and the Internet in particular have touched and changed our lives permanently. ICT offers seemingly infinite possibilities, but society has a tendency to take it for granted.

The spread of ICT devices has been profound. There are now more cell phone accounts than members of the human population. It is estimated that 1.75 billion people are using smart phones in 2014. In addition, there has been an explosion in information since 2007, with data growing 20 fold just in the last three years. In fact, we now produce one Exabyte of data each and every day, which is the equivalent to 100,000 times all the amount of text data in the Library of Congress. In light of this, human society is poised for the greatest deluge of information in history. One intriguing question is, if we start to lose or are unable to store all data, are we headed towards some form of digital amnesia?

Security and privacy are key issues in the digital age. Of particular concern is the question of whether the right to privacy has been compromised by spying, hacking, and providers of services. Security for the enormous databases being expanded every day, whether governmental, commercial or scientific, and now kept in the cloud, has become a major concern.

Dr. Serageldin then turned to social connectivity. The scale of the social networking phenomena is staggering, not to mention the speed with which it has penetrated all areas of society. 1 in 4 members on the planet is estimated to be connected to a social media site. The socio-psychological aspects of virtual socializing has been the subject of many studies, and poses many interesting new questions.

Finally Dr. Serageldin noted that for many, the deluge of information invokes visions of apocalypse. However, for Dr. Serageldin, he found the recent changes exhilarating. He also called for managers and other leaders to embrace and bring onboard the young.

Mr. Takuya Hirai stated that government, academia, and industry have a responsibility for keeping cyberspace safe and ensuring it is a powerful force for good. Mr. Hirai first presented an example of how ICT has empowered and revolutionized small business owners. Many small business owners now rely on online transactions and ICT infrastructure for their daily activities. A key question is what the roles of the government and the private sector are in this regard. Privacy, cost, and not stifling innovation are among the many questions that policymakers must consider.

One of the key challenges of the new era is cybersecurity threats. Mr. Hirai informed that, as a Member of Parliament he had proposed a new law, the Basic Act on Cybersecurity, which would have a significant impact on creating a Japan with greater cybersecurity. The Act also reaffirms the role of the private sector in cybersecurity. It seeks to promote greater awareness on cybersecurity in the critical infrastructure sector, research and institutional sector, as well as individuals. A new cybersecurity

headquarters will be established within the government to spearhead such activities.

As society becomes more high tech, there will be increasing need to enhance ICT infrastructure and security, which would require careful and committed investment. Mr. Hirai believed that this was a fully achievable goal.

Mr. Olivier Piou confirmed the digital world was expanding rapidly. The digitization of the world is revolutionizing lives, and we have also come to expect its services 24 hours a day, seven days a week. However, more education is needed to ensure that cyberspace is a civilized space. What is promising is that all citizens expect action.

Mr. Piou argued that digitization and privacy should go hand-in-hand and were not conflicting goals. While high profile examples of data theft have had tremendous negative consequences, they have at the same time helped raise awareness among society of the importance of data security and privacy. Mr. Piou thought discussion of the topic of ICT security and privacy was particularly apt.

Government and civil servants have a role to play. First there is a need for verifiable limits so that private citizens know what to expect in terms of data security. The second point is to promote education among citizens about protecting private data and enhancing data security. Mr. Piou believed that protecting private data means giving people the identity, rights and respect that they deserve.
Scientists also have a role to play. Standardization and interoperability are important. At the same time, they have a responsibility to consider the ethical implications of their technological developments. Specifically, they should develop privacy-compatible technology.

The private sector also has a responsibility to educate its customers on the risks that exist, and the measures they can take to protect themselves. The most common protection is firewalls and passwords, but these are far too weak compared to the threats that exist. Two-factor authentication is essential. It is encouraging that this authentication method is gaining support. Not only does it protect citizens, it also offers them a sense of comfort.

Mr. Piou also proposed that dialogue should be promoted at the international and national levels, and suggested that an existing international body, such as the OECD, could organize and supervise this.

Mr. Joichi Ito stated that almost no system was invulnerable to attack. However, governments have been investing tremendous amounts in the attack space, so that many of the young people are working with governments and law enforcement now. Typically these exploits cannot be used over and over again. Instead, this technology is held almost like a nuclear bomb. When building the Internet, the young hackers better understood the security than the builders did. The US made the mistake of trying to arrest these young people, and created an antagonistic relationship. Now they have learned from their mistake, and are making greater efforts to engage them. The type of people who are good at attacking cybersecurity systems tend not to end up in large firms or the government. The promising news is that those who know how to destroy the Internet are also more in love with it than regular members of society, and are hence unlikely to want to harm the Internet.

This reflects the need to understand the incentive systems in place. More strategic thinking about the architecture of Internet security is also required. However, with all companies, unless there is a need to do something, companies are not incentivized to conduct said activities and take on additional costs. For example, the location where memory is allocated on a computer is standardized, making it very easy to carry out massive cybersecurity exploits. If this was simply changed, it would prevent mass attacks. However, this makes debugging and other things more difficult and computer companies have no incentive to do this.

Mr. Ito called for urgent action, and warned that much like the Earth' s environment, unless rapid action was taken, there was a risk of catastrophic and irreversible impacts on people's lives. In light of the phenomena of Bitcoin, attention has also be called to online transactions. It could have as significant impact on banking and law as the Internet originally had on commerce. If we wait or hesitate, creating architecture appropriate for this will become ever more complicated.

Mr. Edward Screven first expressed his belief that many companies, such as Oracle, are in fact incentivized to maintain as much security as possible. Even if all security flaws are addressed, there will always be dishonest people in the world and as such there will always be people trying to compromise the security of ICT systems. However, Mr. Screven was very optimistic about security and privacy on the Internet. That being said there has been a rush to develop mobile and ICT communication channels, such that not enough thought has been given to secure systems. However, promising products do exist. As customers become more sophisticated, it will create greater demand for security systems, which will further enhance cybersecurity.

One other concern is that of national security and governments tracking private data. The solution is for governments and citizens to agree on a policy, and then ensure the transparency of the implementation of these policies. For example, Oracle has technology that can label and track data for ensuring this transparency. Overall technology has the means to protect information, and ensure that those with a responsibility to track that information are doing so.

Discussion

The first question was for Mr. Piou regarding ethics in ICT security and privacy. Mr. Piou believed that new technology did not require new values. For example, if a new technology is developed, the creator still has an ethical responsibility to think carefully about whether or not it should be deployed to the public. Mr. Piou advocated thinking about ethics at the technology development stage and when making the decision of whether or not to commercialize a particular technology. Developers should own responsibility for who is using the technology. Furthermore, when looking at cybersecurity, we must look at the whole end-to-end process, and it is not enough to only focus on one's own area of responsibility.

Dr. Serageldin asked for views regarding the compartmentalization of data to protect. Mr. Piou said that historically, companies protected data with a firewall, but that was now outdated. Rather than abandoning this entirely, also adopting role-based security authentication, plus information compartmentalization and encryption, are two good and simple first steps for significantly better security. For example, Mr. Piou, as CEO, should have access to financial and HR data in his company, but there is no need for him to have access to technical data. Furthermore, the basic assumption today is that a system will be compromised, but the data can nevertheless be well protected if sufficiently encrypted.

Mr. Screven informed that many companies seemed to look at moving processes to the web as a separate endeavor from their business and have not taken this seriously enough. Mr. Screven advocated both security and depth, such that even deep into the system there continued to be controls on data access throughout.

A member of the audience pointed out that lack of respect in cyberspace seemed to pervade all areas of society and ages. At the same time, there are worries about security enhanced to the point that we have a full opaque web. Mr. Ito believed ICANN was the best system for promoting dialogue in Internet governance across government and industry. There, many non-governmental multi-stakeholder bodies should be brought together to hold such dialogues.

Next a participant from academia asked a question. He noted that Mr. Ito had said that there would have to be a catastrophe before security would get better. Working in academia, he mentioned that faculty members are always trying to get around security. In light of this, will security ever become so simple that they would not interfere with convenience of use?

Mr. Hirai believed the third industrial revolution was driven by digitalization and globalization. We cannot grow without these. At the same time, the Internet has the potential to serve good and also evil. The question is how to avoid the Internet being used for negative purposes. Furthermore, an important question is whether at the end of this third industrial revolution, society would be happier or not. That is one of the fundamental challenges ahead. However, no one can guarantee how things will turn out.

Mr. Piou believed that the catastrophe described by Ito was already taking place. He hoped the situation would not worsen, but believed that now was the time to act. Regarding the question about balancing security and convenience, there is no miracle solution, but convenience is the only way to make security more widely accepted.

Mr. Screven did not believe there needed to be a catastrophe to raise awareness, nor a tradeoff between security and convenience. The question firstly boils down to having appropriate security policies, but avoiding going overboard. In Oracle there is a special council for security that addresses just this question. Sometimes in enterprises or organizations, because there are so many different information systems in use, the IT structure becomes so complex that it is very difficult to create an appropriate security architecture. It is better to adopt a holistic view of technology or select a simpler architecture that is already integrated to make it possible to ensure a high level of security without compromising convenience.

Mr. Ito clarified that when he mentioned a catastrophe, he was not referring to commerce but regular people. People being aware of a risk makes it easier to be secure. He made the point that despite cases of data theft from high profile companies, the average Internet user would not be interested. Mr. Ito also likened security to the immune system. It does not necessarily make a patient stronger to isolate them fully from germs; instead it is better for them to naturally be exposed to smaller, less harmful diseases to build up their immune system.

Next a question was raised regarding how the security burden borne by the end user could be alleviated. Mr. Piou explained that special USB sticks exist, from Gemalto for example, and scientists and enterprises are currently developing technology to make security easier for the end user.

Dr. Serageldin then asked the panelists for closing comments. Mr. Screven made the point that, while it may seem like there are insurmountable challenges, slowly but surely, progress is being made. Mr. Ito reinforced the idea that cybersecurity was like the immune system, while young hackers were like bacteria that make the system stronger. Mr. Piou advocated formulating legislation to define ownership of private data. Mr. Hirai added that whenever technology is introduced, there is a need for a counterbalancing human response.

Dr. Serageldin confirmed that many of the issues with ICT are behavioral issues of the individual and not a fundamental issue of the system. With that, Dr. Serageldin closed the session.

Session Chair

Frank Behrendt, International Representative, acatech - National Academy of Science and Engineering, Germany

Speakers

Neil A. Fromer, Executive Director, Resnick Institute, California Institute for Technology (Caltech), U.S.A.

Kazuhito Hashimoto, Professor, Department of Applied Chemistry, School of Engineering; Research Center for Advanced Acience and Technology, The University of Tokyo, Japan

Takashi Kubota, Executive Chairman, Chiyoda Corporation, Japan

Nebojsa Nakicenovic, Deputy Director, International Institute for Applied Systems Analysis; Professor, Vienna University of Technology, Austria

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

Concurrent Session 201 A-2: Challenges and Solutions for New and Renewable Energies

Opening Remarks

To begin with, the chair noted that the primary interest in renewable energies was not driven by immediate scarcity of fossil fuels, but rather the CO_2 generated by those fossil fuels, which requires a rapid solution. Addressing climate change through fossil fuels needs to address not just power plants generating electricity, but also heating and transport fuels. Solely replacing fossil fuels by other technologies does have some effect on climate change, but does not solve all of the problems. There are problems of intermittency, grid integration, and storage systems. Therefore, there needs to be a complete systems approach. He also highlighted that while investments in power systems have very long cycles, he cautioned that looking forward to 2050, we have to be very clear that technologies may have changed considerably by then.

The first speaker discussed the responsibility of scientists to think about research in terms of potential as a real energy technology. Many scientists are working on dreams of future technologies, whereas the public is more interested in realistic technologies. Future photovoltaics can be divided into very high efficiency types, which is emerging science; and lower efficiency types that have lower costs. Perovskite photovoltaics are emerging as a low cost solution, however, because they have issues of long-term stability, there is very little discussion of this issue. There is also concern about the toxicity of lead compounds used, and replacements for these must be found. He stressed that as well that when looking into new technologies, scientists should also look at existing technologies and how to further develop them.

The second speaker described several technologies being developed by Chiyoda Corporation for utilization of new and renewable energies, including concentrated solar power (CSP) using molten salt as a heat storage medium, methane hydrate development, and a new system for hydrogen transfer and storage making use of organic chemical hydride such as methylcyclohexane.

The third speaker concurred with the idea that a portfolio approach is required to tackle challenges such as security of energy systems, and removing air pollution from energy systems. For this to happen, investment must be secured and several transitions are required, including shifting from cooking with traditional fuels in the home. To achieve sustainable energy for all, initiated by UN Secretary-General Ban Ki-moon, we need to bring access to energy, while continuing to improve energy intensity, and doubling the share of renewables. He argued that these three are synergetic and need to be considered together. He also noted as well that besides the supply side, it is very important to focus on the efficiency of the demand side, which is influenced by regulatory mechanisms and policies as well as behavior. In addition, he stated that the Global Energy Assessment, freely downloadable from www.globalenergyassessment.org, made it clear that these goals can be achieved with the right policies in place. For this, it is necessary to double the investment in energy systems, but that pursuing the goals synergistically is much more efficient than tackling them separately.

The fourth speaker discussed the experience of Indonesia in bioenergy for power generation and transportation. As bioenergy is much more flexible than solar and other renewable energies, it can be used in the transport sector and other sectors. There are private companies in Indonesia producing both biodiesel and bioethanol. For smaller islands in the Indonesian archipelago, biodiesel is also used for electricity generation. However, biofuel production is still more expensive than traditional fossil fuels, and is therefore uncompetitive without subsidies. There is also insufficient capacity at present. Biofuels are expected to reach 5% of total energy consumption by 2025. Indonesia is now the largest producer of palm oil. However, diversification of raw materials and second generation non-edible based biofuels are required.

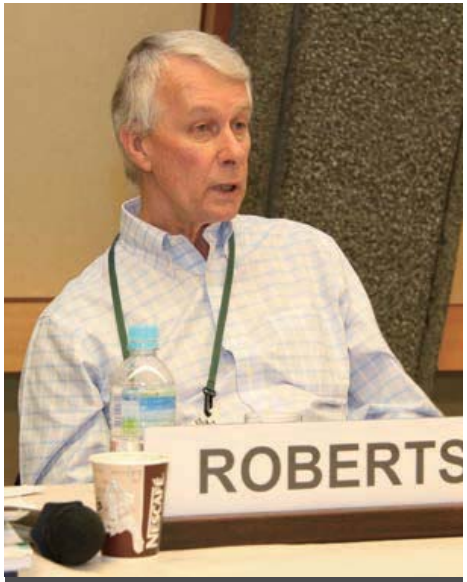
The fifth speaker discussed the integrated systems approach required to combine different new and renewable energies. With nanotechnologies, there is progress being made in efficiencies of solar photovoltaics in order to drive down costs. There is work underway to achieve theoretically possible efficiencies through the use of nanotechnologies, and also hydrogen production in a solar fuels generator. There is also work on cellulose and biofuel generation to make enzymes work better at higher temperatures. All of these innovations are driven by the fact that efficiency will drive the overall growth in renewable energies. However, what has been seen is that introducing small-scale generation technologies into the grid creates a need for either new control systems or backup energy sources, and more efficient solar panels cannot solve this. Batteries may be one answer, but a major challenge is that the electricity distribution system is both a physical system and a market system, and smart control that successfully incorporates renewable generation must understand this connection.

Discussion

One group discussed the fact that the honest advice of the scientific community is crucial, given the geopolitical interests surrounding energy. It was also cautioned that the currently assumed costs of carbon-based fuels do not take into account the associated environmental costs.

Another group discussed the potential of the new technologies presented by Chiyoda Corporation, and the great prospects from the synergies associated with hybrid systems including the hydrogen storage technologies presented. There were also bigger questions raised regarding the challenges of instability of new and renewable energies, knowing who the honest brokers are in advising on energy development, and supporting the public to make good decisions. It was suggested that a full study of costs would be interesting to see if traditional energies are actually as economic as they appear. There was discussion around safety and reliability in systems integration, with a lack of data available on long-term testing. Issues of training and certification were also raised.

One group discussed how the energy mix must meet the scale of the economy and local resources, giving consideration to how to best use technology to take advantage of the available resources, noting that there is also a policy role for the government to play. In a very diverse international discussion, it was noted that there are different resources available in each country, with different approaches being taken to tackle the challenges faced. Based on this, the super-grid can also be viewed as a solution to some of the issues being faced by individual countries, and getting the energy from certain novel technologies such as from ocean currents to where it is needed. In conclusion, it was highlighted that no one solution fits all situations, and that regulatory issues for transfer of technologies from country to country is also important.



Session Chair

Richard Roberts, Chief Scientific Officer, New England Biolabs Incorporated, U.K. [Nobel Laureate 1993]

Speakers

George Hara, Chairman of the Board, Alliance Forum Foundation/Cabinet Office of Japan, Japan

Lindela R. Ndlovu, Vice Chancellor, National University of Science and Technology (NUST), Zimbabwe

Robert Sindelar, President, Providence Health Care Research Institute, Canada

Tomoko Y. Steen, Professor, Department of Microbiology and Immunology, Georgetown University School of Medicine, U.S.A.

Concurrent Session 201 B-2: Nutrition

Opening Remarks

The session chair noted that the availability of good food in less developed countries was one major area of concern. The dilemma, he explained, was that Europe does not need GM foods, as there is no food shortage, and so they felt free to ban them claiming they were potentially dangerous. This political action orchestrated by the Green parties in Europe has resulted in the banning of GM foods in many poor countries, which do face major food shortages. In concluding his opening statement, the chair remarked that there was no conclusive evidence that GM foods were dangerous, as modified foods had been researched and consumed for many years.

The first speaker explained that he would speak on the issue of malnutrition and what information was required to determine effective individual level nutritional recommendations, using the example of his organization, Providence Health Care (PHC). He explained that PHC's population of emphasis were those with significant socioeconomic difficulties, and that even among those patients with kidney issues, for example, their nutritional needs depended significantly on their medical history. He explained that metabolic profiling was one way of providing an instantaneous snapshot of cell physiology, and that future developments in metabolic technology might allow doctors to assess bio fluids and thus distinguish between various dietary treatments. He also mentioned nutritional epigenetics as an effective tool to prevent pediatric development diseases, cancer, and to delay aging-associated prosthesis. In summary of his presentation, the speaker explained that to provide proper nutritional instruction to a patient, an understanding of their metabolic profiling, socioeconomic status, and epigenetics as well as how their nutritional status is influenced by the composition of our gut and microbiological communities would be crucial.

The second speaker explained that he would discuss nutrition, and the business model to make it sustainable and economically viable in the context of Africa. He added that while nutrition was important, other factors such as education would continue to be important to focus upon for improving quality of life in the continent. One major concern, he explained, was how to provide protein to individuals suffering from malnutrition. The speaker explained that his organization decided upon Spirulina, an edible micro-algae which contains 65 to 75 grams of protein per 100 grams, for its nutritional value and relative ease in growing. He explained that the required investment was less than US$5,000, and no aid is required from the UN. In conclusion, he explained that new frameworks for microfinance could help empower poor countries to become middle class and independent.

The third speaker discussed how we can remove the stigma associated with GMOs. One important question is, which general environmental effects on plants are available? Until now there has not been enough science for this. In Europe and North America, there is the topic of food for animals. Nutrition is essential for children, and if children under five years old can be provided with healthy nutrition, this ensures they become more successful in school and everyday life.

The fourth speaker stated that nutrition is directly effective in microbiomes (sets of microbes that live in individual bodies). There are several definitions of nutrition, one important fact is, however, that healthy nutrition ensures a good immune system through the management of microbiome. There are specific issues which need to be discussed in further detail, such as the need for more guidelines on nutrition, especially sugar. Sugar can become the next generation's tobacco, i.e. regarding serious impacts on human health. Besides GMOs, we should also revisit the use of radiation under the FAO/IAEA project that is used to improve food supplies for developing countries. Malnutrition, clean water, and managing massive introduction of fast food to developing countries are all serious issues. Until today, there has been not enough reliable scientific data available that states how much of these particular chemicals are unhealthy. To manage all these issues, we need to pay attention to food security and science policy focusing on nutrition.

Discussion

The first point of discussion was about microbiology and the great benefits that have started to emerge, and the fact that these developments originally were believed to be separate from medicine. However, that opinion is now being reversed. This was followed by the topic of natal medicine. C-section babies do not have the same immune system as babies that are born vaginally. Everyone is struck by how little we understood the microbiome, and the need for much more research. Further emphasis on microbiological research is essential and greater funding of functional studies of bacteria are urgently needed. This led to discussion on the kind of science being funded in different countries. While studies directly related to human health continue to be supported heavily, research inspired merely by human curiosity is suffering.

The group pointed out that malnutrition and poverty do not necessarily go hand in hand. Also, as people and societies age, dietary requirements will change across the globe.

Another speaker pointed out that it is most important to conduct studies on individuals rather than on large populations, and how geographical factors affect nutrition. Examples of this are soil composition, and the fact that the food on one tree might not be the same as it would be in other regions. Pathogens will also vary. All in all, nutrition cannot be thought of in isolation. It must be thought of in relation to the immune system.

Another topic is the potential need for complex food, and how epigenetic factors may play a role in nutrition. The major question here is, what should be the first step for tackling malnutrition? This would surely require examination of soil and plants, but will also need more studies of individual variations among humans so that nutritional guidelines can be modified to account for this. One size does not fit all when it comes to nutritional requirements.

The next representative speaker talked about economic independence and countries who could receive microfinance. This was followed by the topic of diabetes and the countries where it is a serious problem. It will be necessary to take legislative intervention through the government with regards to the sugar level in fast food and drinks. Individual countries must learn how to resolve this. Also, there is a responsibility to talk with the UN so that practices such as breastfeeding are encouraged, and commercial interests motivating populations to use powdered milk are discouraged.

The final representative speaker opened with the statement that correct nutrition starts with education, otherwise diabetes and other diseases can easily become more common. This topic was followed by the clean plate movement in the US, where there are major campaigns to encourage the consumption of so-called clean foods and fear of GMOs continues to be promulgated inappropriately. Therefore the scientific globalization of reliable information about nutrition can be shared through social media, for example. Suitable nutritional advice for everyone is an active goal. However, we must recognize that everyone's genetic background as revealed through genomics is quite different and like medicine, nutrition will also need to be personalized. Finally, possible allergic

reactions to food both traditional and GMOs was another topic that was discussed. Clinical trials in this area can avoid serious problems.

There was also some discussion of the correlation between the food people eat and their life expectancy. Japan is a good example of this. People's nutrition can have tremendous effects on their lifestyle. There is very clear evidence about this.

One participant asked about GMOs and if there is a place or forum where scientists can gather and peruse literature related to that topic. Another participant replied that many experiments have already been done to check if GMOs are dangerous or not; and to date there has been no good scientific evidence of harm.

The session ended with the comment that testing the final product is what is important and the process by which it is produced is usually irrelevant. Social scientists would do well to engage in this process of educating the public.

Reviewing presentation materials.

Session Chair

Paul Alivisatos, Director, Lawrence Berkeley National Laboratory (LBNL), U.S.A.

Speakers

Kenichiro Itami, Director, Institute of Transformative Bio-Molecules, Nagoya University, Japan

Shinichi Komaba, Professor, Department of Applied Chemistry Faculty, Tokyo University of Science, Japan

Yury Koropachinskiy, President, OCSiAl, Russia

Louis Schlapbach, Deputy Director-General, Global Research Center for Environment and Energy based on Nanomaterials Science, National Institute for Materials Science (NIMS), Switzerland

Andrew Wee, President, Singapore National Academy of Science, Singapore

Concurrent Session 201 C-2: New Materials and Nanotechnology

Opening Remarks

The chair first spoke on the connection between nanoscience and issues of climate disruption. Specifically, he focused on three points that he hoped would become the basis for the session's discussion: nanoscience as the key to widespread usage of renewable energy; the key to making fossil fuels carbon neutral; and the many future positive and negative implications that nanomaterials would have. Elaborating on his first point, he explained that solar energy had become much less expensive in recent years, and that nanoscience could potentially contribute to this development through the creation of energy storage technologies such as batteries. On his second point, he explained that nanoscience could help make fossil fuels more efficient such as through the usage of nanomaterials to help negate the effect of carbon on the earth's atmosphere and environment. Regarding his third point, the chair noted that there were still many future implications for nanotechnology, some of which could still not be imagined, and that researchers, industry, and government would continue to need to discuss these issues going forward.

The first speaker began by noting that his research group was focused on carbon based nanomaterials. He explained that the greatest challenges for carbon based nanomaterials were issues related to mixture and new forms of carbon. With regard to the mixture problem, he noted that current technologies did not allow flexible structuring and synthesizing, but that nanoscience, through the utilization of carbon nanotubes, could help alleviate this. With regard to the second issue, he explained that research and development of a three dimensional carbon nanotube with a negative curvature was advancing at a rapid rate.

The second speaker explained that he was currently working on a rechargeable battery for electricity storage. He noted that while lithium-ion batteries were currently being used in zero-emission vehicles, concerns over safety and material cost meant that new technologies would need to be designed and produced. Continuing on, the speaker stated that he was working on creating and developing advanced sodium-ion battery technologies, which required safer materials and chemicals to create than lithium-ion batteries, and were cheaper to produce. In conclusion, he explained that the development of new nanomaterials would help offset the cost of expensive chemicals and rare minor metals.

The third speaker brought up the topic of the future of nanomaterials and its relation to carbon emission. He explained that given that modern human society was based on the growing consumption of energy and materials, the continued discovery and development of new technologies would be required to respond to increasing demand, in order to prevent further harm to the planet. He stated that single wall carbon nanotube technologies were continuing to advance, with their production methods becoming simpler and costs of production lowering, leading to the real possibility of significant positive effects on the environment. Cooperation from scientists and various industries is essential in achieving this.

The fourth speaker began his talk by stating that new materials had great potential to improve quality of life. He focused his talk on three points: the consumption of energy for ICT purposes, and the potential usage of nanomaterials to help alleviate this demand; improving the handling of heat currents through nanomaterials to control flow and storage; and the usage of nanomaterials to store hydrogen at high densities and help absorb carbon to avoid environmental damage.

The fifth speaker spoke on the recent emergence of 2D materials and graphene as a major topic within nanoscience; how graphene has affected nanotechnology; and the future implications for funding of nanoscience. With regard to the first and second point, he explained that the development of graphene applications would depend on the issue of manufacturing high quality large area materials, lower production costs, and the discovery of new means for usage of the technology. As an example, he raised the possibility of the usage of graphene in the manufacturing of mobile phones. In response to the third point, he stated that there was an explosion of research currently underway in graphene in China, US, and other countries, but that it was still unclear whether the emphasis on funding such large flagship programs, versus smaller PI driven projects, would be better for science and technology in the future.

Discussion

One participant asked what the main goal was in creating a sodium-ion battery. The response was that the goal was to create a battery that did not require the use of metals.

Another participant commented that they had doubts about the economic feasibility of capturing and storing huge amounts of CO_2, and that carbon capture and usage (production of energy) was more realistic. Another comment was made that nanomaterials could eventually succeed in taking CO_2 and converting it back into fuel, for example, using sunlight, which would help create a stable carbon-based energy cycle.

There was a question regarding how nanoscience and nanomaterials could be translated into real functional devices, systems, and technologies. The explanation was that the fundamental self-organization by nature was the glue to translating these technologies into real life usage. Another participant added that there were already hundreds of examples of translating nanotechnology into real devices and systems, but that each case was unique and depended on the material, usage, and market.

One participant wondered aloud how the current components of traditional industries could be enhanced using nanotechnology, and stressed the importance of the market place in determining the direction forward for such technologies. A question was asked about whether there was a more efficient conduit from research to industry to help speed up the process. In response, a participant commented that co-location could be one helpful means to translating laboratory research into industry and real products.

One comment was that when developing new materials, researchers and industry representatives alike should be aware of the potential toxicity of nanomaterials.

A request was made for an industry representative to comment on the toxicity of nanomaterials. One such participant commented that there were no known industry related diseases related to carbon nanotubes. Another added that the popular notion that nanotubes could puncture cell membrane had no scientific basis, and that no studies had conclusively shown that there were detrimental health effects. Another representative commented that mechanisms were being developed to study and understand the potential health risks of nanotechnologies.

Returning to the topic of co-location, a participant commented that one way to bridge research and industry would be to recruit top researchers and professors to industry positions. Another participant commented that there were academic institutions that encouraged their faculty to be entrepreneurs and pursue industry and business related activities.

A participant asked how the architecture of computers could be changed to be energy efficient from an economic point of view. Another participant answered that there

were systems being designed that mimicked aspects of the human brain, which required substantially less energy consumption and were built based on a different architecture than that of a traditional computer. One more participant added that the type of materials used in the construction of the system was also an important component to the question of energy efficiency.

There was a comment that standards in categorizing materials, and its relation to toxicology, was missing. In response, a participant stated that this would take time as the technology continued to advance.

One participant asked how governments decided which specific areas within nanotechnology to focus on. In response, another participant commented that specific research areas were based around industry clusters, and that the sectors were decided upon by government, based on how successful they could potentially be when translated into the marketplace.

A comment was made that enthusiasm in nanotechnology had declined in Japan in recent years, and that it was important for governments to continue to promote and encourage innovation, research, and industry in this area. In response, another participant commented that his government had established multiple nanotechnology research centers and other facilities to create the necessary ecosystem for innovation.

Taking cohesive notes.

Session Chair

Cherry A. Murray, Dean, School of Engineering and Applied Sciences, Harvard University, U.S.A.

Speakers

Rawya Saud Al-Busaidi, Minister of Higher Education, Ministry of Higher Education, Oman

Yves Bamberger, Scientific Advisor of the Chairman and Chief Executive Officer, Électricité de France (EDF), France

Scott M. Heimlich, Vice President, Amgen Foundation, U.S.A.

John C. Hemminger, Vice Chancellor for Research and Professor of Chemistry, Department of Chemistry, University of California, Irvine, U.S.A.

Sung Hyun Park, President, Korean Academy of Science and Technology, Korea

Isao Taniguchi, President, Kumamoto University, Japan

Concurrent Session 201 D-2: Science and Engineering Education for the 21st Century

Opening Remarks

The chair opened by describing her academic and industry experience in the public and private sectors. Science and technology is at the core of both the problems and solutions of the world. Therefore, science and technology education is critically important. STEM education at the college level is especially important. There are valuable opportunities to work with students who will be influential in these fields.

There are two major steps to learning: transmitting information to someone, and assimilation of information. The first step of education is teacher-centric, and the second part is student-centric. Students learn not by getting information but by assimilating information, which is more difficult. She said one of the critical issues for 21st century education is shifting to student-centric education, as well as integrating research and academia with society and real-world solutions, while at the same time integrating disciplines to create a wide, interdisciplinary approach.

The importance of digitization is also something that should not be overlooked. It was noted that there is a digital gap between teachers and students, and also between developing and developed worlds.

The first speaker then made their opening remarks. The critical infrastructures or great sociotechnical systems like the electric system, like the Internet, or like the railroad system are the everyday support of modern society. Most contacts with science and technology for citizens and students are done through these systems. He posited that one of the problems with engineering and science schools is that explaining how these systems work is absent from the curriculum. Students learn about individual parts of the system, but not about the system at a macro level. Explaining how these systems work would be an effective way to attract more students to study science and technology.

He suggested that it is not only an opportunity for interdisciplinarity, but also to develop systemic approaches, in the curricula and in research. It is even more important to develop such courses in the universities, so that many jobs in all countries are directly contributing to the life and to the development of the great systems.

The second speaker made her opening remarks next, saying that the 21st century is a time of rapid and pervasive technological change. As world population increases, various logistical and infrastructural problems arise, such as access to clean water, energy sustainability, healthcare, and so on. Thanks to science and engineering, the world we live in has never been better; but there are still challenges involved in creating a more sustainable world. Useful developments in today's science and engineering must be highly collaborative and interdisciplinary to reach and benefit the widest number of people. Today's challenges are global in scope, so it is necessary to develop solutions that are also global in scope.

Oman, currently in the process of establishing a new government university, has been considering these issues. It prepared a study of exemplary institutions from around the world. Early on in the process, it was decided that the university would focus on interdisciplinary programs, such as: Energy, Resources and Stability; Systems Design and Technology; Medicine and Life Sciences; and Community Development and Wellness. It was further decided that all students should be involved in hands-on research projects that allow them to develop analytical problem solving skills. It was also decided to focus on internationalization as an admissions policy at the university, with goals to recruit and admit many students from abroad. This will be necessary to educate a new generations of leaders.

The third speaker discussed the need for a more technically-educated workforce to drive innovation, and the dire need to develop a more technologically-informed and sophisticated policy community. To achieve this, it is necessary to introduce programs that encourage students to take science and engineering courses in university. In the US, many students actually enter university as science students, but they change their academic focus partway through their academic career. It is important to make students outside of pure sciences aware of applications of scientific and technological knowledge. This knowledge is also applicable in policy-making. The more one introduces these options to students in university, the longer they stay in these programs in university. In addition, it is important to make a balance between theoretical and experiential approaches in these programs.

The fourth speaker stressed collaboration in engineering education, which was necessary to foster a new era of innovation. To make global and local societies more active and innovative, it will be necessary to produce not only new research achievements, but also to educate students as world leaders and encourage them to pursue interests in engineering and technology. One way this may happen is through collaborating with various industrial and governmental organizations. This is because scientific innovations are more valuable when their results can be seen in society.

He said that when he asks his students why they want to study engineering, they often answer that they think it will get them a good job, and lead to a bright future. When students ask him why they must study so hard, he always answers that it is not for themselves – so they can get a good job – but rather so they can benefit all society, on both the global and local level. Engineers and scientists should be doctors for society. They can diagnose and heal society's problems. They are also creators who should be highly educated not only in science and engineering, but also in humanities and ethics. In addition, internships can train students in these fields very effectively. During collaborative internships, new kinds of science and technology can be developed, as people from various fields discuss and debate.

Some important Japan-specific issues are promoting interdisciplinary collaboration, encouraging female engineers, and fostering international collaboration and exchange of technology and ideas. To solve the problems of society, it is important to collaborate with as wide a range of people as possible.

The fifth speaker introduced the concept of Total Quality Management in Universities. Quality is important in terms of both content and process, where the content is delivered to customers. In this configuration, customers means both students as well as society in general. When considering quality as a process, it is important to see it as a set of procedures, tools, methods, and philosophies. In this approach, quality is a checklist item where each of the activities required to practice and achieve quality is specified and evaluated for its presence or absence. In this process, one must define what a customer needs, is promised, and ultimately receives.

In Korea, there is an evaluation criteria of quality management in higher education called the National Quality Management Award. There are seven criteria in this evaluation: leadership; strategic planning; students, stakeholder and market focus; measurement, analysis, and knowledge management; staff workforce focus; process management; and management results. All of these seven criteria are further broken down into more granular items, which means that once they have been evaluated,

universities can know specifically where they can improve. There are many benefits of the Total Quality Management program for universities. It allows them to align their resources, identify their specific strengths and opportunities for improvement, improve communication and effectiveness, and achieve their strategic goals.

He then introduced a case study of Sogang University in Korea. It is a small but very well-regarded university, which focused its management on three major areas: education, research, and service, and established five core strategies for further developing their programs. These strategies included selecting the right students, building a capacity for creative education, implementing finance extensions and industry-university cooperation, leading internationalization, and overall aiming for customer satisfaction.

The university project for customer satisfaction was implemented with the EASY Project, where: E stands for E-communication, A stands for Assistance, S or Satisfaction (for example with regard to medical services and campus cultural activities), and Y or You, First.

The sixth speaker then addressed the audience. He described how the Amgen Foundation – the main philanthropic vehicle of Amgen, Inc. – is deeply committed to advancing science education both at the kindergarten-high school and university levels. Given the focus of the session, he discussed how the predominant goal of many of the Foundation's higher education programs is to inspire the next generation of innovators.

While the Amgen Foundation funds a wide range of programs in the U.S. and abroad, he focused on two initiatives spearheaded by the Foundation at the university level: the Amgen Scholars Program, and a new online course on biotechnology manufacturing under development with MIT. Amgen Scholars allows hundreds of undergraduates annually to undertake research projects at top institutions across the US and Europe, including MIT, Cambridge and Stanford. To date, more than 2,400 Amgen Scholars – hailing from over 500 colleges and universities – have participated, with more than 90% of those who have completed their undergraduate studies now pursuing an advanced scientific degree or career. The Foundation has also funded MIT to develop a massive open online course (MOOC), Making Biologic Medicines for Patients: The Principles of Biopharmaceutical Manufacturing, which will be available globally via the web in 2015.

Lastly, he described Amgen Foundation initiatives to excite students earlier in the pipeline. One such initiative is the Amgen Biotech Experience, which now reaches more than 60,000 secondary students a year across Amgen communities with a robust biotech experience in their own classrooms.

Discussion

The first to speak discussed the issue of motivating students to study engineering and science. One way to achieve this is to implement programs to encourage this study in this area before beginning high school. It is also important to provide people with opportunities to study science because sometimes these kinds of programs, and careers, can be accessible. Technology is now everywhere – many people think of technology, for example smartphones, as a black box – and universities should be able to produce citizens who understand how technology works – to see inside the black box.

Another issue is how to organize science and engineering curricula. Many globalized companies and organizations require new employees to have field-specific, specialist knowledge, and not just basic knowledge. Therefore, it is important to educate students to have this specialist knowledge while also giving them flexibility to move between fields and disciplines.

One participant spoke of his involvement in higher education in China. University graduates in China face a world where their skills cannot be applied. Also, there is a gap between the cultural attitudes and awareness of existing professors, and today's young students. In China, there are now about 7,000,000 university graduates annually, and while this figure has recently grown exponentially, and is still trending towards growth, it is still not at the level required by the national and international community.

There was a comment on the issue of university recruitment in Korea for science and engineering programs. One of the challenges is that these subject areas often require intense study and long commitment to academic programs. Many students are discouraged from pursuing an academic career in these fields. Therefore, it is necessary to educate students from a younger age, mentor them, and attract them to further higher-level study. In Korea, there are programs where gifted high school students are paired with research students or professors to promote this idea.

Another participant spoke about the importance of programs that focus on experiential learning. In addition to the practical hands-on experience students get at these programs, one of the other benefits is that students can become part of a social cohort – and that this may lead to further study in science and engineering. The other thing that educators must consider is that there is already fairly extensive literature on the effectiveness of different educational programs. It is important to consult this literature when making policy decisions. Another challenge is for academia to make connections with society – perhaps through publishing and sharing human interest stories.

The next speaker spoke about the priorities universities should take, saying that universities exist in a conservative world. Teacher-based and learner-based systems must also be calibrated correctly for instruction to be conducted efficiently. Today's students require increased flexibility and customization in their study programs.

Another participant raised the point of management methods for higher education. Universities in the 21st century face many expectations and requirements, and they also have to produce an elite workforce. Therefore, science programs in universities must focus not only on natural sciences and engineering, but also human sciences and ethics. Improving integration between university programs will be increasingly important as the 21st century progresses.

The example of medical schools was raised, where students learn different skills very effectively, but many students struggle when it comes to integrating these skills together. Engineering schools face similar challenges and lacks in their curricula.

The final speaker pointed out that the world has changed because the pace of communication has increased, and competition has become heavier. Universities must evolve to meet these challenges, and educate their students to have a broad perspective on the issues facing global society. This requires a different kind of faculty – a new generation of faculty – who do not require the same kind of incentives that the previous generation required.

Session Chair

Adel El Sayed Tawfik El-Beltagy, Minister of Agriculture & Land Reclamation, Ministry of Agriculture & Land Reclamation, Egypt

Speakers

Jerome Delli Priscoli, Member of the Board of Governors, World Water Council (WWC), U.S.A.

Jean-Michel Herrewyn, Senior Executive Vice President, Global Enterprises, Veolia, France

Pavel Kabat, Director General and CEO, International Institute for Applied Systems Analysis (IIASA), Netherlands

Catherine Mulligan, Associate Dean and Professor, Building, Civil, & Environmental Engineering, Concordia University, Canada

Masaji Santo, Senior Vice President, Division COO, Infrastructure Business Div.; (Concurrently) Division COO, Environmental Business Div., Mitsubishi Corporation, Japan

Avigad Vonshak, Professor, Jacob Blaustein Institutes for Desert Research, Ben-Gurion University of the Negrev, Israel

Concurrent Session 201 E-2: Water

Opening Remarks

The chair opened the session with his belief that water was one of the most important topics on the planet and was fundamental to civilization and human existence. The key question is how to optimize water use. New technologies have made this possible, not only in river basins, but also on farmland. At the same time, any discussion of water must deal not only with quantity but also quality. This includes issues such as desalination, decontamination and prevention of contamination. In addition, water is an issue of particular concern for the dry regions in the world. It is a fact that the dry regions are becoming dryer, and unless this is addressed, we will see grand exoduses of people, and significant social upheaval in these regions.

He then presented an example from Egypt, a country with very finite sources of water. Water optimization is therefore a critical issue. In the past Egypt had the most sophisticated irrigation systems in the Nile delta, but this is now being fully modernized. Developments in science technology will play a role as well, including advances in areas such as nanotechnology and genome technology, which could create greater resilience against salinization or dryness. Finally, people are at the core of discussions on water issues, and as part of this, the development of human resources. Greater efforts need to be made to raise the knowledge of people to give them greater capacity and adaptability.

The chair also made the point that no country or actor can solve these issues by themselves. He therefore called for stronger international collaboration, as well as participatory approaches that seek to engage the people and raise the awareness of civil society.

The first speaker offered remarks next. He stated that water concerns were growing but despite this, funding for tools and capacities to monitor and measure water's behavior was reducing. Furthermore, this is a struggle that affects both wealthy and poor countries. The main issue faced by humankind is economic water scarcity and a lack of balance between supply and demand. As such, the issue concerns distribution rather than absolute scarcity. For example, recently, water use trends have delinked economic growth and per capita water use. This has been driven by a variety of water-related technologies.

Transitions in allocation of water are also critical to social stability. In wealthy countries this means moving from subsidy-based allocation to those based on macro-societal problems. In poorer countries, this usually means moving from concerns over water access to concerns over multiple uses and investing in water infrastructure. Moreover, water has many uses; and by discussing multiple uses this provides opportunities to jointly create benefits rather than conflict over allocation. It is an effective venue for dialogue, and offers a learning ground for building communities rather than generating large scale social conflict.

In light of the fact that many people around the world live in regions where water is seasonal, infrastructure is extremely important. Water infrastructure investments also build resilience in the social system, as water storage is also one of the key methods to deal with risk and variability in climate. They also address issues related to health.

Discussions on water include issues of water security and disaster vulnerability. All wealthy countries have reduced damages from water disasters to around 5% of GDP. For poor countries, this can be as high as 25%-30% of GDP; untenable for social stability. Given that human society is urbanizing and settling in larger groups near the ocean vulnerability is increasing. Societies should take a more active approach to making decisions related to managing risks associated with water events, rather than passively accepting the decisions of management levels.

Finally, the speaker called for more dialogue and new dialogue between rich and poor on water resources. Wealthy countries tend to prescribe to the poor based on how they use water today, rather than how they used water when they were poor. More effective foreign policy aid is needed. Furthermore, new ideological and ethical consensus on water is needed, which focuses on the common ground of engineering means and environmental ends, extending beyond the status quo and existing notions of preservation, to ideas of co-designing with nature.

The second speaker began with business-as-usual water productivity and GDP. As of 2010, 22% of the global population live in areas of over 40% water stress. This number is projected to increase to 45% by 2050. GDP and energy are coupled, and many energy-related are water-dependent. Many renewable energy industries in particular are highly water-intensive. There is a very high chance that this will be critical in the near future.

Another major concern is the fact that while usually price volatility allows economic actors to take actions, such as to make investments, in the water industry water prices are stable and heavily subsidized. In some countries with very heavy water stress, there are subsidies on water parts. This strongly limits economic actors.

However, there are reasons for optimism. It is possible to develop methodologies to push economic actors to look at things in a different way. For example, companies could factor water into their direct and indirect costs. This could also transform the way companies assess potential investments.

The third speaker first presented a few key figures behind the challenges on water. In particular, he highlighted the fact that 6000 km^3 is used each year. In fact the largest water use is in Asia. If current trends continue unabated, Asia will become dewatered by 2030.

He also pointed out that supply of freshwater is being limited not only by glacial melting, but also industrial developments. Salinity is another major issue around the world, in areas such as the Bay of Bengal or the Mekong Delta. Groundwater sources have also been declining. There are also no comprehensive studies addressing water-energy nexuses. This issue is not receiving enough attention and is perhaps even being actively neglected.

Furthermore, water should not be isolated, but should instead be looked at as a cross-cutting issue. The water community and the climate community, despite coming together in the recent past, have now grown apart again. A possible reason for this is that the climate community constantly labels and focuses on the idea of climate change as a problem, rather than looking at issues of climate and water as an opportunity for water-proofing or new innovations and technology. There are many opportunities for flexible solutions. In addition, while there exist technologies for producing clean water, not much is being done to address cost. Currently the water produced is simply not affordable for the average farmer in a developing country.

The fourth speaker addressed the water-energy nexus. She first pointed out that urbanization was increasing, leading to a growing need for dialogue on sustainability between government, academia and business. Energy and water are intimately related. Energy is required in water infrastructure, for example, particularly for water pumping.

There are also issues such as water leakages in infrastructure, or new chemicals in water, that are becoming more difficult to treat. However, perhaps society should look at other water treatment systems, such as anaerobic

water treatment that would produce biogas, or the incorporation of solar panels into water treatment systems. She also informed that she was working on the development of water sustainability indicators. Almost 20% of energy use in water systems is for pumping water, so solutions for more efficient pumping would be desirable. There is also the issue of industrial or transport accidents leading to contamination of water. New approaches are therefore needed.

On the academia side, better and newer ways of training students is necessary. The speaker's organization promotes closer interaction between its own engineers and social scientists, as well as members of government and industry. The hope is to raise mutual understanding and knowledge.

The fifth speaker then discussed the water-energy nexus issue from a private sector point of view, looking at a specific case of a desalination plant in Chile. The plant is based in the Atacama Desert, an area with critical water shortage and also rich mine reserves that require considerable water for development.

Among the major challenges were regulations prohibiting new mines using underground water, and the fact that mines were located high up in mountains, requiring significant water transportation energy. To address this, Mitsubishi Corporation invested and built desalination plants providing water sources to mines. For mines located close to the plant at low altitudes, the plant provided desalinated water directly. For mines at higher altitudes, instead of providing desalinated water directly to the mine, the government allowed the mine to use underground water in exchange for providing the desalinated water to local reservoirs for drinking and irrigation purposes. This water exchange was conducted to mitigate the energy cost of transporting the water and has significantly increased water efficiency. Another unique aspect of the project was that Mitsubishi bore the cost the construction and operation of the plant. This therefore allows mines to focus on mine development costs, rather than utility costs.

The sixth speaker began by noting that water issues concerned the amount of resources available and number of users, pointing out that the total amount on Earth is not depleted; and thus the major problem arises from the increase in users, with the realization that 70% of water usage is accounted for by the agricultural sector. There is therefore increased pressure from users for feeding an additional 2 billion people by 2050, without even taking into account rising standards of living in developing countries. Therefore, the real challenge with water use efficiency is the number of calories produced with each unit of water used.

Furthermore, there exists a gap between technology and application. Technology is not the major problem; rather the problem is the cost or value of product obtained from each unit of water invested. Pushing the world and farmers to do more of the same is not the solution. Solving food problems by exhausting water reserves is not a true solution. He also warned against providing salinized water for farmland, as eventually the soil will be salinized; and while water can be desalinated, soil cannot. Salinized water could instead be used for growing fish, turning this into a question of recycling water. Overall, under such a scenario, farmers will have higher income, and therefore higher economic security.

The speaker also stressed that it was important to not look at water as a problem of technology, but also as a social problem. In light of this, we must identify ways to educate and develop the capabilities of farmers, as well as their ability to adapt. Furthermore, he shared the example of a village in Gujarat where 90% of students at a school he visited were boys, while the girls were instead transporting water over long distances. Therefore, he believed that the provision of supplies of sweet water could even address other social issues, such as gender equity.

Discussion

The participants first discussed the fact that integrated water resource management planning was an important tool. Science and technology should play a major a role in promoting and developing solutions for specific problems. Big data also offers solutions for better water management. Awareness of local issues would also have a positive impact on the implementation of any potential solutions and raise their acceptance.

Another point was raised regarding unconventional water use. This should be a new focus of water technologies. Water produced together with oil is one interesting example. Much water is produced alongside oil in countries such as water but technology is needed to harvest that water.

Discussion also covered the disappearance of the first inland sea. This failure was due to governance and water pricing. Despite this, these continue to be issues that are not adequately addressed. The question was also raised on whether water was a local or global issue. Water is no longer a national issue. That is a misconception. It must be addressed at a much larger scale.

Successful examples of water management in Singapore were also presented. Measures include maintaining diversity of sources, ensuring high political priority, and active communication to society. Furthermore, unlike other resources, the price of water should be directly correlated with volume of consumption.

The participants then addressed public-private partnership. Greater partnership between the public and private sectors is required. Currently, this is failing around the world. The nature of such partnerships has to be fundamentally changed. Guarantees are needed to provide support. Profit should also not be shunned.

Discussion turned next to closed-loop systems incorporating energy efficient technology and other factors. The importance of holistic systems and solutions was highlighted. Climate change was also raised. Climate change does not necessarily mean less water, but could mean more water at higher elevation. Water distribution must also be considered. In agriculture, better practices are needed to ensure the water security of those further downstream.

To solve regional issues, region-specific legislation is first of all required. Technology must also be specific to the problems in particular regions. Furthermore, different circumstances require different systems, be it decentralized or centralized.

Access to information and technology is also important for addressing water issues, which is easier said than done. This idea is also linked to concepts of education. Participants also highlighted the importance of adopting a long-term vision. There are many examples of mismanagement of water, where some have sought to solve issues in the short-term, but exacerbate the problem in the long-term.

Water use relates to geographic areas around the world. Trans-boundary issues are important. Governance is therefore important, and a global code-of-conduct must be agreed upon. Moreover, a win-win scenario must be created, otherwise there will continue to be conflict and competition. Furthermore ethics are also very important for science and technology. The question was also raised of whether rich countries and international trade would be able to consider ethics. Water is also often a siloed issue. However, it must be considered in relation to other issues.

There was also vigorous debate on subsidies, examples large scale business destroying smaller farms. At the same time subsidies can be a very sensitive issue and linked to issues of culture. For example, rice is very heavily subsidized in Japan, and has been for a long time.

The participants then returned to the topic of pricing. This is a very sensitive issue. In some cultures, people are very reluctant to put a price on water, and consider free access as an accepted right. Regarding closer dialogue between policymakers and scientists, there needs to be closer connection between science and technology, and diplomacy. Perhaps scientists need to be educated on how to communicate more effectively with policymakers to have a larger impact on society.

Finally, another very significant point was the need for greater knowledge for science and technology to be effective. To do this, capacity building and human resource development is needed. Funding for this would also be required.

Session Chair

Matthias Kaiserswerth, VP Europe, IBM Research and Director, IBM Research - Zurich, Switzerland

Speakers

Koichiro Hayashi, Professor, Institute of Information Security, Japan

Uri Rosenthal, Chairman, Advisory Council for Science, Technology and Innovation (AWTI), Netherlands

Ichiro Satoh, Professor, Information Systems Architecture Research Division, National Institute of Informatics, Japan

Pindar Wong, Digital 21 Strategic Advisory Committtee, Global Commission on Internet Governance, Hong Kong

Concurrent Session 201 F-2: Privacy for ICT

Opening Remarks

The chair began the concurrent session on Privacy for ICT by introducing the panel speakers and touching upon the relation between big data, the freedom of speech, various cultural values, and issue of privacy. He mentioned that the volume of online data that the world has generated from 2013-2014 has been the equivalent of what we have generated in total up until 2012, noting that it has been growing at an exponential curve. The chair also noted social media and mobile being two other big trends whose use is seemingly expected from users, the acceleration of the technology adoption curve, the issue of government spying, the impact of the cloud and other emerging technologies on the public, and concluded his opening remarks.

The first speaker commented on privacy for ICT being a broad topic before providing a handout on a case study questioning if the retention of communication data was lawful. He then presented case studies on data retention directives and judgments by the EU Court of Justice before concluding that four major regulators – law, norms, market, and architecture – had profound impacts on society, whose impacts must be considered.

The second speaker commented that technology and its evolution was the wrong discussion, and that the STS forum should help reframe that discussion to be on ethics. That is because ICT cannot be done in isolation; and touched upon the future interactions of robotics, big data, and genomics.

The third speaker stated that he was also in Japan on behalf of the Dutch Government, mentioning the upcoming Global Cyberspace Conference in The Hague next year; and commented on keeping the Internet open, the relation between security and privacy, digital evidence in the criminal system, and privacy by design on both hardware and software sides.

The fourth speaker commented on the gathering and assessing of data, such as in medical; the balance between business models, services, and data protection; and concluded the need for harmonization between countries.

Discussion

A participant discussed the difference between security and privacy; experiments being done with users having the notion of having control of their information; the length of privacy policy agreements, which could either be made simpler or which could be made to follow particular standards; and the differences in generational and cultural viewpoints in technology and user privacy.

A participant agreed on the topic generational and cultural differences, emphasizing that certain Asian languages do not even have a word for privacy developed in their language. He touched upon the positive side of access to information, such as the increasing amount of public official corruption being exposed as a result. He also questioned what level of privacy was appropriate, bringing up an example of people with dementia being lost in the system, and proposed that instead of legislating privacy, the amount of control over privacy should be given to the user.

Another participant discussed the question of giving up some privacy to have more security; the ethical questions that have to be grappled by different societies: cultural aspects on what exactly is considered private; who will actually be thinking about these ethical questions, such as the STS forum; and having a "committee of mothers" or a greater female perspective in this area.

Another participant brought up the issue of having a review board, the concept of self-regulation, and having sources of ethical experience or an ethical framework in order to maintain future regulations, noting that the STS forum had a unique depth in the subject that would enable it to tackle these issues.

Another participant discussed the issue of backlash, or the overregulation of flaws that develop only after they happen; and the understanding of terms and conditions and if it should be taught at school, questioning if people did not understand the policy agreements or if they just did not care.

The last participant discussed having a model that recognizes the rights and classes of data users, knowing where data will eventually be used, the compartmentalization issue of data, real time data problems such as with location data, as well as ways of retaining data as technology moves forward.

Session Chair

Brian Cantor, Vice-Chancellor and Principal, University of Bradford, U.K.

Speakers

Pascal Colombani, Vice Chairman, National Strategic Council for Research, Ministry for Higher Education and Research; Chairman, Valeo, France

Junji Nomura, President, International Electrotechnical Commission (IEC), Japan

Ashok Kumar Pandey, Managing Director-Corporate, Saud Bahwan Group, India

Dirk Jan van den Berg, President, Delft University of Technhology, Netherlands

Deborah L. Wince-Smith, President & CEO, Council on Competitiveness, U.S.A.

Concurrent Session 201 G-2: Competition and Cooperation among Global Industries

Opening Remarks

The session chair first stated that competition among companies is essential in a globalized world, but we need to balance it with cooperation. Ultimately, great value is the goal. He stated that he wanted to review the role of government in competition and collaboration.

The first speaker stated that his French company needs innovation above all else to survive. A large proportion of the budget of his company goes to R&D, which is the heart of innovation. In-house developments are not enough, and open innovation is necessary. His company cooperates with academia all around the world to a large extent. He stated that they have to take note of products that will become a reality in five to ten years in the future. He believed that partnerships with start-ups are important; and they help them to develop when they are promising and then, sometimes, buy them.

Innovation anywhere in the world is of interest to his company. They also partner with many large companies, including defense industry companies. Open innovation is at the heart of R&D, although IP sharing is an issue. It may lead to specific types of partnerships, including joint ventures. He added that start-ups have the concern of access to capital and large markets, and he believed it was harder to get in Europe than in the US. The role of government is to try to distinguish what will create the long-term future. The framework for long-term, riskier, upstream research must be established by the government, he stated, and appropriate funding is its responsibility. Government may venture into such areas that private industry will not yet venture in.

The second speaker stated that markets are becoming more and more interdependent. Today, goods are no longer made in a country; they are made in the world. In today's world, companies are fiercely competitive and yet they have to collaborate more than ever before.

He added that the speed of innovation has accelerated to a point where individual companies are no longer able to develop everything alone. He stated that the IEC is the world's leading organization that publishes globally relevant International Standards in electro-technology and supports all forms of conformity assessment. Through active participation in IEC work, companies find it easier to build competitive products of consistent safety and quality, protect and disseminate their intellectual property, and in the process reassure buyers, investors, regulators, and insurers.

The third speaker stated that rapidly evolving and potentially transformative technologies and increasing R&D expenditure are encouraging firms in high technology industries in cooperation. These collaborative efforts between industry giants ultimately help consumers enjoy better products at lower prices due to economies of scale, pooling of complementary resources, more integrated technologies, and reduction of duplication of efforts.

However, he stated, we must acknowledge the underlying dilemma which companies face while collaborating as they are driven by the aspiration to be the market leader, have a competitive edge and risk misappropriation by bigger partners. He stated that there is the dilemma of major competing brands. Should a market leader who is way ahead of the competition in terms of technology cooperate and share the proprietary R&D expertise with other manufacturers? In his personal view, though, it is that the manufacturers should sacrifice their shorter gains and choose the path of collaboration. He stated that governments should provide bigger incentives for popularizing vehicles and technologies beneficial to the general population, like for hybrid vehicles, which are popular only in certain pockets of the world.

In conclusion, he wanted to reiterate that competition would steadily increase in the race for market dominance and profit maximization amongst industry leaders and governments vying for economic supremacy and power. At the same time, it is crucial that global industry champions foster the spirit of cooperation, and greater collaboration for the benefit of mankind and serving society. He concluded that that was the only way to balance competition and collaboration.

The fourth speaker stated that globalization has rendered us increasingly interdependent with massive opportunities and also risks and challenges as a result. In terms of cooperation between and within corporations, states, and universities, the least likely actors to cooperate internationally toward the resolution of grand societal challenges are private industries. Private industries instead excel at competition, which can be a significant driver to ever-higher performance.

He asserted that at universities, competition and cooperation can very much go hand in hand. Global industries would benefit from increased and more meaningful cooperation. Closer links with the academic research community can promote this. One mechanism to catalyze the innovation of the private sector in a cooperative context is Public-Private Partnerships (PPPs). PPPs commit industry, universities, and the public sector in a joint effort to push the boundaries of knowledge and enhance competitiveness too.

The fifth speaker stated that standard setting is among the most successful in the area of collaboration, and this needs to be accelerated. The trends which accelerating this are speed-to- market, the complexity of systems, and also global supply change and the resiliency of those. Another exciting dimension is that we are in the era of great revolutions, e.g, in the fields of nanotechnology, IT, biotech and cognitive space. The world is being rewritten in digital, genetic, atomic, and neural code. This convergence requires companies in every sector to reach outside of their comfort zone and work in a way that they have not worked before. She shared a few examples of where the opportunities are huge, but some of the challenges are going to require new ways of collaborating. Importantly, she added, that means new ways to manage intellectual property is necessary to allow companies to economically benefit.

In the area of industry collaboration, she mentioned the nexus of energy productivity and 21st century manufacturing, and how the two are coming together. Non-fossil jet fuel for aviation is another important area for collaboration. Airlines manufacturers and start ups and universities are collaborating in this area. Industry-lead collaboration and competition are shown in the recent unveiling of the first ever 3D-printed electronic automobile. It was an open innovation project. Government must create the regulatory framework and capital cost structure, but at the end of the day the private sector must lead, she concluded.

Discussion

A group stated that barriers exist. In addition to the three groups already mentioned, government, private companies and universities, there is also the public. The public needs to be accepting of the competition and cooperation. Another barrier is regulation. It needs a certain amount of flexibility. Regulation can never keep up with innovation. Product liability, particularly in the US, can also hold back industry. Small and large companies can work together at universities. These days, with crowd innovations, innovation itself can have a very different character. There is also interaction with the customers. We are in general, the group stated, moving in a very different area that opens up many opportunities for new forms of innovation.

Another group stated that the government, particularly in Japan in the 1960s, pushed in the area of particular new technologies. Companies would join in a government project in Japan. Collaboration should not be limited to one country. There is academia-academia collaboration and industry-industry collaboration. They all must also benefit. "Collaboration for the competition" is a strong ideal.

Another group stated that we should think about how to get self-interested parties, universities and companies, to come together to address challenges that are global, such as food security. Health care is one area where cooperation is very poor. How can we have agencies get together? STS can play a role in bringing parties together, especially globally diverse stakeholders. We now need purpose-driven organizations. The group then addressed multi-industry cooperation. The group stated that the Nissan-Renault cooperation is a model of success in the automotive sector. It is a joint venture. Vertical collaboration has been successful and is relatively easy to do. The group asked how you can get collaboration when the companies come from different industries. There is the problem of the mismatch in time horizon, especially in automotive and IT. The group concluded that universities can serve as host organizations in that respect.

Another group stated there is much more areas of collaboration in the R of R&D. There needs to be balance between the partners in collaboration. Vertical collaboration is easier. There are problems in trying to get standards, such as with electric cars. Collaboration among industries would be important in the fight against Ebola. The group saw a tension in the role of government in collaboration in that governments have a national interest in developing the collaborations.

Another group stated that standards and cooperation are the most important in collaboration. Standards make it possible to compete. Private companies want to keep their own intellectual property. Specifications and standardizations are very important in terms of the supply chain. Government restriction in the way of rules and regulations is stopping innovation. There is tension when countries only want to support their own companies. The tax structure can cause friction and prevent collaboration. To have successful collaboration, there must be a balance between regulations and society.

Session Chair

Megan Clark, Chief Executive, Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia

Speakers

Sergio Alcocer, Undersecretary for North American Affairs, Ministry of Foreign Relations, Mexico

François Darchis, Senior Vice President, Member of the Executive Committee, Air Liquide Group, France

Peter Halpin, Chairman of the Board and Chief Executive Officer, World Resources Company, U.S.A.

Greg Lilleyman, Group Executive, Technology & Innovation, Rio Tinto, Australia

John R. McDougall, President, National Research Council (NRC) Canada, Canada

Tomonobu Uchida, Director, Senior Vice President, JX Nippon Oil & Energy Corporation, Japan

Concurrent Session 201 H-2: Efficient Use of Global Resources

Opening Remarks

The session chair first thanked everyone for attending the session, and introduced the session's theme of the challenges posed by limited resources. The challenges now facing mankind cannot simply be solved with more inputs and more waste disposed into the atmosphere; now the planet reaches its breaking point and mankind must aim for sustainability.

The first speaker gave a presentation concerning the initiatives taken by JX Nippon Oil & Energy Corporation to conserve resources. These initiatives included researching simple chemicals as alternative fuel sources, using unused waste materials for ethanol sources (cellulosic bio-ethanol techniques), and hydrogen supply for the fuel cell vehicles which are to be launched on the market by 2015. The company was entering the hydrogen supply business, and laying the groundwork for a network of hydrogen fueling stations ahead of the launch of these vehicles in the consumer market. They plan to use surplus hydrogen from existing oil refineries, use inexpensive hydrogen imported from overseas, and use hydrogen produced with newer and more efficient renewable energy techniques. Last, he discussed transport systems for hydrogen supply, introducing the use of chemical hydride and utilizing existing oil facilities to transfer hydrogen efficiently. The snag in that process was how to recover hydrogen from the hydride, but they were preparing a prototype of a facility that was equipped with the necessary technologies, and hoped to have it ready by 2018.

Next, the second speaker presented on efficient use of global resources, and the paradigm humanity faced: that if we live as we always have, we will expend the entire planet of resources. He shared his opinions for what actions should be taken on different levels. Citizens should be given a voice and be trusted to do things by themselves, and governments need to acknowledge opinions and act in those interests. Governments have found difficulty with economy issues regarding that, when separate interests collide. Companies are another element, as they have the responsibility to anticipate markets and provide solutions, and they must be more and more conscious of the future and invest in that, rather than focusing only on short-term. The final element was universities, which had to prepare citizens to work in government and companies and set people up to be able to devise solutions. Humanity has always demonstrated that they can beat the difficulties facing them, and the speaker stressed this was but another.

After that, the third speaker addressed 'efficient use,' and how it was closely related to sustainable use. He thought that most recent discussion had simply focused on energy and energy sources, and the results of that which implicate climate change. Certainly that was true, but there were so many other resources that were essential to life and well-being, particularly water and soil, since they did not immediately tie to climate change. Water and soil were crucial to discuss, particularly in the areas of food security. Science and technology are fundamental in providing solutions to this, but there is a wealth of suspicion towards engineered solutions to food security. Loss of soil and deforestation were part of a vicious cycle that severely threatened food security as well. He suggested developing an inventory of resources and developing efficient management.

He described other detriments, such as climate change, affecting this depletion: Mexico felt the brunt of these, being hit with two hurricanes at once on both of its coasts. Society had to be engaged in outreach efforts to stop the bleeding, and social science research had to be done to fully understand the effects that resource depletion would have for humanity. Life cycle analysis of disasters should be performed to develop public policy to prevent disasters, rather than just responding to them. To conclude, he reiterated that science and technology were fundamental in tackling these problems and to make sure society was sustainable for the future.

The next presentation by the fourth speaker was on the perspectives of mineral resource use. Humankind's demand for resources will continue to grow over the next few decades, according to their forecasts. While the absolute numbers may be wrong, looking at the growth of China, South East Asia, India and Africa, the trend is inevitable. Given that the world has finite resources, which are non-renewable, he said that we could all accept there is a need to address these issues. One day technology may find and unlock more resources and new materials that can substitute for things like steel and oil, but even so they still will continue to be needed. Recycling and reuse are a big part of efficient use, but on their own will not be able to meet the demands of the coming decades. Improvements in technology, such as for finding new resources, better mining technologies, and more efficient management, will be essential.

The speaker introduced two concepts: the first being that the resources industry has only a "temporary stewardship" for the land and resources they use. Industry practitioners need to be cognizant that the land they temporarily use will have a much longer life after mining activities are complete. Investment proposals must include closure plans, and what the final land use will be beyond the period of temporary stewardship and resource extraction.

He discussed a small anecdote regarding bauxite mining in China. The company negotiated with individual farmers to rent out their land, which was actually of poor quality for farming. After mining the land, the company improved the land for farming before returning it to the farmers. It was a good example of how land used for mining can be restored to a good state and redeployed for other purposes.

The second concept he offered was that the mining industry needs to ensure it efficiently extracts metals and minerals in order to minimize the environmental footprint, in terms of less energy use, better recovery of minerals, and so on. Transportation of rock is one of the biggest issues they face, with many millions of liters of diesel and other liquids used in the process. One option is automation, which can perform such jobs more efficiently. Finally, the speaker stated that it was important that new resources are unlocked through improved methods and efficiency, rather than a failure to innovate, and that industry is keenly following those developments.

Next, the fifth speaker spoke on the perspective of recycling. In spite of the importance of solidifying the reliability of the supply chain, significant barriers still lay in implementing the effectiveness of recycling. Developing countries were often targeted as cheap places for high-tech companies to operate, with a lack of regulation and rules in place to prevent pollution and waste of resources. They have not only contributed to the destruction of biodiversity, but have contributed to destruction of social justice. Resource nationalism was at the heart of the issue, such as several primary nations that cartel premium metals. Conflict-free resources are essential, and the world demands transparency. Investment in natural resource development has shifted in line with those trends.

He discussed the BASEL Treaty, part of which governed hazardous waste and improved transparency and waste management standards, but it was developed in a time without the degree of globalization society has reached and is severely lacking in many areas where management is most crucial. It overlaps with OECD rules and bilateral agreements, creating conflicting regulations that are affected by the treaty's outdated assumptions. There has been much more awareness of the issues that discrepancies and lack of enforcement have had on the environment, but policies need to be strengthened and rules made stronger.

Finally, the sixth speaker discussed their role on the National Research Council of Canada, where they address critical needs and challenges for industry, government, and society. They end up doing mission-oriented work with a clear focus, which requires efforts that are broad enough that they can really make a significant difference. For instance they were working on initiatives to improve crops that handled various soil conditions, and use of agricultural waste for things like biofuels. However, the issue of resource consumption was at the forefront: few people would accept a reduction in their standard of living, and those who were concerned with survival on a short-term basis would not acknowledge that efficiency is a duty, as it was simply not a part of their reality.

He stressed that the issue was not really that the Earth was running out of resources, so much as that they were creating an incredible amount of waste—whether it was food, energy, manufactured goods, or inefficiency itself. Individual values must somehow align with global society needs, and dealing with the clash of old assumptions and new behaviors. The challenge was clearly how to build a global consensus for effective global stewardship. People would not willingly give away their prosperity or opportunities to improve their lives. Perhaps they could take the step of matching consumption with their own production, and include standards that are more life-cycle oriented, and whole system thinking that is self-sustaining with a touch of bio-mimicry. All of it is built around education and understanding.

After all of the presentations, the chair opened the discussion session, asking everyone to reflect upon the questions raised.

Discussion

At one table, discussion began with the idea where if the people all believe in the law of thermodynamics and realize that resources are truly limited, then the real issue is distribution. There had to be a paradigm shift in thinking, thinking about how we can return things back. Additionally, they were concerned about the waste produced in procuring basic materials such as palm oil and rubber, wondering if there was any way they could reduce that waste or simply make the waste itself into a resource of its own. There was little research into whether it had been effectively used into bioenergy. Another participant pointed out that no process would be 100% efficient. The issue was not simply dynamics; the resources were lost in a usable form. There were also concerns about the implication that resources were unlimited, that efficiency and recycling could solve everything. They thought they had to change the rate of production and improve distribution. That could be accomplished both through higher education and simply a better look at how we use our daily resources, which could lead to a bigger discussion of and awareness of unequal distribution. Another participant suggested that waste itself might be the key.

At another table, discussion revolved around current issues of waste management that citizens were currently dealing with. More and more, citizens and governments were becoming aware of the fact of climate change and global warming, and how perception had changed about the issues now that the implications of industry were staring them in the face. The responsibility, globally, would be to find scenarios where the dialogue was approachable, and not necessarily at such high levels. If we could be responsible and capable to develop global solutions and develop sustainable models, that would be the most successful model. The social aspect and the technological aspects were colliding. Places like China had no structure at all about implementing changes and making it sustainable, even if they had some awareness—there was no unification on the issue, although high-level figures were making statements and effecting some kind of change. Catching up with one set of problems came with the caveat of missing problems in another, subverting efforts to be truly effective. Many companies in developing countries only paid lip-service to CSR, and market forces did not seem to be effective in generating that change.

A third table discussed how to solve the complexity of the issues and bring that in a presentable, understandable form. An example was genomics work, where advanced countries had come together on a common issue—why could that not happen with resource sustainability? A point was raised that they did not necessarily have to limit that to advanced countries; South America was putting out very advanced and effective solutions to some of the problems faced. But they needed some kind of system for everyone to gather and share. However, even with only two parties, if the approach taken is not immediately competitive, the challenges would never go away. There was a growing consumer demand for responsible behavior, such as Tesla and their electric cars. A 'cool' factor was crucial. Advanced countries usually came up with 'sexy', expensive solutions to these problems, but developing countries came up with simple and inexpensive solutions. They reiterated though that they had to work on high efficiency, even though it would not be cheap; but the very fact that it was not cheap meant it was all the more crucial. It was very much a risk-reward model.

Discussion at a fourth table centered on the odd discrepancy of trade expanding and borders between countries stiffening. One of the conclusions they reached was that waste was going to be a new resource. There had been some initiatives towards this, such as a business that dealt exclusively with the redistribution of waste. Confidence in those new businesses would be extremely important. One participant pointed out that if barriers were going up, that meant confidence was breaking down; with dialogue had to come confidence-building measures, and something real coming out of that dialogue. They ended their discussion with a poignant reminder of how much energy was dispersed in the production of a single iPhone.

The chair brought the discussion to a close, and asked the tables to share their opinions. The first table she asked discussed the separation between producers and users and the suffering that comes as a result. They needed a system of cooperation, and the broader concept of the 'oil in the ocean' issue, and creating alliances with mutual benefits. The issue of sustainable industries in developing countries was a burning issue, because you could no longer go into a developing country and tell them what you were going to do. Examining the entire value chain was crucial, and also understanding where the resources were being used. They also discussed long-term investment strategies, and the idea of where value was going. It was no longer simply a question of the cheapest product being the best; efficiency would now be more important than cost, as it took into account the entire chain.

The second table spoke on efficiency of water resources, and came up with a number of points. The first was a consensus that they were moving in the right direction, but the speed of it came into question. There was also an acceleration of the awareness of the impact. Second was the availability of information, and people taking advantage of the information they now have in their hands. Corporate citizenship and CSRs were flourishing, again showing that we were moving in the right direction. The issue was becoming more social than technical. On the bad side, although there was global consensus on the issues, some countries were hesitant to act and protect their interests, and regular citizens often would not address an issue if they did not really see it. Corruption was another issue they had to address. One suggestion was coming up with integrated approaches to these situations that they discussed, such as integrated approaches to mineral recycling. They also discussed energy efficiency, and having awareness of even the little, simple things they could do. Energy frugality was another principle we could all follow. Finally, education was essential to all of these points.

The third table brought up the limitation and distribution of resources, and how a better redistribution could better benefit the planet as a whole. The main theme was the amount and quality of the resources, and how satisfied society was with them. In order to preserve resources, the efficiency of its use should be improved, which science and technology could really improve upon. Of course, a bigger consciousness should be built in increasing recycling and recycling waste. Finally, they wondered if it was possible for a country to make a broad statement and action, such as the United States, to really take the lead on that issue.

At the final table, they had two main points. The first was in examining food, water, and energy, they concluded that waste was another resource to manage. The second was reexamining the value chain, thinking that they had to look at it from a systems approach level, with inherent variability. We see from the BASEL Treaty that we need better communication and a greater understanding of what limitations we deal with.

The chair brought the session to a close, reflecting on the looming challenges that humanity was going to face. In 60 years, humanity will need to produce as much food as it has ever produced; in 35 years, it will need to produce as much energy as it ever has; in a mere two years, it will have produced as much information as it ever has. She suggested that we should ask for, and step up as leaders to emphasize, global cooperation and handling of resources. Additionally, she asked us to reconsider if we are custodians of our water, land, air, and resources, instead of owners? That would lead us to rethink our position. She reminded everyone of Mr. Omi's words, that every issue has 'light and shadows'. Here the light would be the potential of social responsibility, of open trade, of improved technology, of the potential data available to us for managing resources, and of automation. Some of the shadows included national borders, pollution transfer, and buckling confidence in the world order, fears of the fragility of the Internet, fear of GMO food, and the loss of soil.

She noted that the group came to clear calls of action, something rare in her experience. The participants all called for better care of soils, better custodianship, better dialogue on trade, better cooperation on efficiency of resources, and examining biological systems to learn from nature, and effective global stewardship of resources. With that final statement she closed the session.

Plenary Session 202: Global Health

Session Chair

Henry A. McKinnell, Chairman, Moody's Corp., U.S.A.

Speakers

Yasuchika Hasegawa, Chairman of the Board and CEO, Takeda Pharmaceutical Company Limited, Japan
Klaus Lindpaintner, Chief Scientific Officer, Thermo Fisher Scientific, Austria
Richard Roberts, Chief Scientific Officer, New England Biolabs Incorporated, U.K. [Nobel Laureate 1993]
Shinya Yamanaka, Director, Center for iPS Cell Research and Application (CiRA), Kyoto University, Japan [Nobel Laureate 2012]

Advances in global health are constantly taking place, whether in medical devices, drug development, or treatment techniques. As a result, in our lifetime, there has been an addition in lifespans of 20-30 years. However access to healthcare remains unequal, with many people around the world still unable to receive the most basic medical treatments. In this session, the speakers presented some of the cutting-edge developments in the healthcare field, and discussed ways to ensure that the benefits continue to be enjoyed by a greater number of people around the world.

Opening Remarks

Dr. Henry A. McKinnell chaired the session on global health. He opened by discussing the fact that more advances in global health were constantly expected. Progress has of course been made, and in our lifetime, there has been an addition in lifespans of 20-30 years. That represents the light in global health. Moreover, Dr. McKinnell believed a golden age for medicine was still to come. Six patients have now been successfully treated with stem cells for macular degeneration, for example.

On the other hand, access to global health is not equal. More than 1 billion people do not have access to organized healthcare in any way. As such, many shadows exist. HIV/AIDS is a 100% preventable disease, but people are still dying from the disease or newly affected. Moreover, the number of infected patients continues to grow. Measles can be prevented by a vaccine that has existed for decades at less than US$1 a vaccine, but still many are dying, especially children under the age of five. As such, there still remains much to be done.

Prof. Shinya Yamanaka spoke of the vision Center for iPS Research and Application (CiRA), which is to promote research for the sake of improving the lives of patients. 25 years ago, Prof. Yamanaka wanted to help patients as a surgeon; however, he was not successful. He therefore turned to research, and after 20 years developed iPS stem cells, which allows the creation of pluripotent stem cells from skin or blood samples from a patient. Once such cells become iPS cells, they can be transformed into any cells in the body, be they in the heart, brain, or liver.

iPS cells are now being applied in cell therapy and drug development. The very first treatment using iPS cells was successfully conducted for macular regeneration. However, careful follow-up with the patients is still required before this can be considered a total success. Clinical trials with iPS cells are also being begun for patients with Parkinson's disease. There are similar efforts to treat heart disease and prevent heart failure using iPS cells. Blood disorders are another target. In addition, Japanese society is aging more rapidly than the rest of the world. Soon Japan will run out of the necessary blood donors. iPS-derived blood cells could be one possible solution. Cancer is another major health issue faced around the world. iPS cells can be used to create T-cells for combatting cancer. As for HIV and AIDS, HIV-resistant blood cells could be produced from iPS cells.

However, creating iPS cells from individual patients can be extremely expensive, and is therefore not yet feasible as a common treatment. To reduce costs, Prof. Yamanaka and others are working to develop iPS cell stocks. This should hopefully reduce not only the cost, but also the time required for helping patients.

Additionally, when making cells from iPS cells, it should be possible to recreate diseases in a petri dish, which would offer insight into disease modeling and drug delivery. This offers much broader possibilities than cell therapy, for which target diseases are limited. One disease that can be modelled is hepatitis.

Drug development is a time-consuming process and success rates are often very low. However, by using iPS cells in various steps of drug development, it is hoped that this will double or even triple success rates. Another researcher at CiRA has been able to recreate achondroplasia in a petri dish. Then by applying a variety of common drugs, he found that a drug for cholesterol control could have a significant impact on treating achondroplasia. It would be unthinkable to test a variety of drugs on a human being, but with iPS cells, this is now possible in the petri dish. Drug toxicity can also be assessed. Furthermore, by taking cell samples from a diverse population for iPS cell stocks, it is possible to predict, to some extent, drug efficacy. Overall, it is hoped that iPS can contribute tremendously to furthering global health.

Prof. Dr. Klaus Lindpaintner spoke about the conceptual and effective importance of innovation for driving health in human society, focusing on biomedical research. Throughout human history, engineers and their contributions to sanitation, the food produced by farmers, and the work of educators have often had a broader impact on advancing public health than the medical profession itself.

Those in affluent societies often take for granted the access to clean air, clean water, and so forth, and are often unaware of the essential role that monitoring all this with analytical instruments provided by the "enabling industry"—companies that produce technologies—plays. These companies provide necessary tools, and continue to innovate ways to keep mankind healthy. They have transformed cardiovascular medicine. Furthermore, when HIV first emerged, it was a catastrophic disease; but advances now make it possible for patients to live for many years after being infected by the disease. This has also contributed to the dramatic advances and revolution in regenerative medicine. However, there is nevertheless the need to find balance between expensive innovations and technologies, and a priori preventative innovations, which also require significant investment. Preventative medicine is particularly important for developing countries.

At the same time, information and knowledge management play a significant role in educating society on how to maintain better health. This too is an area that has been supported by the enabling industry. As such, the enabling industry will continue to play a vital role in making the world a healthier, cleaner, and safer place to live.

Mr. Hasegawa also advocated infrastructure for health emergencies. The WHO should be at the center of such infrastructure. At the same time, he called for open architecture in public health to enable an open and flexible approach to addressing public health problems. He also pointed out that in the past, those who sought to deliver disease treatment in developing countries were idealists, but time has shown them to be realists instead. Globalization is also encouraging business to invest in global public health.

Therefore, the notions of first world charity and third world dependency are coming to an end. Finally, Mr. Hasegawa expressed his belief that global health was an idea whose time had come.

Sir Richard J. Roberts spoke about the vital roles played by bacteria in human health. Research aided by DNA sequencing is now focusing on the hugely important, but little known, bacteria that constitute the human microbiome. A key issue for the future of health care will be to understand how the bacteria in the human body work. Having made our bodies their home, bacteria have developed very ingenious ways to protect it by fighting off disease. Fecal transplants, for example, have been effective in treating some diseases that are drug-resistant. Similarly, it has been found that some bacteria are developing proteins that could combat cancer. Research in this field is relatively inexpensive, and could be conducted in developed and developing countries alike. Learning more about human microbiomes and how to manipulate them can significantly reduce healthcare costs around the world.

Discussion

The first question from the audience was about sharing more knowledge and compounds from industry to academia. Prof. Dr. Lindpaintner agreed with the idea, and believed it was already being conducted. Mr. Hasegawa agreed with Prof. Dr. Lindpaintner. He said that such initiatives were at a primitive stage and more efforts should be made. Dr. McKinnell thought it also made sense from an economic perspective.

Next, a participant suggested that global health issues should be reflected in Sustainable Development Goals. Dr. McKinnell agreed, and believed health was an important part of economic development. However, the challenge is to get the right level of investment. Mr. Hasegawa noted that the current approach in medicine was to allow people to fall ill and treat them afterwards. However, preventative methods and greater healthcare coverage are ideas that need to be addressed.

Next, a member of the audience asked about the economics of patent regimes and how best to share knowledge. Dr. McKinnell believed the key question was how to provide healthcare to those who could not afford it. The issue is that research is very expensive. One strategy to address this is differential pricing, where higher prices are charged to societies that can afford it, so industry can then work on ways to provide these to developing countries. However, patents should nevertheless be maintained. Without patents, there would be no medicine and no drugs. Prof. Dr. Lindpaintner believed that while patents were important for sustaining the activities of researchers, there were also opportunities for shared patents, as seen in the semiconductor industry for example. He recommended having an open mind and exploring flexible systems.

Sir Roberts commented that the approach advocated by Dr. McKinnell made sense when developing drugs for developed countries, but less so for developing countries. A better approach would be to identify less expensive ways of bringing good drugs to the market. He thought that perhaps the work of Prof. Yamanaka could assist in this.
Prof. Yamanaka believed that while academia patents helped prevent monopolies, patents for private companies protected monopolies. With patents, academia can license technology and ensure it is distributed.

The discussion then turned to the role of computational studies and how it could contribute to medical health, such as through high throughput screening. Prof. Dr. Lindpaintner believed that data creation was no longer a problem. Instead, the issue is how to make sense of all the data that is produced. Sir Roberts agreed that computational studies and bioinformatics could play a very important role. However, one issue is that not enough attention has been given to testing algorithms and hypotheses. More energy needs to be devoted to this.
Dr. McKinnell said that when trying to help with delivering healthcare in developing countries. Rather than focusing on treating individuals, developed countries can help at the system level, training academic institutions and clinics, who then train medical professors. However, the issue that occurs is that these medical professionals are hired away to developed countries. Prof. Dr. Lindpaintner commented that this system would change only with economic development. The problem with healthcare in many developing countries is the infrastructure. Mr. Hasegawa agreed that without economic development, any attempts to educate and so forth would have to take a backseat to more pressing economic concerns.

Session Chair

Robin W. Grimes, Chief Scientific Adviser, Foreign and Commonwealth Office (FCO), U.K.

Speakers

Andrei Yureivich Gagarinsky, Advisor of the Director, National Research Center "Kurchatov Institute," Russia

Richard K. Lester, Head, Nuclear Science and Engineering, Massachusetts Institute of Technology (MIT), U.S.A.

Massimo Morichi, Senior Vice President, Research Development & Innovation, Areva Group, France

Hajimu Yamana, Professor, Research Reactor Institute, Kyoto University, Japan

Concurrent Session 203 A-3: Nuclear Technology Prospects

Opening Remarks

The session chair discussed the current nuclear fuel cycle and the questions around how long this can be sustained and what the alternatives are for the future, including exotic fuels, accident-tolerant fuels, alternative claddings, and the challenges associated with each technology. There was also the question raised of whether fast reactors would play a major part in the future of nuclear, and whether the fuel cycle can truly be closed. Finally there was the question of whether fusion or fission reactors would come to the fore and whether the history of nuclear energy would extend 1,000 years out into the future.

To begin with, the first speaker explained that Japan has a difficult and complex position with regard to nuclear, due to low public understanding and high public opposition to nuclear power, while the government position is that nuclear is an important base load power source, due to its extensive benefits, including geopolitical stability, low CO_2 emissions, and reinforcement of energy security. Therefore, for the future of nuclear in Japan there needs to be enhancement of safety culture, reinforcement of the existing hardware infrastructure to be able to withstand natural events, and an answer to the management of spent fuels, as Japan has already accumulated around 17,000 tons of spent fuels. There is a need to be flexible in using all available options, including reprocessing and storage. International collaboration will be very important for the development of advanced nuclear technologies for the future of Japan's nuclear industry. New technological approaches will be very important to attract young people to work in the area of nuclear power. International collaboration is also important in addressing the challenges of the cleanup from the Fukushima nuclear power station accident, to take advantage of the experience of different countries in the nuclear field.

The second speaker discussed the challenges related to waste, noting that there is a lack of a waste treatment culture in the international community. He stressed that the waste considerations need to be considered right from the very outset of a nuclear program. He stated that the key technological aspects to be considered include mixing of different levels of waste and management of spent fuel at different levels from the pool level, to transport, and long-term storage.

The third speaker pointed out that low-carbon energy, as a share of global primary energy, is steady at 13% due to a growing share of renewables making up for a decline in nuclear power generation. In Russia, government policy supports the country's nuclear industry for aggressive world nuclear market penetration, and the balance of public opinion is in favor of the use of nuclear energy. In terms of developments toward closing the nuclear fuel cycle, there is also the revival of a concept dating from the 1970s, of a hybrid thermonuclear reactor to produce fissile nuclei, which can improve the neutron balance of fission nuclear energy. He concluded that we owe it to future generations to develop nuclear energy as a low-carbon source for future use.

The fourth speaker commented on nuclear energy and its role in helping solve the world's energy problem. The world in fact has four separate energy problems, which are to meet the rapid rise in energy demand, manage energy security risks, minimize the local environmental effects of fossil fuels, and climate. To solve these problems, a major expansion of nuclear energy is required, but today the prospects for expansion of nuclear are mixed, with some countries pursuing new nuclear projects while other countries are retreating from nuclear. Comparing the plans for new nuclear plants with the plans for decommissioning of current plants as they reach their end of life, it appears that the contribution of nuclear to carbon mitigation is as likely to shrink as it is to grow.

To address these issues, innovation is required in nuclear governance, nuclear technology, and in education. Much more capable international institutions are required to address the governance issues for nuclear energy. For technological innovation, nobody can say what nuclear will look like in the second half of this century, but some expectations include moving toward a requirement for walk-away safety, smaller reactor designs to reduce capital risks, lifetime fueling of reactor cores, and integrated power plant/waste disposal systems. A third area of innovation is in education. The future leaders must combine scientific rigor, engineering excellence, and knowledge of society.

He also commented that Japan has stood as a symbol of nuclear disaster, and following Fukushima it has also fueled many predictions of the end of nuclear energy. However, he stated that we are actually just at the beginning of the nuclear era, and therefore he expressed hope that colleagues in Japan would join in the efforts to make nuclear energy safe for the world.

Discussion

One of the groups discussed technical innovations, governance and public acceptance. Questions raised included the use of thorium as a fuel, which could provide some safety advantages. There was discussion of the investment in fusion research. There was also discussion of what could be done to prepare for a time when the world recognizes more clearly the need to address climate change, by ensuring that advanced nuclear technologies are available for consideration at that time. There were ideas shared about how to strengthen international institutions, and relying less on government but more on business activities, and bringing in concepts of effective stress tests. Regarding public acceptance there was the question of whether public acceptance would follow from the other activities and innovations, or whether it needs to be addressed as a challenge in itself.

There were also discussions in one group on themes surround public perception, noting that nuclear innovation often comes from revisiting ideas and technologies from the past, that governments can benefit from assistance with public perception in order to better reach broader audiences such as mothers with children, so as to avoid raising fears in public, and that a broader range of spokespersons for nuclear might therefore be beneficial. There was a shared sense that issues should be proactively addressed by the nuclear community as a whole, and building an international body of knowledge on dealing with nuclear disaster. The importance of getting the messages right first time was stressed, as the record cannot be reversed.

In one group there were discussions around the costs of different energy options on a whole systems basis, including carbon costs. This led to a discussion of how to plan for nuclear as a part of the energy mix, including waste management, and the availability of fuels for recharging every six years. There was a question about whether there is a true understanding of the value of the waste from nuclear, and whether there is a broad enough understanding of the full range of uses of different radioactive isotopes in medical and research fields. There was also a discussion of the skills required for the future of nuclear energy and whether the expertise was being shared through international collaboration.

The importance of education was further underlined with emphasis on the time required for education to become established, as well as the importance of public education regarding the relative scales of the waste generated by

nuclear and carbon-based fuels. There was discussion on issues specific to Japan, such as regulation required to ensure safety, and a clear message that this regulatory body was very different to the regulation that had existed in the past. The point was also raised that there should be greater raised awareness of the fact that newer generations of nuclear systems are much safer.

One group discussed the fuel cycle and future technologies, and aims to close the cycle. There was also discussion on the economics and how sharing greater information on this would also bring benefits by improving the general understanding of the economics of the backend, but it was noted that it is not so easy to put accurate figures on external factors such as environmental impacts.

Session Chair

Hiroo Imura, President, Foundation for Biomedical Research and Innovation (FBRI), Japan

Speakers

Shigeki Kawabata, Vice President, Molecular Medicine Research Laboratories, Drug Discovery Research, Astellas Pharma Inc., Japan

Hilal A. Lashuel, Executive Director, Qatar Foundation, Qatar Biomedical Research Institute, Qatar

Manuel Peitsch, Vice President, Biological Systems Research, Philip Morris International R&D, Switzerland

Stephen Kevin Smith, Dean, Faculty of Medicine, Dentistry and Health Science, University of Melbourne, U.K.

John Tooke, Vice Provost, University College London, U.K.

John Eu Li Wong, Senior Vice President, Academic Medicine, National University of Singapore (NUS), Singapore

Concurrent Session 203 B-3: Preemptive Medicine

Opening Remarks

The session chair began by pointing out that non-communicable diseases (NCDs), such as cardiovascular diseases, type II diabetes, obesity and cancer are increasing worldwide, becoming a serious health and economic burden not only in developed but also in developing countries. The highest prevalence of severe cardiovascular disease is seen in low-income countries, which may be due to access to healthcare and quality of healthcare, but type II diabetes is also a factor, as it is rapidly becoming more prevalent in these counties. NCDs develop through complex interactions between genetic make-up and environmental factors, and several studies have shown that low birth weight are associated with increased risks of NCDs heart disease and diabetes in later life. This has led to a hypothesis that children born in an adverse environment who later live in an affluent environment develop these lifestyle diseases, due to epigenetic changes. This means that healthcare will need to start from the fetal stage rather than the present practice of preventative care for NCDs beginning around middle age in many regions around the world. Alzheimer's disease is a good example of a disease that requires a preemptive approach, and which is increasing in prevalence with an aging society. Present preventive medicine aims to reduce risk factors obtained from population based studies, without viewpoints of personalized healthcare, but future preventive medicine should be more individualized based on genomics and personal history.

The first speaker stated the importance of preemptive medicine. The sheer magnitude of the chronic disease burden and rising healthcare costs necessitates a move from a reactive model of care to a preemptive strategy that focuses on appropriate targeted early intervention to achieve better outcomes. As an example, in pregnancy and early childhood, a variety of conditions impact gene expressions through multiple processes. Data has been published linking the extent of newborn body fat to maternal antenatal fasting sugar, as well as the impact of antenatal maternal depression on newborn babies' right amygdala. Understanding the biology of developmental programming of non-communicable diseases may allow early intervention to change the natural history of the disease. Evaluating this in different populations is important due to gene-environment interactions.

Another crucial point in preemptive medicine is data mining and analytics. Endocrinologists working with computer scientists have identified multiple patient characteristics ranging from socio-economic to biochemical laboratory tests, and co-morbidities that predict higher healthcare resource consumption. This data may allow a multidisciplinary team to intervene early enough to prevent deterioration. Other applications of preemptive medicine include pharmacogenomics to identify patients at risk of adverse drug reactions, such as the association between HLA-B*1502 and Steven-Johnson's Syndrome with the use of carbamazepine, and genomic profiling of pathogens to identify drug resistant strains prior to the administration of antimicrobials.

Finally, social programs which are affordable and applicable to the general population are needed to encourage positive behavioral change to live healthier and prevent or minimize the burden of chronic diseases.

The second speaker began his presentation by stating that the current global health care system was unsustainable because of issues related to cost, the chronic disease burden, and demography. He explained that the best way to counter this unsustainability was preventive care through conventional public health measures designed to improve health-related behavior, and a deeper understanding of human biology leading to preemptive medicines that would prevent or delay the development of chronic diseases. He noted that there were two fundamental challenges: first, that preemptive practices would actually be effective; second, challenging a patient to take preventive medicine practices for the entirety of their life. He then explained his belief that diabetes, vascular disease, dementia, and mental illness should be the primary focus for public health organizations in the area of preventative medicine. In conclusion, he stated that the combination of targeting those predisposed to suffer from certain illnesses based on their genetics and early phenotypic characteristics, and taking general preventative action, were the best means to alleviating the burden on the global health care system.

The third speaker brought up the issue of aging populations and emphasized that not only was treatment important, but that prevention and early diagnosis was also important. The first and foremost aim of medicine has been to prolong life. Large amounts of medical expenditure had been used for end-of-life care. By 2025, healthcare costs are estimated to soar to 50 trillion yen. Facing this, we must make a serious efficiency drive in healthcare. Preemptive medicine analyzes the genetic information of a person and attempts to make predictive diagnoses before symptoms appear, as well as provides therapeutic intervention. Preemptive medicine is the ideal, and it is a direction towards where we should be heading. However, at the same time, we must not make the leap too soon either, and instead start by creating a flow of early detection and early treatment, reducing large costs in long term care.

The fourth speaker stated that it was clear that preventive medicine represented a shift in medicine and healthcare from reactive to proactive, from curative to preventive, and from preventive eventually to predictive. Despite the large amount of research that has been done, we still lack sufficient understanding of the underlying mechanisms of many diseases. We must continue to invest in basic research to further our understanding of the fundamental, social, behavioral, and molecular causes of human diseases. Any discoveries no matter how small will help contribute to preventive medicine in the future. In essence preventive medicine is ensuring healthy living.

In Qatar and other countries in the Gulf region, 15-20% of Qatar's population is suffering from diabetes and a much higher percentage are prediabetic and/or suffer from obesity, a major risk factor for diabetes and other chronic diseases. This is due to the rapid changes in lifestyles in these countries. Therefore, ensuring a healthy lifestyle is the most important aspect. Qatar is proactive and has taken several majors to increase public awareness, build sport and recreation facilities and increase awareness and promote healthy lifestyles. Recently, Her Highness Sheikha Moza Bint Nasser launched the Qatar Genome project, a national project that aims to achieve whole genome sequencing of the entire Qatari population. All together, these initiatives pave the way for the implementation of pre-emptive medicine and personalized healthcare in Qatar.

The speaker emphasized that Qatar's population and size combined with its large investment in biomedical research and commitment to leveraging its resources to push the limits of innovation make Qatar the ideal place and partner in developing and piloting novel and innovative approaches for the prevention, treatment and management of diabetes and other diseases.

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The fifth speaker explained that preventive medicine is dependent upon the ability to both predict and intervene at a very early stage of a disease. This ability in turn depends largely on a deep mechanistic understanding of disease mechanisms, which can be enabled by Systems Biology. One important goal is to reduce the risk of cigarettes causing preventable diseases, such as cardiovascular diseases, chronic obstructive pulmonary disease and lung cancer. The development of Reduced Risk Products by the industry has the potential to play a major role in this goal. A robust scientific assessment of such Reduced Risk Products is essential to their development. Systems Biology, integrated with toxicology in an approach called Systems Toxicology, is a key component of this assessment. He also stressed the importance of teaming up globally and collaborating through knowledge-sharing activities for such endeavors. Furthermore, he stated that there needs to be an open approach to sharing and collating data from different studies.

The sixth speaker noted the importance of focusing on the consequences on individuals and health care systems of using preemptive medicine. Once a large amount of data on individuals is available it is required to be linked to outcomes. For a recent study in Australia, 5,000 children were tested in their very first years of life as part of a 'healthnut study.' 1 in 10 children suffer from a food allergy, however it is interesting that if the parents are of the child are born in Asia there is a 30% chance of suffering from a food allergy. Once this situation is identified preventive medicine can be introduced. However, it is required to be started early so that the right preventive medicine can be introduced resulting in a dramatic reduction in allergies. Up to the present day, no country has introduced any effective system for this. It was suggested that trying to involve the government would be ineffective, as there is insufficient capacity to handle this kind of system. He stated that we need to be thinking of the healthcare system as an integrated mechanism, which will require a huge transformation.

Discussion

The first conclusions raised from the group discussions were about the importance of finding and diagnosing diseases such as tumors or cancer at a relatively early stage. For example, there could be a predictive system to predict a heart stroke. One of the major questions here is what makes diseases occur. When we look at diseases, we always look at what goes wrong; however, we should also look at the positive side. For example, the aging in Japan. Out of all the countries in the world, Singapore seems to be very efficient in implementing new systems. However, legislation should be made in order to implement changes. Another crucial point is that poor people have limited financial options to see doctors, and solutions need to be sought to address this.

One of the groups discussed issues that are linked to preventive medicine, such as nutrition, environmental factors, and taxonomy of disease. There are two divisions, the genome and the mechanism of how the individuals get the certain phenotype. Another point raised was sharing the information of accumulation of data and infrastructure. In order to achieve better medical care in preventive medicine, we need to be concerned about both policy and society.

The next topic discussed was regarding preventive medicine using personalized and targeted medicine. This can be applied particularly to Alzheimer's or cancer treatment. As for the use of biomarkers, there are both negative and positive effects, however a combination of both would ensure greater credibility. Another crucial topic raised was related to economic support that is essential for R&D, which is a major challenge. Last but not least, patient education was considered to be important, but it was stressed that there should also be understanding regarding the fact that some patients do not want their genomic data to be published.

There was some discussion on the concept of how global health is going to be impacted by personalized medicine, and that health awareness for the public is thus very important. It was suggested that this could include initiatives such as group activities. The importance of changing behavior was noted, and it was indicated that public understanding would be required in order to generate the desired effects. It was reiterated that individuals will become increasingly responsible for their own health and cannot rely solely on government or doctors to protect us as medicine becomes more and more personalized.

Making a point.

Session Chair

Hiroyuki Yoshikawa, Director-General, Center for Research and Development Strategy (CRDS), Japan Science and Technology Agency (JST), Japan

Speakers

Arthur Carty, Research Professor and Executive Director, University of Waterloo Institute for Nanotechnology, Canada

Henrietta Egarth, CEO, Austrian Research Promotion Agency (FFG), Austria

Katsumi Kawahara, General Manager, Technology and Innovation Center Preparation Office, Daikin Industries Ltd., Japan

Mark Liu, President and co-CEO, Taiwan Semiconductor Manufacturing Company, Ltd. (TSMC), Chinese Taipei

Kevin McAlea, Senior Vice President, 3D Systems Corporation, U.S.A.

Pascal Metivier, Executive Vice President, Research and Innovation Director, Solvay Asia-Pacific, Belgium

Richard J. Parker, Director of Research & Technology, Research and Technology, Rolls-Royce PLC, U.K.

Concurrent Session 203 C-3: New Manufacturing Technologies

Opening Remarks

The chair introduced the concurrent session by noting that for 10 years, the STS forum had been promoting discussions of the *lights and shadows* of science and technology; in other words the opportunities, dreams, and wishes as well as the threats, and concerns surrounding these topics. Continuing on, the chair stated that he hoped discussions would revolve around the potential means to achieve prosperous and successful manufacturing and industry, while simultaneously maintaining sustainability of international peace and the environment. In conclusion of his remarks, he asked all participants to propose their ideas on how to overcome international competition through collaboration of manufacturing industries including research and development.

The first speaker began by explaining that the vertical integration of networked production systems and the creation of horizontal value-added networks were posing a major challenge for the production systems of the future. She explained that in general, Austria had a strong international competitive position in industrial technologies, and in the research and development of materials in particular. Looking forward, she stated that in order to remain competitive in the global market, Austria would require the ability to take a broader view of production systems, open communication, and creativity for the development of disruptive technologies.

The second speaker spoke on the topic of the semiconductor industry. He began by noting that collective innovation had helped to provide continuous opportunities and advances throughout the history of the semiconductor industry, and that the technology had contributed to the development of driverless cars, cloud computing, the Internet, wearable technologies, smartphones, and smart cities amongst many other areas. In conclusion of his remarks, he commented that the semiconductor industry should work in hand with innovators to move the industry further forward, and would continue to play a pivotal role in new manufacturing technologies looking toward the future.

The third speaker began by noting that the chemical industry was an industry that faced multiple challenges, and had a poor public image in general. Expanding on this, he explained that the three key challenges facing the chemical industry were sustainability; the drive for better cost and productivity; and developing new forms of products which enable new manufacturing technologies. Regarding the first challenge, he explained that there was a need to continuously improve safety measures in the chemical industry; a need to find drastic new solutions to reduce energy consumption; and a need to find new technologies to reduce waste emissions from industrial plants. Expanding on the second challenge, he stated that combining multiple operations into one to improve capital and efficiency was important. Finally, regarding the third challenge, he noted that the chemical industry would have to work to help its downstream customers develop new manufacturing technologies. In conclusion of his presentation, the speaker stated that while the chemical industry was considered to be mature, there was nevertheless a need for a major breakthrough in manufacturing technologies sometime in the future.

The fourth speaker started his presentation by stating that global demand for rare earths had been growing because of their usage in a wide array of current, magnetic, electronic, and energy technologies. He explained that rare earth metals were distributed in small quantities all over the globe, and that with the increasing need for rare earths in military and high tech manufacturing, competition among nations had increased substantially over the past several years. In conclusion of his remarks, he wondered aloud why industry had become so dependent on single sources of earth materials, and why R&D to find replacement materials had not been designated as a strategic priority at an earlier point in time.

The fifth speaker began his presentation by raising several challenges in his industry, namely; challenges related to the material and processing fields in manufacturing and information technology. He explained that reducing the number of materials per unit, designing recyclable products, and responding to the shift in customer value from hardware to software were several potential means to address these issues. Looking to the future, he stated that in order to proactively address these challenges, enhanced industry-academia collaboration, and advanced innovative educational systems for training manufacturing engineers would be vital.

The sixth speaker discussed the topic of 3D printing. He stated that much of the current interest in 3D printing was based on its potential to revolutionize personal and industrial manufacturing. With low cost printers now available on the market, he explained that content creation and associate technologies would allow consumers to create more personalized products. Continuing on, he explained that speed, cost of components, material properties, and investor interest would be the main factors responsible for determining future advances in 3D printing technology and its success in the market place. In conclusion of his presentation, he stated that the continued evolution of 3D printing and associated technologies would change the current manufacturing paradigm, lead to higher levels of product customization, reduce economies of scale, and contribute to cost-effective local manufacturing.

The seventh speaker gave his presentation on high value-added manufacturing. He began by stating that high value manufacturing includes activities which involve "deep knowledge." He expanded on this by explaining that there were a number of key components which help organizations drive value through manufacturing, such as utilizing research and technology, exploiting scientific and experiential intellectual property, and an understanding of the customer and solutions which are developed to meet customers' complex requirements. Before concluding his presentation, he spoke on the topic of 3D printing, and stated that once the technology had reached a certain level, it could potentially create higher value-added manufacturing through rapid prototyping; creating components with novel combinations of materials; and creating complex geometrical forums which would be impossible to form any other way.

Discussion

The first group summarized their discussion by stating that they discussed new disruptive educational approaches at the university level; the shifting of manufacturing to underdeveloped countries as a result of 3D printing technologies; ethical issues related to 3D printing and other disruptive manufacturing technologies; the need to find alternative materials that can replace rare earth materials; intelligent robotics; and nanoparticles.

The second group summarized by stating that they discussed the usage of 3D printing for testing and new component creation in the aeronautics and semiconductor industries; the prevalence of the Internet of Things in relation to both industries; and the need for disruptive innovation in both industries in order to shorten the time required to develop innovative products and technologies.

The third group stated that they discussed future challenges in manufacturing stemming from digitalization; the importance of shortening the developmental period of products; the essential need to address environmental sustainability;

and the challenges going forward of figuring out how to analyze big data; and the imbalance between R&D cost and final product cost.

The fourth group stated that they discussed the ethics surrounding new manufacturing technologies; the creation of new jobs as a result of the advancement of 3D printing technologies; counterfeit products in 3D printing; and the importance of seeking replacements for rare earth materials.

Last, the fifth group summarized their discussion by stating that they discussed maintaining sustainability, such as through the Three Rs; the crisis of equipment manufacturers in the global shift from hardware to software; the democratization of 3D printers allowing small businesses to create new products and values; IP infringement related to 3D printing; and the government's role in bringing together a diverse group of people to create higher value technologies and its responsibility to help offset the costs related to unemployment resulting from the shift from hardware to software.

Listening closely to presentations.

Session Chair

Marzan Aziz Iskandar, Former Chairman, Agency for the Assessment and Application of Technology (BPPT), Indonesia

Speakers

Takashi Gojobori, Distinguished Professor of Bioscience, King Abdullah University of Science and Technology (KAUST), Japan

John Kilama, Director and Founder, Kilama International Consulting Group, LLC, U.S.A.

Taizo Nishikawa, Deputy to the Director-General, United Nations Industrial Development Organization (UNIDO), Japan

Wahid bin Omar, Vice-Chancellor/President, Universiti Teknologi Malaysia (UTM), Malaysia

Ellis Rubenstein, President and Chief Executive Officer, The New York Academy of Sciences (NYAS), U.S.A.

Takashi Shiraishi, President, National Graduate Institute for Policy Studies, Japan

Sibusiso Sibisi, Chief Executive Officer, The Council for Scientific and Industrial Research (CSIR), South Africa

Concurrent Session 203 D-3: Capacity Building in Developing Countries

Opening Remarks

The session chair opened his remarks by stating that maximizing the potential of mankind requires a high level of international collaboration. This requires the support of many infrastructures, including educational systems. This will result in increased international understanding and eventual shared understanding between developed and developing countries.

In many developing countries, much effort has been directed towards developing science and technology. His country, Indonesia, is an example of this – where the government has begun many initiatives to educate young innovators and support their endeavors. However, despite significant progress, much will still have to be done to solve the problems of these countries, as well as many developing countries.

The first speaker of the session began by touching on some of the foundational touchstones for dealing with the problems of inspiring students to begin studying and continue studying science and technology. Early childhood development is one of the central areas of global challenge. Nutrition and cognitive development are especially important areas – many children develop foundationally in these respects before they are four years old.

Inspiring middle school students to tackle these topics is also a key area of importance. Inspiring girls is another challenge. There is little role-modeling for girls in relation to science and studying science. And, finally, one of the key, often overlooked, challenges for developing countries is inspiring gifted secondary school students – they too often lack role models, or the ability to predict a future career or academic path for themselves in this area. This is why the recently established New York Academy of Sciences initiative called the Global STEM Alliance that was announced on September 22 at the United Nations, based on a Malaysian challenge to foster a "Nobel mindset" in various developing countries, has engendered 90 partnerships including nations such as Malaysia, Rwanda, the U.S. and leading organizations in the Mexico, UK, Sweden, Croatia, South Africa, Benin, and more.

The Academy and its partners are creating a kind of "Facebook for Gifted Children." Instead of feeling isolated at their current high schools, they can connect with other gifted children throughout the world but, of special value, they can get mentoring from an unprecedented network of brilliant young scientists from countries throughout the world. A similar project, aimed specifically at gifted girls and identifying young women scientists and engineers as mentors, is also under development.

The second speaker focused on the capacity building of ASEAN. It was established for the purpose of promoting regional peace and stability, in addition to economic co-operation and enhancing the global competitiveness of member countries. Many collaborations have resulted from ASEAN, including, looking to the future, the ASEAN Economic Community (AEC). AEC will be founded based on three pillars: ASEAN Security Community, ASEAN Economic Community, and ASEAN Socio-Cultural Community. This aims to transform ASEAN to a region where there is free movement of goods, services, investment, skilled labor and capital. There are also ASEAN initiatives which aim to establish and maintain collaborative education programs.

In the case of Malaysia's higher education, universities have played a major role in knowledge creation, and are seen as the key driver of the knowledge economy. Research has become a core academic activity, and students are being trained in the process of research. The university's role and mission is to contribute to the socio-economic growth of the nation. Currently, there are 20 public universities, 59 private universities, and over 450 colleges in Malaysia, with over one million students currently enrolled across all institutions.

International students are also increasingly choosing to study in Malaysia, beginning to flow into Malaysia, with over 25,000 in 2013. The AIMS initiative (ASEAN International Mobility for Students) has been instrumental in achieving this. One of the benefits this increased level of international students has is increased collaboration between young scientists from all over the world.

The third speaker began his address by observing that the title of the seminar, which refers to capacity building, assumes that there are very different challenges to capacity building in developing countries as opposed to developed countries. It is important to consider what the respective obstacles are in these two situations, and what may be easier to accomplish in a developing country as opposed to a developed country.

One of the challenges developing countries face are the challenges of unemployment and poverty. In order to drive growth and prosperity and create enough jobs, it is important that the capacity to develop education systems and infrastructure, even if this does seem like a glib response. However, this does not tell us what we can do to meet these challenges, and accomplish capacity building. It is important to have goals and images in mind of what kind of country, continent and world one would like to see in the future. It is imperative to articulate this vision, so it can enter our effort to work for capacity building.

Ultimately, it is too vague to say "we need better education," because an overarching response to these challenges is important. It is important to recognize the obstacles that can be used as inspiration to develop technology and advance science not just in developing countries, but all around the world. In addition, it is important to recognize the issue of inspiring and motivating students to study science.

The fourth speaker began by discussing an initiative to train mid-career officials, such as policymakers in the field of science, technology, and engineering. These are strategies to introduce new processes, and drive new demand for the growing middle classes.

However, the question of how to achieve human resource development, especially in developing countries, is a difficult one to answer. The problem is that systems are different all over the world. For example, dynamic ecosystems of innovation in Silicon Valley cannot be applied in other countries of the world. There are many factors at play, including cultural, legislative, and funding-dynamic issues. There is no such thing as a one-size-fits all program for human resource development. That is why solutions must be tailored to fit specific situations and specific countries.

That is why a research institute has been developed to study these issues. The institute has taken a collaborative approach with academic, entrepreneurs, industry, and government. It is important to train mid-career officials from developing countries in the fields of science, technology and innovation. In addition, a program for senior-level officials has been developed as well. The hope is that these senior-level officials will be able to come to Japan a few times a year to conduct independent study. Capacity building is a continuous and mutual process, not a one-way process.

The fifth speaker next began by stating that capacity building is nothing new. It has been around for many years. He gave the example of former US President Harry Truman's inaugural address, in which he said that developed

countries have the responsibility to spread technology to developing countries.

There are debates about what the best way to do this is, whether through education, through collaborative development of technological solutions, and so forth. He argued that education is not the central issue. One example he mentioned was that recent advances and research breakthroughs in HIV treatment have come from first-generation immigrants or those living and working in developing countries.

He believes certain problems in developing countries have been exacerbated by people from developed countries helping the wrong people, or helping the right people in the wrong way. That is why it is important that policy-makers make goals and systems for supporting developing countries which ask the question whose capacities should we develop – for example, students or middle-management, and so on. Also, it is important to consider what the next steps are after capacity programs have ended.

Capacity building involves more than educating citizens or promoting policy. Individuals also play a very important role, in the sense of an inspiring creator, businessman or leader.

The sixth speaker then began by introducing the unique mandate of the United Nations Industrial Development Organization (UNIDO), for which capacity building in developing countries is one of main activities. The world today is a world of inequality, not only within nations but also from nation to nation. A significant part of the gap was found by UNIDO to be attributable to the gap between development levels of science and technology and productive performance. Within a discussion of the post-2015 development agenda, there was an overarching consensus that poverty eradication remains the imperative. But at the same time, there seems to be common understanding that it can only be possible though inclusive and sustainable economic and industrial development. Industrialization creates jobs, profit and improves productivity. It is only through those dividends that a country meets in a sustained way many development goals such as employment, health, education, women empowerment, etc. As industry develops, it enhances the application of STI and leads to additional investment in skill and innovation. Industry is a seedbed for innovation, and innovation in turn is the driving force of economic transformation.

The outcome document of the Open Working Group for the post-2015 development agenda, which has just been submitted to the current UNGA, articulated 17 SDGs, which includes "build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation" as the 9th SDG. Importance of STI as a means of implementation of many SDGs including industrialization has been identified. To narrow the technology gap, UNIDO believes that both technology transfer and innovation are imperative, which could create real impact only with a strong partnership with the private sector. Innovation does not take place without institutional support mechanisms as a National System of Innovation. We provide TC services to strengthen NSI including capacity building in the area of productivity measurement and analysis. This will help policy makers recognize the necessary policy intervention.

The seventh speaker began by introducing King Abdullah University of Science and Technology (KAUST) in Jeddah, Saudi Arabia. The campus is enormous, and King Abdullah invested about $3 billion to build the university in under 3 years. The current number of faculty members was at around 120, with 800 graduate students from 85 countries. It is a very competitive university, because instead of paying tuition, their students attend thanks to fellowships and stipends. It has the second-largest endowment of any university in the world.

In terms of academics, KAUST is aiming to conduct the most advanced research in Saudi Arabia. It focuses on the innovation keywords of Food, Water, Environment, and Energy, and is one of the most productive research universities in the world. The KAUST community, and the KAUST paradigm, has a very collaboration-focused, international slant. In this respect, it would be a valuable experimental laboratory for capacity building. By collaborating with other groups, the Kingdom of Saudi Arabia is hoping to become a knowledge-based society, and to make a greater contribution to the world.

Discussion

The floor was opened to discussion. First, a question was asked about KAUST, and how many of its current students are from Saudi Arabia. The response was that 28% of all KAUST students are from Saudi Arabia, and that the amount of Saudi Arabian students at KAUST may not exceed 40% because of its internationalization initiatives.

One participant then stated that it is important to design capacity building projects prudently and comprehensively, not simply as one-time deals.

Next, another participant touched on the topic of what is different about the situation in developing and developed countries, and how to quantify that difference. It is important to develop scientific programs that become part of the network of institutes and nations which are based in recognizing that difference.

The next participant remarked that they were surprised that many assume homogeneity when discussing developing countries, especially those countries in Africa. For example, South Africa has highly developed post-doctoral scientific institutes and systems, focusing on research, drug development, and so on; but when it comes to programs developing and promoting widespread science classes in schools, or to support science students in university, there is not as much infrastructure. Before addressing issues of capacity building in developing countries, it is important to differentiate the different issues in different countries. If this is done, then it is possible to approach these issues strategically with sensitivity for each country's unique challenges, and also their unique strengths.

Another participant agreed that South Africa is indeed a developed country, with institutions of the level and style seen in developed Western countries. South Africa could become a leader for Africa in the same way that Japan was a leader in Asia. However, many countries in Africa are not as developed as South Africa. Technology transfer in Africa could become important, because it means that agricultural products could be made to meet international standardization processes, and start to be exported all over the world.

The example of Qatar was brought up, as well as the fact that while the population is small, the amount of money was great as a result of their oil and gas economy. The problem Qatar had was that when it invested money in research, it did not initially do so strategically. Instead of investing in issues that affected Qatar directly, they invested in subjects such as black holes which have no bearing on Qatar's economy and society.

The next participant said that it is important to find new modes of discussion which do not focus so heavily on the language of describing countries as developed or undeveloped, and to develop a new vocabulary and new paradigm which focuses on solidarity. The major reason for this is that the world is becoming more global, and issues or challenges in single countries have effects far beyond their borders.

One suggestion was that one key issue was to stop thinking about borders or peoples, and to begin thinking about equality and sustainability. Being able to collaborate across international borders is very important. Therefore, the industry-government-academia triangle, which was discussed in the concurrent session yesterday, can achieve large-scale goals like addressing climate change.

The next participant spoke about the initiatives started by Iranian universities to promote science and technology education, and also increase the benefits these programs will have on Iranian society. One of the key things to consider is that there is the possibility that students will leave their home country once they are educated in a process called "brain drain." It is important to put programs in place to inspire students to stay in their country after graduation and continue to benefit their home society and culture.

The final participant mentioned that in order for these economic paradigms to shift, the traditional conception of capacity building must be abandoned in favor of a more targeted approach.

Session Chair

Charles Kennel, Distinguished Professor Emeritus, University of California, San Diego (UCSD); Scripps Institution of Oceanography, U.S.A.

Speakers

Yves Bégin, Vice-Rector, Research and Academic Affairs, Quebec National Institute of Scientific Research (INRS), Canada

Ogunlade R. Davidson, Dean of Post-Graduate Studies, University of Sierra Leone; Former Minister of Energy and Water Resources, Sierra Leone

Rowan Douglas, CEO, Capital Science & Policy Practice, Chairman, Willis Research Network, U.K.

Jim Falk, Honorary Professional Fellow, Melbourne Sustainable Society Institute, University of Melbourne, Australia

Takeshi Nakagawa, Professor and Director, Research Centre for Palaeoclimatology, Ritsumeikan University, Japan

Akimasa Sumi, President, National Institute for Environmental Studies (NIES), Japan

Peter Wadhams, Professor of Ocean Physics, Department of Applied Mathematics and Theoretical Physics, University of Cambridge, U.K.

Concurrent Session 203 E-3: Adaptation to Climate Change (RACC6)

Opening Remarks

The session chair began by explaining that when the special session was first begun six years ago, adaptation to climate change was a new concept. However over time, discussions have grown in depth and sophistication. He then presented a statement that had been drafted on RACC and presented selected highlights. For example, the growing number of extreme weather disasters in recent years has made the issues of climate challenge increasingly visible. Additionally, in terms of discussions of the importance of regions, the importance and impact of the Arctic on the rest of the globe was also stressed. RACC is also working in partnership with a number of entities with similar goals. He then introduced the other speakers and invited them to offer opening remarks.

The first speaker focused on the challenges of climate change in the Canadian Arctic and Subarctic. Warming has many consequences. The sea ice cover has been significantly reduced, which has triggered heat exchange between the sea and the atmosphere, which further aggravates warming. Some changes are also irreversible, such as melting of glaciers, melting of permafrost mounds, and declining animal populations. Technical innovation is urgently needed to address these changes. However, it would be overly simplistic to assume that this alone will solve the issues.

The North is a region suffering from a variety of crises, not only warming, but also issues of demographics, energy, food security and more.

The second speaker focused his remarks on Africa, a continent with unique characteristics. Africa is not yet industrialized. As such, much of the greenhouse gas emissions on the continent come from deforestation. 30% of energy produced on the continent is still agro-power. He then made the point that greenhouse gas emissions continue to rise, and that there was a huge gap between the pledged targets and actual trends. The impacts of these emissions can therefore only be expected to intensify. Human society must adapt and develop greater adaptive capacity, but this is particularly difficult for developing countries.

One problem exacerbated by climate change is food production. Over half of the countries on the African continent are food producers. Therefore, focus has been placed on increasing food production yields through irrigation and other means. However, this issue is then how to deal with the surplus. He advocated building up agribusiness to address this and to consider agribusiness as an adaptation measure, and emphasized the importance of converting agriculture into economic empowerment.

The third speaker reminded everyone that the world is not going to change energy consumption habits due to melting glaciers in the Arctic or the destruction of animal's habitats. He focused on a capital-based approach and shared an example of how the spread of urban fires, the effects on industry, and the subsequent efforts to ensure new factories gave rise to legislation and changes in common practices that transformed how industries behaved and made urban fires a thing of the past. Similarly, and more recently, the rise of smart financing and more rigorous stress tests have made greater resilience a necessity to acquire capital. The need to better factor in risks has helped transform behavior and markets.

The fourth speaker opened by discussing different scales for viewing problems, such as the local, national, and global. Adaptation and mitigation have in part been separated due to the different scales through which different organizations have looked at these issues. He then spoke on geoengineering and how this was most frequently discussed at a global scale. However, there are a variety of innovative solutions being developed at different scales, within the broad categories of carbon dioxide removal, solar radiation management, and ocean acidification-reversal. A wide range of issues shape the debate about these different proposals, including so-called moral hazards. Solar Radiation Management not only produces different outcomes in different regions, but also raises the question of what governance mechanisms would be required to set the required global average temperature. The speaker reemphasized the need to understand connection between the local and the global, and that if there are to be novel innovations to address the thermal changing of the planet, they must be at a level at which people are able to make the appropriate judgments and decisions on risks, safeguards, compensation for negative impacts, and methods.

The fifth speaker noted that when trying to predict unprecedented climate change, one must look at geological archives. However, traditionally, geology has not been very good at dealing with timescales that humans can handle. Therefore it is very difficult to apply the lessons learned in the geological timescale to the human timescale.

When discussing global warming, temperature targets are often presented; however, policymakers always make the mistake of assuming that climate change occurs gradually. Looking at geological archives shows that climate change can occur in sudden jumps. In addition, the difference between the glacial age and post-glacial age was not just temperature, but the fact that the glacial climate was much more unstable and flexible. This made agriculture a poor strategy for food production and survival. If the next glacial shift occurs and the climate once again becomes highly fluctuating, then agriculture will no longer be viable for the food production of human society.

The sixth speaker began by explaining that the environment around science, particularly in Japan, was declining; and that there was a need to regain the support of society for science.

He then discussed a project conducted by the National Institute for Environmental Studies (NIES) and the Malaysian government, seeking to create a low carbon society. The reconstruction of the Fukushima region is also an important issue that NIES is also involved with. Working with industry, NIES is producing a future town plan for reimagining a community in Fukushima Prefecture to make it a low carbon community. He also touched upon the necessity of a global carbon management system. The carbon cycle must be clearly monitored, and NIES has developed a satellite to assist with this.

The seventh speaker first clarified the distinction between mitigation and adaptation. Adaptation entails living with changes, while mitigation entails combating the changes. He then touched upon sea ice retreat in the Arctic and climate change, and the self-fulfilling cycle involved. He then raised the question of whether this issue must be mitigated or adapted to. A variety of geo-engineering solutions have been proposed, such as marine cloud brightening. This offers possibility that geo-engineering may be able to reduce the rate of sea ice retreat.

Another issue is sea level rise, which is a matter of adaptation and not mitigation. There are concerns also that the rate of sea level rise may be more rapid than assumed by the IPCC. Originally, this did not take into account glacial ice melt at all, and though recent assessments have taken this into account, the model is likely still not realistic enough. Furthermore, as sea levels rise, serious consideration will need to be given to the abandonment of coastal cities and terrains.

The threat of a methane release from the melting of permafrost is also a major concern. There is evidence that methane emissions are increasing as a result of this melting, and if there is a significant methane pulse released into the atmosphere, then the rate of warming will be too rapid to adapt to. Therefore, we must find a way to deal with this issue before it happens.

Discussion

To start the discussions, a question was first raised regarding mechanisms for combatting climate change, and what it would take to introduce systems such as smart capital. It was pointed out that smart capital already exists in a small part of the financial sector in insurance and reinsurance. However, 95% of the world's capital do not have to rigorously factor in risk. Part of the reason is that accounting and managing takes place on an annual venture, rather than the next 10 or 20 years. Applying the regulations that currently apply to insurance and reinsurance to other parts of the financial sector could have a tremendous impact. If capital had to take into account some of scenarios posited by scientists, this could be a game-changer.

Next the participants discussed geo-engineering. The point was raised that even if geo-engineering offered viable solutions for adapting to climate change, it may distract global society from actually reducing emissions themselves. Another discussant noted that research in geo-engineering was advancing rapidly, and likened it to nanotechnology. At first nanotechnology received resistance as well, but it is necessary to assess the risks of each individual technology and hold more discussion, rather than dismiss the whole field.

It was then noted that locally, climate change was happening far more rapidly than the IPCC's assumption. This must be addressed. The reality is that extreme weather phenomena are taking place more frequently around the world. There must therefore be greater effort or some sort of mechanism to connect the local and the global.

One participant asked if it was really possible to say global society had invested enough to truly say that there was technology for removing carbon emissions from the atmosphere. The participants agreed that more effort needed to be made to pursue such research ad it should not be ignored, as such technology would be very attractive.

Regarding sea level rise, one participant informed that the sea level would rise by 4m by the end of the century. The contribution from melting ice sheets is accelerating, and the implications, both in terms of human life and financial impact, will be tremendous. Economically there will also have to be cities that will have to be abandoned in the medium or long-term. This will result in a significant loss of wealth. Similarly, the costs of flood-defenses and so forth will also rise.

One participant pointed out that things were changing rapidly, and yet scientists seemed to fail to communicate the severity of the issues we face. For example, a two degree Celsius rise in atmospheric temperature means very little to regular members of society. It is much more persuasive to discuss issues that have a more direct impact on people's daily lives, or at least are perceived by the public to have a more direct impact.

Discussion turned to the power generation industry next. Without strong political will, it will be difficult to have strong mitigation measures. While such political will can finally be seen in the United States, following the discovery of shale gas, unless India and China will change their policies, there will not be a reduction in emissions. At the same time international will is needed, or solutions will be limited to the local and national level.

Returning to the gap between what scientists communicate and reality, one participant pointed out that while he understood why scientists were conservative in the information they communicated, he thought there were nevertheless sections of society who wanted to consume the whole truth. What science needs is a partner to back it up and that wants to consume the unvarnished truth, allowing scientists to more openly and accurate communicate scientific data.

Session Chair

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

Speakers

Noha Adly, First Deputy to the Minister, Ministry of Communications and Information Technology, Egypt

Trish Damkroger, Deputy Associate Director At-Large of Computation, Lawrence Livermore National Laboratory, U.S.A.

Devdatt Dubhashi, Professor, Department of Computer Science and Engineering, Chalmers University of Technology, Sweden

Satoshi Murabayashi, Managing Director, The Bank of Tokyo-Mitsubish UFJ, Ltd., Japan

Ryozo Nagai, President, Jichi Medical University, Japan

Ilya Zaslavsky, Director, Spatial Information Systems Laboratory, San Diego Supercomputer Center, University of California, San Diego (UCSD), U.S.A.

Concurrent Session 203 F-3: Big Data

Opening Remarks

The chair welcomed everyone to the concurrent session on Big Data, introduced the other speakers, defined big data as the collection, transmission, storage, and use of massive amounts of data for scientific and practical applications, commenting that it was driven by the digitization of all manner of records, that sensors were getting very cheap, and because of the demand for new algorithms and applications. He discussed the four dimensions of big data as being volume, variety, velocity and veracity; and touched upon the technical challenges, such as how to fuse heterogeneous data sets and how to train people, before concluding his opening remarks.

The first speaker started his presentation on various views of big data, the amount of data being produced daily, and how to effectively manage such large volumes. He commented on decision-making processes, the issue of irrelevant data and how to filter that data, as well as privacy concerns.

The second speaker touched upon urban futures and how to aggregate information into sustainable solutions for problems; healthcare, particularly with imaging technology and how to handle the large amounts of data that emerges from it; briefly reiterated the issue of privacy; and emphasized the need for collaboration between technologists and social scientists.

The third speaker stated that the volume of data was currently moving too fast to analyze, that the data was currently underutilized, but that its utilization in data driven sectors could be of benefit. She then listed several challenges that should be addressed, the need for the education of talent, as well as the personal protection of privacy and the issue of the ownership of data. She then brought up creating appropriate governance and the key players that should be involved, before concluding her remarks.

The fourth speaker brought up the use of data in the medical field, the assessment of treatments and survival rates, the cost of randomized control trials, the need for different data sets for patients of different nationalities, and the need of a good system for medical management and policy making. He added that many medical health records were not standardized, and that stimulating discussions on these topics would also be a good place to start. Big data was the way the medical sector needed to proceed in the future.

The fifth speaker brought up the issue of bioinformatics, particularly with viruses and therapeutics and their mutations; and climate modeling and the observational data that comes from these models. She also commented on the need for visualization tools that need to be available; workforce management, developing talent, and retaining talent; and concluded her presentation.

The sixth speaker discussed how financial services utilized big data and the actual size of the large amount of data. He detailed that improvements were made in three key areas, including sales and marketing, such as with product recommendations and social media data used to understand customer behavior; risk management, such as with methodologies to detect unusual transactions and the assessment of cyber threats; and financial markets, such as with high frequency trading.

Discussion

A participant questioned what has been gained through big data as of today. Another participant responded that churn rate analysis has dramatically improved. Examples brought up included instantaneous Netflix movie recommendations, the Google translate database, greater accuracy in predicting weather, medical phenotypes, the sequencing of genes, behavioral monitoring analytics and applications used by the government and military, high dimensional statistics, as well as economic analytics and its effects on future investment. A participant discussed that we had a huge amount of input data but questioned what is the output required from computers. Other participants brought up issues of asking the right questions, verifying the analysis of data, and the availability of the analytical framework that would allow people to mine the data.

Another participant commented on the thinking process of data scientists to cope with outliers in datasets. Another member discussed why demand prediction was not used outside the commercial sphere as it could be used in other areas such as in the public sector. Another attendee questioned the training of data scientists and how to cope with excessive noise in data sets. A participant responded that in the public sector, big data was used in cases to improve water distribution issues and traffic conditions. Members then discussed the policy issues that arise from these situations. Another participant then reiterated the need to be asking the right questions and to know the goal you want to achieve by using the data.

Participants then brought up the issue of genetic data also involving members of family, the development of a standardization of health records, the differences of electronic health records between countries, and EHRs. Members then discussed inductive versus deductive data, questioned the establishing veracity of data, the conversion of big data to small data, the multidisciplinary aspect of big data, and the importance of the quality of sensors. A member then questioned, in 10 years, will the topic of big data have turned out to be hero or hype? Most agreed that there would not be as much hype, but that it would be implemented in many areas. An attendee predicted that AI would be the next big hype and that it would be built on big data.

The session chair thanked everyone for the informative discussion, and concluded the concurrent session.

Session Chair

Devang Khakhar, Director, Indian Institute of Technology Bombay (IITB), India

Speakers

Michiel Kolman, Senior Vice President of Global Academic Relations, Elsevier B.V., Netherlands

Børge Diderichsen, Vice President, Professor, PhD, R&D Outreach, Novo Nordisk, Denmark

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

Yuko Harayama, Executive Member, Council for Science, Technology and Innovation (CSTI), Cabinet Office, Japan

Hitoshi Murayama, Director, Kavli Institute for the Physics and Mathematics of the Universe, The University of Tokyo; MacAdams Professor, University of California, Berkeley, Japan

Youngah Park, President, Korea Institute of Science and Technology Evaluation and Planning (KISTEP), Korea

Torsten Nils Wiesel, President Emeritus, The Rockefeller University; Co-Chair, Board of Governors, Okinawa Institute of Science and Technology (OIST), U.S.A. [Nobel Laureate 1981]

Concurrent Session 203 G-3: Responsible Public Dialog in Science &Technology

Opening Remarks

The session chair stated that this particular session reflects what the STS is really concerned with. There was a similar session at last year's STS, which included outreach to journalists. Next, he went around the room and let the speakers introduce themselves.

The first speaker stated that he can claim that he has the privilege to work for a company that has fully embraced technology to communicate science. He looked at three technological innovations that present unique opportunities to engage more effectively with wider audiences outside the research community; social media, mobile platforms and data visualization. Giving members of the public access to scientific information was one way of engaging them. But what if there was a way for the public to participate in scientific research? How much more powerful that would be in terms of raising their interest? Through a growing number of applications for mobile platforms, that had become a reality. Big data is a term that comes up in any random discussion, and surely is a phenomenon that can greatly contribute to connecting the public with science, especially when it comes to data visualizations. He stated that there was a shared responsibility for all involved in science and science communication to accurately communicate about science.

The second speaker stated that there was an irony that as the general public is enjoying scientific products, they also demand that science can immediately solve problems; but the public opposes some things like genetic engineering on an irrational basis. However, such misunderstandings can be avoided by simply engaging in responsible public dialogue, and being careful to follow all government regulations as closely as possible; a lesson he learned from his own experience in working for a Danish pharmaceutical company. This lesson also applied to social servants. Scientists should speak directly to the people, without the use of public relations people. They could invite the critical NGOs to see their work and explain to them the projects they are currently working on. He stated that scientists should admit their mistakes in science immediately. Public servants are concerned with whether genetic engineering will have a negative effect on the public. There was a law passed in Denmark concerning genetic engineering, and that satisfied the government and the people. He stated that some scientists are mistrusted precisely because they are experts. To regain trust, scientific social responsibility had to be established. He concluded that ethics should be the basic motivation of scientists.

The third speaker stated that the human population is growing fast, and that almost two-thirds of it are living in cities. The problems that emerge from this scenery are complex and enormous in scale, especially regarding resources; are there and will there be enough resources to provide a decent life for all the inhabitants of the Earth, and not just for a few privileged people? He added that in general, we are now forced to acknowledge that the future is no longer what it once was. In this global world, a 'glocal' system is essential to our balance. Within this vision is the mission to give citizens an understanding of the role and importance of research, innovation, science and technology in our individual lives and in a common future. He added that we need to contribute to the making of a cultural citizenship. EXPO 2015 will be held in Milan, and all STS members were invited to attend.

The fourth speaker stated that there were two groups in the past; scientists and the general public. There were those who are producers of knowledge and those who were users and receivers of knowledge, and you had one closed club and the outsider. This kind of dichotomy was the mainstream thinking. She wondered whether this dichotomy still existed, or whether there was something different now. Thanks to the development of the Internet, there was greater access to information. Citizen science was now becoming visible, but was not yet clearly defined. Regarding the dichotomy, the opposite thing might have been happening. For example, as a researcher you have your own ideas in your closed club, but instead of remaining in your closed club, you can open the door. Scientists can put their ideas on a website, and non-scientists may find it interesting. There was integration happening in the creation of knowledge. It was limited, but it was happening. The general public could contribute to the construction of knowledge. The public needed to be given a sincere, frank discussion of science. It is up to us to review the relationship between science and the citizen. The distinction was not so clear. The public can become more expert on various topics.

The fifth speaker stated, jokingly, that his work was useless to the public. He hosted public events and published books for the public. He cared about outreach to the public. Taxpayers support his research. Secondly, there was self-interest in trying to get more funding. Common people responded positively to the issue that Japan would need to reduce funding. Common people, surprisingly, supported the continued support of science in Japan. He wants to bring out the inner scientist in common people. Women had to be inspired to study science more. Children become fascinated with science when presented properly. Public lectures have also been given regarding the necessity of these issues. He stated that scientists should teach common people by posing questions, rather than just giving answers. One had to be careful when dealing with the media, as they commonly have their own agenda. Outreach can be inspiring to people.

The sixth speaker stated that we encounter risk every minute. As our society has changed so fast, risk was inevitable. She provided two examples of governance deficit cases in Korea. A protest began after the government reversed a ban on US beef imports, and a TV show on the subject resulted in mass demonstrations. The first thing done by the government was a legal action against the broadcast company, rather than giving a sincere explanation based on the scientific facts. Eventually it caused a fall in trust of the government, and incurred a huge social cost. The other example was of a woman who died due to the SFTS virus transmitted by a tick bite. As the term "killer tick" was used, it triggered anxiety among the general public. The authorities and media should have refrained from using exaggerated expressions. Although the right solution should be mostly based on factual scientific evidence, the general public has a tendency to seek multiple favorable ways that match their respective situations. To fill this gap, good risk communication among scientists and the general public is necessary.

The seventh speaker stated that scientists have a responsibility to make sure that what they publish is accurate. Recently, it has been reported that a large percentage of the articles published even by the most reputable journals cannot be confirmed. In most cases, this is unintentional; rather it is due more to the pressures, particularly on young scientists, to publish for career advancement, for recognition and to obtain funding for their research. Unfortunately, such pressures can lead to results being submitted prematurely and at times not reviewed well enough by peers before accepted by the journal.

A blatant example of the failure of scientists to adequately communicate with the public in a timely manner is the failure of the acceptance of GMO products among EU countries. Another issue concerns the lack of public information about the critical need of non-human primate research for understanding the causes, the prevention, and the treatment of brain neurological disorders, such

as Alzheimer's, Parkinson's disease, and mental illnesses. He concluded that the public needs to be reassured that scientists are searching for the truth while keeping the best interests of the public in mind.

Returning to the session chair, he stated that in India there were far fewer researchers as compared to the US. There was very little public dialogue in India about the risks and benefits of science. NGOs had a much wider network than scientists in India to convey information about science, and NGOs even sometimes oppose the actions of scientists. Communication that could better inform the public was necessary in India.

Discussion

One group stated that as most people are not aware of the Nobel Prize, it was hard to tell the public what you do as a scientist to benefit society. Some people had issues against science, e.g. GMO, since scientists could not explain themselves well to society. Scientists should better explain their findings. Scientists often are unaware of the outside world, and only know science in the narrow sense. They ought to approach children and start introducing science to them at an early age, like kindergarten. Scientists should learn from other professionals about how to explain what they do, and explain how science impacts everyone's lives. They could also learn from journalists and novelists on how to convey the importance of science.

Another group asked how the public's trust could be engaged. Museums with hands-on experiences could be useful. K-12 students need to be exposed to science more by teachers who are able to convey the excitement of science. Scientists should be engaged more in the everyday public debate about timely issues like global warming. Journalists need to be dealt with carefully, as they sometimes misrepresent the issues at hand. A participant stated that people in remote areas need to get information about science. The group concluded that we need to move to a knowledge-based economy.

Another group stated that they reviewed best practices of people in their group. Citizen apps were useful, as was supplying the data for them. The earlier people were engaged, the better would be their ownership of what the outcomes are. Some were surprised that policymakers did not get enough attention in the meeting, as they were an essential target audience. People often blog about science without having proper information. The mindset of scientists should be that they want to be candid about what they do and do not know. What kind of training do we give to scientists to make them more effective? People who have a science background and have experience dealing with the public would be useful. YouTube is being utilized to explain scientific ideas more and more. Experiential science is also necessary to demonstrate more excitement, and digital education should be further explored. The group was impressed that the Swiss consulates have a website about science. An exhibition will be shown showing the sketchings of Nobel laureates in such a way as to show the audience about science.

Another group stated that scientists do not connect well with the public. Better communication would lead to better funding. Outreach sometimes brings some colleagues to look down on scientists who do outreach, and this is wrong, although that bias admittedly exists. Outreach actually helps with research and is not just a waste of time, particularly if it engages the public. Trying to get media to work for you as a scientist is important, even though the media sometimes has a different agenda. The press can be a good intermediary. Innovation in outreach is necessary, and hands-on experience is important. Giving ordinary people experience with science hands-on will get them fascinated.

Another group stated that in prohibiting certain kinds of experiments, rationality was being eliminated. How to restore trust in science was a major problem. Fukushima was a disaster in credibility, and a combination of ignorance and fear. Another issue was how scientists could simultaneously embrace the old and new media. Some countries have a science spokesperson who is a scientist, and a science council to get the message out when ordinary people are forming their opinion. Scientific social responsibility and communication is needed in the long run from the ground up. Creating a love for science is necessary.

Once the discussion was over, the chair thanked the participants and concluded the session.

Session Chair

Ernst-Ludwig Winnacker, Secretary-General, Human Frontier Science Program (HFSP), Germany

Speakers

Hiroko Akiyama, Professor, Institute of Gerontology, The University of Tokyo, Japan

Peter Bakker, President and CEO, World Business Council for Sustainable Development (WBCSD), Netherlands

Susan Hackwood, Executive Director, California Council on Science and Technology, U.S.A.

Angélica Natera, Executive Director, LASPAU (Academic and Professional Programs for the Americas), Harvard University - LASPAU, Venezuela

Gayle Schueller, Vice President, Global Sustainability, 3M Company, U.S.A.

Concurrent Session 203 H-3: Social Innovation for Sustainability

Opening Remarks

The session chair kicked things off, calling for a closer and more intimate discussion. He introduced himself, then the speakers and their accomplishments. He next introduced the session theme, social innovations for sustainability, and gave a few examples of the concept in action, such as microfinance and fair trade. It was clear that social innovations were required almost everywhere in our lives, and we may have to expand our thoughts about the subject far beyond what the Brundtland Commission[1] did years ago, without compromising future generations.

The first speaker began her presentation on changing social systems, and the resultant changes in people's values and behavior, often reflected first in local communities and spreading out to the greater macro-level. She shared experiments redesigning communities for aged society. A drastic change in age structures required extensive change of infrastructure and greater innovation to compensate. For 25 years, her team studied the health, economic status, and social relations of Japanese men and women when they age. Altogether, 80% of them began to lose their independence in their mid-70s.

Human bonds are weakening, particularly among men. That suggested three priority issues: Japan had to made individual and collective efforts to push up the point where people lose their independence; second, they have to create an environment where people with disabilities can feel safe and active; and third, to maintain and strengthen human bonds. The existing community was built when the population was much younger and does not suffice for a highly-aged society. She discussed projects already ongoing that served the needs for an aged community, such as alternative means of transport, outreach through ICT, and home-based health care. Their ultimate goal was to make a contribution to sustainable society through the linkage of longevity, health, and wealth.

After that, the second speaker shared her personal story as a mother of three with business experience and an understanding of the consumer space. As 3M thinks about sustainability, the focus is on megatrends and challenges the world faces collectively. 3M sees innovation and collaboration among academia, industry and government as essential for society to ensure a stable and vibrant global community aimed at all people living well. The company has a vision of "3M innovation improving every life"; thus they regard it as their mission to find out where in daily life 3M can make a positive impact. This world is one where everyone has a responsibility, and everyone wants to seek out their role in it. 3M also seeks to work in partnership with governments and other stakeholders to provide technology that improves lives, where even just a bit helps. For instance, 3M technology helps provide a means of producing solar electricity in rural Kenya to avoid situations where children die due to exposure to fuel burning indoors. As a corporation with a technology base, 3M believes it is their role to help contribute to the social good of the world.

Next up was the third speaker, who spoke first about the challenges related to achieving a sustainable, good quality of life. That requires collective knowledge and innovation was a must for that. Everyone agrees that innovation results from experimentation, and communities that allow for different ways of thinking. The role universities can play in that can affect all levels of society. With the combination of appropriate factors, education itself can become an important tool for sustainability, and universities were an obvious place for that to happen. She offered some examples about entrepreneurship opportunities in Guatemala, the scholarship opportunity Zero to Always in Colombia, and a course in social innovation at Harvard. Her organization itself worked on providing opportunities to students from Latin America, not just to offer them an education but also to involve them in innovation opportunities. All of us had to take responsibility to address issues for the future, and universities are poised to be the engine which pushes social innovation forward.

The fourth speaker then spoke about his role in sustainability in business, and how they have defined what sustainability should be, considering that the world will soon grow to nine billion people; and for them to live well. We also have to move ourselves back within the boundaries of the planet and cull our growth. Business has a crucial role to play in this. Business was good at incremental improvements, but to keep things sustainable, they had to change the rules of the economy—they cannot continue models based simply on financial results. Technology would provide key elements of the solution but could not fix it all. Soon, every business on the planet would have to show its efforts in sustainability, and come up with solid, real solutions. Technology, especially robotics, was touted as a panacea for many problems; but if resource management and sustainability was meant to be an issue, then why are we focusing on robotics, which would consume even more resources? He hoped that academia could bring the best possible facts to business, as business preferred to work with concrete facts. They also hoped that risks were made clear and how to prioritize them. They also hoped that research and development could be scaled up. Finally, he asked for the best possible behavioral science for change.

The fifth speaker spoke on the high-tech world and how sustainability, and science and technology, factor into it. She focused on five open-ended points: what is to be sustained and why; that science and technology creates problems while solving others, that science and technology are value neutral, but some choices for sustainability require value judgments; where the social innovations that help in balancing contradictions in priorities are; and possible social innovations based solutions, and particularly the role of the social sciences and humanities. There was a rising concern about technology being a problem and the 'looming' catastrophe it will cause, and the fact that science and technology induces fear and mistrust in people for various reasons. There was a sense of loss of control in the approval process, with people feeling like the process is out of control and they have no say. It was another dichotomy: people fear the technology, but the technology will end up providing the solutions.

She asked us to think about where we can find value in technology, when it values neutrality the most. She used care ethics as an analogy, a social innovation that could help decide what to do for the future. That led into further questions: if humans are the most valued species, and if that holds true, then what is a human? To finish, she thought that the honesty of a scientist must be beyond the legal threshold, and social sciences must become part of producing solutions. Perhaps we could find a set of shared values in compassion, which can develop trust and dissipate the fear of technology.

Once the presentations concluded, the chair started off the discussion.

Discussion

A question was asked to the floor about everyone's opinions on collaboration efforts. One response to that was that establishing communication at all was the hard part. In academia itself, it was difficult to collaborate between different disciplines, much less between academia and business. When they discuss talking about future societies and the kind of societies they would like to live in, they realize a shared dream and start working together; in

1 Gro Harlem Brundtland, *Our Common Future*, United Nations 1987

essence, starting with the goal and working backward. Some examples of that collaboration were experiments carried out in bed towns for major metropolitan cities, helping the residents to build active communities once they retire, since their knowledge, skillsets, and network are based in the metropolitan area which they cannot reach so easily.

In business, that collaboration took a slightly different form. One participant responded that it was always a work in progress, as they found different ways to connect scientists; and framing their discussions in the context of global or social issues, such as those resulting from major disasters or global health issues. Another viewpoint on business came from developing initiatives on sustainability, aiming to describe societal goals first in order for business to be able to propose business solutions, and from there business can develop business plans, gain financing, and make strategies. Creating a common agenda was important for securing business support—even though it was painfully difficult at times—and a shared language of terms and definitions that people are comfortable with. There also had to be a system in place for measuring results.

A comment came from the room about the process of responsible innovation, and how those in academia felt it the concept had been watered down by business. Those from business had been pursuing the same thing, and essentially they wanted passionate, educated, grounded people to work for them and be very knowledgeable. In their company, they eagerly encouraged their people to work in the areas that interested them the most, and which had profoundly changed up their business model, where new products came from having that space to work with. Additionally, anyone with a great idea had to build a bit of understanding that businesses get such proposals all the time and there is not enough consolidation towards what a business was trying to achieve. Knowing who to talk to was important. It was still often the case that if the CEO or the board is not interested in the idea, the idea will not move forward. You also had to ask yourself what it was that you wanted to achieve.

One participant on the business side was asked what experience they had working with universities. They responded that they worked with a number of organizations that specialized in diversity, with one group working with Harvard University, discussing how they could better connect about sustainability and society. It ended up being an excellent opportunity for them to connect directly with students and see what kind of mindsets they had. They also worked with a major all-female university about sustainability initiatives, where both sides benefitted immensely from the experience.

A question was asked regarding open source policies and intellectual property, using Tesla as an example. The response was that they certainly agreed that it was an important step in social innovation, but that they were not so sure it was sustainable, as they had to think about the R&D funds that they might or might not get. They had to look at the crucial areas where humanity needs to develop, and work for open source technology in that area; but traditional business did not need it so much.

Another point of discussion was raised, which noted that business interests still limited action in many areas, and that government had to be stronger to play a bigger part. The Kyoto Protocol was enacted sixteen years ago, but with almost no action; proof enough. They suggested that scientists come up with simple ideas to spark discussions and not just speak platitudes. They needed a holistic education system, emphasizing family education; school was just one part. Other participants were hesitant about trusting government with so much power, however.

The discussion next turned to the fear of technology, and the anti-technology movement. There was a growing gulf between those who spoke the 'language' of science and technology, and those who had to rely on the media to 'translate' it for them. The solution there was more education, and it was on the onus of science to better explain things and explain them in colloquial, familiar ways. People without higher degrees in science were legislating on things they did not know, effectively enacting policy on things they had 'translated' for them. Communication between science and politics was essential, and they had to figure out what was 'usable knowledge' for each other. Facts, again, were essential; but politicians also paid particular attention to the means of communication. One initiative discussed was a science interpretation course, as a way to give future scientists and policymakers the 'language' they needed, and which had already found great success at the university it was implemented in.

One commenter spoke on the rapid development of their home country, finding it curious how societies fragment at a certain point, reflecting on Dr. Akiyama's presentation on rebuilding communities in bedtowns. Economic development had come at the cost of community, and the participant was concerned about that future. He wondered if there were ways for stakeholders to prevent that same sort of fragmentation, to avoid taking what they saw as the wrong path. Perhaps, they thought, sustainability comes from looking at a whole, instead of trying to quilt together fragments of a society. They wanted to focus on caring, more than efficiency.

In response, universities were developing ways of making education more relevant and meaningful, and they agreed that a common agenda was important. In that regard, universities likely had a common agenda; and perhaps they had to teach social innovation as a discipline itself. They also had to make sure that all the countries were on the ball with that agenda. They could agree that the way we build society needs a dramatic improvement, not an incremental one. A fundamental problem is that the shareholder-centric curriculum is driving society off a cliff, and that had to be transformed before anything else. Externalities needed to be included, and to consider the impact a business has on society and the environment. The French and Peruvian governments were particularly engaged in this area. Another point was made that issues never seem to be raised until they are of crucial importance. A way to think about that was to think about business as not shareholder-centric, but of a model of co-production. The interaction between academia, business, and government should be improved upon, instead of being purely incremental. Models had to be created for this, instead of simply talking generally about it. Creating a generation of people who have learned something other than a shareholder-oriented model was essential in order to prove that there was not just one way to do things.

With that final comment, the chair closed the session, reflecting on the variety of issues that were discussed. He hoped that everyone had some thoughts to take home.

Plenary Session 204A: Science and Technology for Developing Countries

Session Chair

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

Speakers

Abdulaziz M. Alswailem, Vice President for Scientific Research Support, King Abdulaziz City for Science and Technology (KACST), Saudi Arabia

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

Ashwani Kumar, Member of Parliament, Rajya Sabha, India

The issue of developing countries is an important one to focus on, as it is crucial for these countries to leverage science and technology to address their challenges. The problem is getting these countries up to speed in areas like STEM mastery and R&D investment. Science and technology can vastly improve our lives, even improving our personal happiness and satisfaction. True innovation in the big fields of research is what the developing countries need to aim for. Innovation will spur industrial development, but more importantly, will help make a sustainable society for all.

Opening Remarks

Prof. Zakri Abdul Hamid welcomed everyone to the session on science and technology for developing countries. He was pleased to see that many participants from outside the developing countries had joined the sessions. Considering that three-quarters of the UN were developing countries, it was an important topic to broach. The positive social economic changes we experience today were largely the result of accelerated pace of science and technology. Time and again we have seen that science and technology leads countries to greater heights and propels them further, thereby increasing economic wealth and quality of life for the citizens. Developing countries had to leverage science and technology to create more opportunities to tackle the problems they face.

However, their challenges were quite different than those faced by developed countries. One was their poor mastery of STEM subjects; another was insufficient investment in R&D; yet another was the number of RSEs—researchers, scientists, and engineers—which was at a ratio of 50 out of 10,000 workers. For the discussion, he offered to approach the issue through science for government, science for industry, and science for social well-being. The first point would consider the lack of investment of R&D development and the lack of focus; the next would examine various challenges affecting growth of local industries and aim at increasing the number of RSEs; and the last was focused on how science and technology can help improve the livelihood of the people, particularly for the impoverished. In Prof. Abdul Hamid's role as science advisor to the Prime Minister of Malaysia, the Prime Minister said that he wanted to see the jobs that could be created through science and technology, and also to see the wealth that science and technology could provide. The message was clear for the scientific community: communicate these answers, or else be reduced to irrelevancy. Prof. Abdul Hamid then introduced His Excellency Dr. Ashwani Kumar from India to speak.

His Excellency Dr. Kumar thanked Mr. Omi for his invitation to the plenary session. He believed that when discussing the broad subject of science and tech in developing countries, we needed a broad frame of reference for people from all over the world viewing it as a non-negotiable tool in their advancement as humanity. Debate on science and technology must mean the betterment of the lives and living standards of a large number of people, and greater freedom. He also believed that despite the most significant science and technology advances recorded to date, and the most unprecedented advances in wealth, the world is still desperately impoverished in the well-being and happiness of all. The challenge then was to ensure that the instrumentality of science and technology is expressed in human happiness, in whatever way we conceive of it. Acute poverty was a reality in most parts of the world, but it was always the developing world that was hit the hardest. For that reason, he expressed his gratitude to Mr. Omi for making this session a theme of the STS *forum*.

Debate had already started in most countries about whether they spend enough on R&D, or if what they spend is justified. He added that not only is that expenditure justified, but most countries are not spending adequately enough to beat the challenges faced by science and technology, nor to meet the challenges of the world faced by the people. The figures brought out by the UN and some of the other agencies are such that leave no room for debate, and no one country can handle the challenges alone. What is the way forward? The only way forward for developing countries was 'destructive innovation' and 'frugal innovation'. Frugal innovation had provided novel solutions for India. India's initiatives in affordable medicine had propelled R&D research and benefitted many lives; and simple computers distributed to farmers helped them plan and manage their resources without relying on a middleman who would undercut all of their profits, among many other examples.

This was not to say that developing countries should not focus on being leaders in science. Developing countries need to focus on the big areas if they are to develop a voice in science and technology. In conclusion, he quoted John F. Kennedy: "Our children may be victims of fate, but let them not be victims of our inaction." The fact remains that if we do not rise up now to face the challenges that stare us in the face, the current generation will not forgive us and we will fail to live up to our legacy. The urgency is to act today, and it is true that there is no tomorrow, because there is no Planet B.

Next, Dr. Abdulaziz Alswailem from Saudia Arabia took the floor, quoting that innovation policy can be the key for success for any country, if it is implemented at every level. And with that in mind, working in science and technology was no longer a choice: it was survival.

The first goal he had in mind was using natural resources to discover common interest. Innovation did not simply need to be limited to researchers and universities; governments had to invest in innovative schemes because it was pure survival. A tremendous number of issues could be discussed, such as highlighting targets for each country and utilizing science and technology to make sure those goals are reached.

He mentioned the two Ks: knowledge and knowhow. Having knowledge and amassing it was of course crucial, but knowhow was what would move it to the end users. Most developing countries did not have the ability to do so, and if those initiatives were in place, most often they were exceedingly basic. R&D spending was crucial, but there was no need to compare "apples to apples," as he put it; that was to say, there was no real development taking place. Most developing countries allocated a bit of their GDP to research, but not enough to development; and he reiterated that it had to be useful research, not that which confirmed what we already knew. Developing countries simply could not afford to do research that was not useful. They had to expand types of research activities and innovation, not simply put out publications and rack up citations.

Next, he spoke of 3 Ds: the dimensions of product space, research space, and human capital. Bringing these altogether would ensure that research goals were met, and Saudi Arabia supported all of these. The fruits of that investment lead to the four Is, indicators of achievement. They managed to multiply their numbers of universities by seven; scholarship had expanded by 30; publication had expanded 374% in ten years; and the number of patents multiplied by ten. Those were clear results of Saudi Arabia's investments in science and technology.

Finally, Dr. Ryoji Chubachi, President of AIST, touched upon the remarkable current growth of science and technology in developing countries, and the sustainable society that AIST aspired for. He noticed the extraordinary development of science and technology with the amount of investment and the number of researchers, which were clear metrics that showed the progression from an agrarian society to an industrial one. That came with its own caveats, such as increased pollution and social stratification; but these countries used science and technology at the same time to lead social innovation in these situations and avoid these problems. Social innovation was becoming a great force in mobilization. Seeking true affluence along with environmental conservation was crucial. Innovation not only provided the solution for immediate difficulties and industrial development; it also had to create and contribute to sustainable society. Innovation should help maintain an appropriate balance to solve the issues facing humankind.

AIST worked together with research institutes in developing countries extensively, particularly in green innovation. They undertook projects to convert non-consumable biomass resources into fuel, and were researching life innovation as well. They were researching biomarkers that will quickly identify disease, for instance. AIST always aimed for the pursuit of a sustainable society; however, when they looked back on development, they found problems such as environmental burdens, a widening income gap, and overcrowding in urban areas. The mission of AIST was not only for industrial development and economic wealth; they always aimed to maintain the balance of growth. AIST reaffirmed its commitment to obtain sustainable societies in developing countries.

With that, Prof. Abdul Hamid opened the floor for discussion.

Discussion

An audience member brought up issues related to Internet development and smartphone technology. He asked the panelists what their experiences were in mobile banking, mobile insurance, and microbanking; and if they viewed

that as an essential step in development. His Excellency Dr. Kumar replied that it was technology in the making, and that it was the future. They were already seeing its uses in the digital economy, and noted that it could only become more refined. It could add to developing countries' economies' competitiveness, and truly make the world shrink even further. It was one area of technological development where progress was unstoppable. The current transfer of information seen in the present day was unfathomable even a decade ago, but the reality of the sheer amount of data available was sinking in, and it was bound to play an increasing role in the future. Mr. Alswailem also commented that they had to examine infrastructure as well, before they examine its applications, and that each individual had the right access to the Internet. Once they achieve that, they can consider other issues. In Saudi Arabia, they had a huge project going to improve Internet connectivity, no matter where in the country you were. Adding to that, Dr. Chubachi said that ICT was necessary for development, but that ICT was very independent and individual, and they were concerned about ethics involved.

The next commenter spoke about South Korea's experience in developing into an advanced country, and how it invested 4% of its GDP into R&D. They wished to share their experience with developed countries, and hoped to establish a platform for collaboration between developed and developing countries. Prof. Abdul Hamid admired South Korea's development, and cited it as one of their models.

A member of academia also made a comment, and said that in order to have the transformation they wanted, they had to transform the people, particularly in developing countries. He hoped to see an increase of health care workers, and wondered if developing countries were working towards that. Many also wondered about future jobs of the 21st century, and how they could train students for jobs of the future. He asked the panel if there were any such developments in developing countries. Inspiring children to pursue science and technology careers when they had no idea what science and technology even was would be a challenge. Malaysia had made great strides in this, but he wondered what the other countries were doing. His last worry was about involving women in science and technology, and encouraging girls to get into that field. He asked what the STS *forum* could do to encourage that kind of thinking.

Prof. Abdul Hamid agreed that those were crucial points, and that they had launched one of the most ambitious projects for youth in India. The willingness was there and the infrastructure had been set up, so they had great hopes. While

developing countries needed advancements in science and technology the most, there seemed to be a greater number students pursuing those degrees mostly because of the promise of wealth. One thing they needed to tell people was that science was not a career. Rather it was a mission towards a better world, which would inspire youth to go into science. Science should never be neutral in its functionality, and now that the world faced a moral crisis, it had to shed its neutrality and emphasize that it would solve the challenges humanity faced—the message that would inspire the youth with a mission. Mr. Alswailem also commented on how researchers from Saudi Arabia were working together with developed countries, bringing in technology innovation. Many of those researchers were indeed women, and Saudi Arabia also had the Future Science Initiative in place, inspiring their youth to go into science.

Another audience member asked where developing countries concentrated on building infrastructure before they got started on other initiatives. His question for India concerned the challenges they faced that convinced politicians in their country to invest in science and technology, and what level of investment there was. Second, he asked about collaboration with stakeholders and academia, and what that meant. A last question was asked by a participant from Beijing, concerned about climate change. China's growth over the past 30 years had been incredible, but China only understood rather late that it was one of the main contributors to pollution. He wanted to know if the developing countries could give any advice to the Chinese government about preventing further pollution while still developing.

To the first question, His Excellency Dr. Kumar responded that when India became independent, science was regarded as a symbol of the nation's progress; that was how it built dams, power stations, and a space program. India's R&D expenditure was 2-3% of GDP, but it was not nearly enough. Most R&D came from the government, and the private sector was not contributing enough. More communication was needed between science and policy-makers. Mr. Alswailem responded that the answer to the stakeholder question regarding private investment was easy: bring them to the same room, make them share responsibility, and they will come to the appropriate conclusion. To the last participant, Dr. Chubachi responded that all countries had to harmonize nature, humankind, and science to realize a sustainable society.

Prof. Abdul Hamid brought the session to a close, noting that there was a general consensus on what developing countries had to do for the future. He emphasized that the STS *forum* was an excellent venue for communication on these issues and tackling the issues of science and technology in developing countries. With that, he concluded the session.

Plenary Session 204B: The Future Role of CTOs

Session Chair

Elias A. Zerhouni, President, Global Research & Development, Sanofi, U.S.A.

Speakers

Saik Hay Fong, President, Singapore Technologies Dynamics Pte Ltd., Singapore
Ray O. Johnson, Senior Vice President and Chief Technology Officer, Lockheed Martin Corporation, U.S.A.
Naoto Nishida, Director, Executive Officer, Corporate Executive Vice President, Toshiba Corporation, Japan
Kazuhiko Tsutsumi, Corporate Advisor, Mitsubishi Electric Corporation, Japan

The recent emphasis on science and technology, R&D, and innovation has placed renewed focus on the role of the Chief Technical Officer. In this session speakers from different industries discussed the strategic importance of the CTO and attributes needed for success. What is clear is that the CTO of today is very different from the CTO of the past. Technical expertise alone will not suffice. To succeed, CTOs nowadays require broad skillsets and perspectives, including sharp business acumen and excellent interpersonal skills.

Opening Remarks

Dr. Elias A. Zerhouni opened the session with the statement that technology was progressing at a rapid rate, and that it was a challenge for CTOs to keep up. He believed the 4 S and the 4 Cs were essential to the CTO. These are: scope, scales of business, speed of technological progress, social impact; and complexity of systems, convergence across disciplines, connectedness across networks, and competencies.

Dr. Ray O. Johnson shared his vision for the role of a CTO. First, a CTO needs to maintain a balanced portfolio. There must also be prioritization across this balanced portfolio. Data analytics plays a significant part in efforts to analyze investments and take bets on the future. The impact of the CTO is also important. Is he merely an adviser, or a true member of the executive board who has influence and can effect change? A CTO must be empowered to identify that one technology that can disrupt markets. It is also not enough to know about technology and engineering. A CTO must have a broad knowledge of the business, including design, production, supply chain, and so forth. Ultimately, it comes down to business acumen. It is also important for CTOs to understand the lights and shadows of technology.

Dr. Naoto Nishida pointed out that advancements in science and technology were meaningless without sustainable society. Toshiba promotes technologies for promoting a sustainable society. Toshiba is also making efforts to establish itself as the world's foremost eco-company. The role of the CTO is very important for this strategy in all stages, from development, funding, and monitoring progress.

Mr. Saik Hay Fong offered his views on the role of a CTO. He began by explaining the context for his thoughts. First is the concept of VUCA, which pervades the world we live in. Secondly, we live in a borderless world enabled by ICT and social media. Mr. Fong therefore believed that organizations needed to have the capability to change, and the capacity to seize, as do CTOs. This covers not only mindset and abilities, but also structure. Structure must be flexible and scalable. Skillsets must be honed. The ability to absorb new technologies is also important. The empowerment of the young by an enlightened senior executive is also needed. Overall, Mr. Fong believed CTOs were agents for change with a long-term vision, and the courage to take risks.

Dr. Kazuhiko Tsutsumi began by outlining the strategy of Mitsubishi Electric Corporation, highlighting the company's emphasis on research and development and the importance of open innovation. Globalization is also an issue that must be considered. In light of this, there are two aspects of promoting R&D for the realization of a sustainable society. Furthermore, the role of a CTO is not only to pursue profit, but also address issues faced by society such as global warming or efficient resource consumption. Moreover, in addition to a focus on R&D, CTOs must take a holistic view, working closely with marketing, production and others. Otherwise, it will not be possible to propose solutions that impact people and consumer's lives or create new value.

Discussion

The first question concerned the extent to which CTOs were conscious of fluctuations in stock prices in their respective companies, and the effects of press releases about new challenges undertaken by their companies domestically and internationally.

Dr. Nishida answered that the stock market was very severe, and it seemed that the market was slow to respond to Toshiba's activities. As for press releases, Toshiba utilizes many press releases when undertaking new challenges. However, the market does not always react the way companies want. One of the issues is that consumers do not always share the same perspective as companies do, and companies must therefore do more to understand this.

Dr. Zerhouni noted that while CEO and Chairman may call for a long-term vision and investment in technology and innovation, at the same time there was also immediate pressure in terms of the sales price. It is difficult to find a balance between these two seemingly conflicting goals.

Dr. Johnson thought of it in terms of short-term performance and long-term vitality of the company. Nothing impacts near-term as heavily as operational performance. Operational performance must always be maintained at excellent levels. However, in the long-term, there has to be investment for the future. At Lockheed Martin, there is a concept of innovation with purpose. This entails innovation not for innovation's sake, but for business results.

Mr. Fong advocated moving quickly to invest with those who were doing work in areas ahead of the curve. Even if this does not produce immediate results, it nevertheless contributes to the building of skills and expertise in the long-term.

Next, a participant asked about finding the balance and the right structures between innovation that sustains and more disruptive innovation, which paves the way for the future. He made the point that anything invested into the future takes away from sales today. He therefore asked how the panelists made decisions about what to invest in and how much, as well as whether the panelists believed more in centralized research structures or embedded ones.

Dr. Johnson said that based on discussions with other CTOs, the percentage allocation to disruptive and sustaining innovation varied by industry. While it is a zero sum game, there is a need to find the right balance by looking at factors such as operational performance. Mr. Fong said that his company needed to be very close to the market, alert to changes in the marketplace, and react accordingly.

Dr. Zerhouni shared his experience, explaining that R&D in pharmaceutical was inherently cyclical. Small biotech companies start out fully disruptive, and over time there comes a balancing between disruption and consolidation.

Overall, CTOs need to have good understanding of the business and the market when determining the best mix. Personally, Dr. Zerhouni followed the rule of 40% consolidation, 40% expansion, and 20% disruption

Dr. Zerhouni then asked the panelists for any advice they had for young employees who wished to become a CTO in the future. Dr. Nishida advocated working in different parts of the company to gain a more multidisciplinary perspective, while Dr. Tsutsumi said he would recommend that young employees go outside the company to gain knowledge and exposure outside. He believed CTOs had to develop the ability to judge the value of technology and innovation.

Dr. Johnson said that technical excellence had to be assumed, but nowadays the role required far more than that. Potential CTOs must have the experience of running a business, or at least have experience similar to running a business, in order to have the right business judgment. An executive presence and good communication skills are also required so that a CTO can work with the CEO as a true partner.

A participant asked how a CTO differed from simply someone with an outstanding technical background. Dr. Johnson noted that there were many people with deep technical backgrounds who had almost a derogatory view of management and were content to remain in a technical area. However, anyone who wishes to be a CTO must be willing to branch out and really understand the business.

Next, a question was raised regarding the relationship between a CTO and the Board of Directors. Specifically, the participant cited a scenario in which the CTO had a new technology that he believed was revolutionary and for which a new market would develop, although no such market existed yet. The participant wanted to know how the CTO would convince the Board to invest in it.

Dr. Johnson believed a CTO would not be able to do this alone. It would require the full executive team, with the CEO, to deliver both the technical reasoning, and also the compelling business case. It is perhaps the role of the CTO to convince the executive leadership to support the technology in the first place and this will not be possible just with deep technical knowledge and no knowledge of the business.

Finally, a member of the audience commented on the fact that she had often seen companies make the mistake of promoting an excellent science researcher into a leadership role as CTO to reward them for their work, despite the fact that the researcher was reluctant to enter such a position. Sometimes this succeeds, but more often than not it fails. There should instead be a system of promoting and rewarding such technically-oriented employees in a way that allows them to continue their excellent scientific research without feeling obliged to integrate them into the management team.

Day 3

Plenary Session 300, Plenary Session 301
Closing Plenary Session 302

Plenary Session 300: Innovation and Society

Session Chair

Anatoly B. Chubays, Chairman and Chief Executive Officer, RUSNANO, Russia

Speakers

Curt Carlson, Vice Chairman, Innovation, SRI International, U.S.A.
Jonathan Manne Dorfan, President & CEO, Okinawa Institute of Science and Technology Graduate University, U.S.A.
Tetsuro Higashi, Chairman, Tokyo Electron Limited, Japan
Thaweesak Koanantakool, President, National Science and Technology Development Agency (NSTDA), Thailand
Takehiko Nakao, President, Asian Development Bank, Japan

Innovation has the potential to drive economies and offer novel solutions to the challenges we face. However, not all countries and corporations have established the processes needed to ensure continuous innovation, nor have they secured ways to fully harness that power. Moreover, it is necessary to constantly keep pace with rapidly changing trends and needs in society. The focus of this session was on how to translate innovation into actual social impact – a key concern for thought-leaders and policymakers around the world.

Dr. Anatoly B. Chubays chaired the first session of the third and final day of the 11th annual meeting of the STS *forum*. He began by highlighting the goal of the STS *forum* to carefully consider the relationship between science and technology and society. It goes without saying that science impacts society. The ICT revolution makes it very clear how science and technology can change our lives, including how we communicate or cooperate. Perhaps the next significant technology will not be information, but the material base. A pressing concern for the world is growing consumption and finite resources, and this cannot be addressed by information. It is instead likely that the next major breakthrough will come from a material-based revolution. Nanotechnology offers such solutions. In fact, scalable production of nanotubes is now possible. Strategically this could have significant impacts on cutting emissions and other issues faced by society. Dr. Chubays then introduced the other speakers, and invited them to give opening remarks.

Dr. Curt Carlson expressed his belief that this was the era of the global innovation economy. Innovation is now the path to growth, prosperity and sustainability. Innovation opens up possibilities, but also intensifies competition. At the same time, we are still not doing a good enough job of creating prosperity and fostering sustainability for our societies.

The pace of innovation and changes in technology has been tremendous, and the effects on our lives are huge. At the same time, to be viable, innovation has to have a business plan. Innovation is about creating new knowledge and connecting it to the needs of society. As things stand, however, many large companies are not doing enough in the area of innovation to keep pace with the world. Companies like Kodak, Nokia, or Motorola have fallen off dramatically from positions at the forefront of the world. While many CEOs pay lip service to the need to keep up with the pace of the changing world, few organizations have innovation processes to do so. Better education is also needed. Innovation and value production, not simply experiential learning, must be incorporated into education. Students must also learn to conduct team-based projects. Many universities are rising to this challenge and creating such programs. This surely represents the future of education. Human capital should also be improved. In closing, Dr. Carlson proclaimed that this was a very exciting time in the world.

Dr. Jonathan Manne Dorfan then offered his opening remarks. The world has yet to recover from the global financial crisis. Meanwhile, we also face a multitude of other challenges, including overreliance on fossil fuels, climate change, sustainable food production, and others. Regional solutions will not be sufficient. We need global solutions.

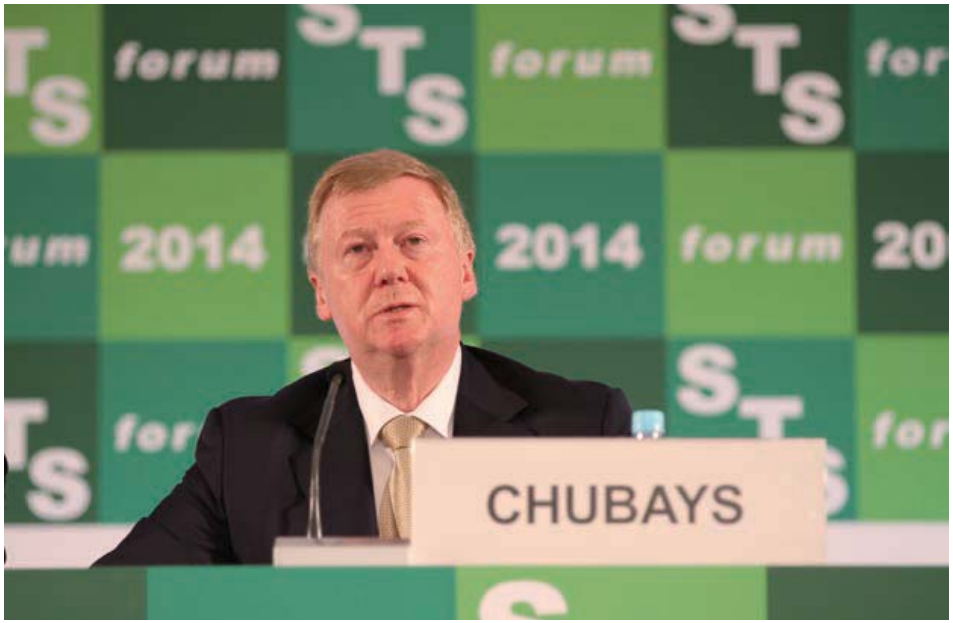
Dr. Dorfan stated that there is a widespread belief that science and technology was the greatest weapon that society had for addressing these issues. He then quoted Prime Minister Abe's speech from the first day of the *forum*, "innovation holds the key for Japan and the world."

The solution to the challenges society faces requires an ever stronger collaborative effort between academia, government, and industry. This collaborative triangle is not a new concept; but nevertheless, many failures can be attributed to our inability to successfully pursue this collaboration. Furthermore, greater attention needs to be paid to the role of public policy.

The university has an important role to play in expanding the scientific training of its students. More emphasis must be placed on developing students in an interdisciplinary manner. We must foster students with a broader world view and a deeper understanding of science and technology's role in the world. Researchers and scientists must not only be able to drive innovation, but also understand how to formulate effective public policy.

Funding remains a key ingredient to driving research. Research investment portfolios must include sufficient basic research elements with a long enough timeframe to be viable. Directive research alone will not foster sufficient innovation for tackling the challenges faced by society. While promoting basic research, it is incumbent on the university to recognize commercially viable technology, protect it, and also to establish channels that ensure this technology is transferred to society. The people must receive the maximum benefit from government investment in research. Dr. Dorfan closed his remarks with a quote from Charles M. Vest, who said, "Industry's near total R&D focus on rapidly commercializing products, when combined with growing constraints on support of university research, could devastate [the US] national innovation system. It could well leave us without a shared, evolving base of new scientific knowledge and new technology. It could destroy the primary source of tomorrow's products, jobs, and health." Dr. Dorfan believed that this sentiment continued to ring true today.

Mr. Tetsuro Higashi shared his thoughts on innovation. Continuous innovation is essential to sustaining society. Innovation and invention are often used interchangeably. Invention usually means the creation of something new, whereas innovation occurs when one finds a better way of doing something that already exists. This reinvention for the better is often driven by market factors that make invention obsolete over time. As such, innovation must be continuous to ensure that an invention or product is viable. This is especially true of the ICT industry, where innovation is occurring at an ever faster rate. This is driven by society's needs and also fueled by technological development. Furthermore, ICT technology is no longer limited to developed countries, but has spread worldwide. The growing popularity of such products has heightened the need for lower cost structures.



Discussing the semiconductor industry, Mr. Higashi noted that inflection points have been essential for the development of the products we enjoy today. Furthermore, the social, economic and technological landscape of the world is constantly changing. Even the best products must be improved. Moreover, countries around the world are all interconnected. That is why, to better serve society, Tokyo Electron is committed to innovation. The time to innovate is now.

Dr. Thaweesak Koanantakool discussed the ways in which innovation could help people at the bottom of the social pyramid, whose needs were often neglected. Social innovation can help fill these gaps. The concept covers mechanisms such as open source, online learning, social enterprise, crowd-sourcing and microcredits. The National Science and Technology Development Agency (NSTDA) supports research for the betterment of society, such as new varieties of rice which are flood tolerant, vaccine candidates for dengue hemorrhagic fever, and assistive technologies for people with disabilities. The challenge is how to make these affordable to many people in society. Dr. Koanantakool presented examples of innovative action research programs initiated by Her Royal Highness Princess Maha Chakri Sirindhorn of Thailand, aimed at merging local wisdom and scientific knowledge to improve nutrition for rural schoolchildren, enhancing access to better education for rural schools, and improving the quality of life of people with disabilities by giving them access to proper assistive technologies. Most of these social innovations can be realized with science and technology, and have been successful in linking innovation with local needs. Dr. Koanantakool was optimistic that science and technology would bring light to the rural poor of human society.

Mr. Takehiko Nakao spoke next. Asia is growing in prosperity, and the Asian Development Bank is working on ways to help its member countries become developed countries through the power of science and technology. In the past, one of the most urgent needs was ensuring food productivity and production to keep up with demographic needs. This was successfully overcome with green technologies.

It is now forecast that Asia will account for 50% of global GDP by 2050. To do this, Asia must continue to innovate itself. Asia has not simply mimicked technology in other countries, but produced innovation on its own. The success of Asia has been the result of more efficient mobilization of capital and labor. Technology transfer to Asia has also been highly beneficial. Nevertheless, to continue to grow, Asia must continue to remain on the frontier of innovation. Much of the innovation in Asia is more reasonably priced and effective at the local level. At the same time, to generate revenue and become developed countries, Asian countries have to be at the forefront of technology.

This will require better intellectual property protection, streamlined regulation, and more funding to innovative startups. Education must also be improved and constantly updated to meet the needs of society. As part of this, vocational training must be enhanced and refocused on the needs of industry and society. Knowledge centers should also be enhanced, and R&D funding increased. The Asia Development Bank is providing support to innovative endeavors, and is also providing guidance to governments on formulating legislation that is more conducive to technology development. Asia has many opportunities, and it should no longer remain a center for production, but should make the transition to becoming a center for knowledge creation.

Dr. Chubays offered final remarks. The question is often raised of whether science or innovation offered greater advantages in the knowledge-based economy. The answer is surely that a balance between science and innovation is needed to ensure the greatest benefit. Dr. Chubays then offered his thanks to the audience for their kind attention, as well as the efforts of Mr. Koji Omi for his vision in conceptualizing and organizing the STS *forum*, before bringing the session to a close.

Plenary Session 301: Key Messages from Concurrent Sessions

Session Chair

Jerome Isaac Friedman, Institute Professor and Professor of Physics Emeritus, Massachusetts Institute of Technology (MIT), U.S.A. [Nobel Laureate 1990]

Speakers

Hiroyuki Abe, Counselor to the President, Japan Science and Technology Agency, Japan
Yoshihide Hayashizaki, Director, Preventive Medicine and Diagnosis Innovation Program, RIKEN, Japan
Nai-Chang Yeh, Professor, Physics, California Institute of Technology (Caltech), U.S.A.
Sakarindr Bhumiratana, President, King Mongkut's University of Technology Thonburi (KMUTT), Thailand
Joanna Rubinstein, Special Advisor to Jeffrey D. Sachs; Director, ConnectToLearn; Senior Advisor to the SDSN, Earth Institute, Columbia University, Sweden
Per Eriksson, Vice-Chancellor, Office of the Vice-Chancellor, Lund University, Sweden
Robbert Dijkgraaf, Director and Leon Levy Professor, Institute for Advanced Study (IAS), Princeton, Netherlands
Masuo Aizawa, Professor Emeritus, Former President, Tokyo Institute of Technology, Japan

Prof. Jerome Isaac Friedman opened the session, and invited rapporteurs from each of the concurrent sessions to present their key findings.

First, Prof. Hiroyuki Abe presented the key messages from energy and environment. The first session covered the shale gas/shale oil revolution. A key question is how much oil and gas can be produced going forward. This depends largely on public policy and national attitudes. Shale gas is a promising field, but constant technological development is needed, particularly in areas such as infrastructure and extraction technologies. Technological developments must account for both greater production, as well as minimizing the impact on the environment.

The second session pertained to challenges and solutions for new and renewable energies. Many renewable energy sources such as solar, wind, hydrogen, or geothermal power represent promising components of our future energy mix. Renewable energies can also contribute significantly to reducing carbon emissions. Furthermore, one advantage of biofuels is that they are often byproducts or waste products. It is important to note that the risks and advantages differ depending on regions and government policies. Some of the risks are, however, controversial. Policies and technologies must take into account regional and local characteristics. No one solution fits all situations. The transfer of knowledge across national boundaries is also important.

The third session was on nuclear technology prospects. We must learn more about the lessons of the Fukushima nuclear disaster. Terrorist threats are also a key concern. Furthermore, we must develop the necessary human resources. Treatment of used fuels is also one key issue. There are two options: re-processing or long time storage and final disposal. Both require further technological developments. International cooperation is also required for the development of capable human resources and of new nuclear power generators.

Overall, a diverse mix of energy sources is an essential part of a sustainable future. The energies we need tomorrow may change, based on both the needs of society and developments in science and technology. Energies that may be advantageous now may not maintain their position into the future. Therefore diversity is a key word for energy, now and into the future,

Prof. Yoshihide Hayashizaki presented the key messages from life sciences. The common theme throughout is that society is aging and birthrates are declining in many developed countries. Regenerative medicine has two goals. These are to keep people healthy, and cure difficult diseases. Six concerns were raised by participants, which were public awareness, evaluation, regulation and guidelines, insurance to cover regenerative medicine, prioritization of regenerative medicine, and cost. These are six important factors for further progress of regenerative medicine.

The second session was on nutrition. Discussion covered social, economic and scientific aspects. Nutrition is the basis of human health, and is the cheapest form of maintaining health and preventing disease, alongside exercise. There is no evidence that GM food is harmful and yet there is still controversy surrounding it, despite offering a significant solution for nutrition concerns. Formal guidelines need to be made to enhance transparency and better communicate their benefits. Environmental effects should also be taken into account. The main concern and obstacle is the need to remove the surrounding stigma. Sustainable provision of supplements were also discussed.

The third session was on preemptive medicine. The basic concept is to move from early treatment to disease prediction through biomarkers and other technological developments. The main targets are non-communicable diseases, such as heart disease, mental disorders or obesity. In preemptive medicine, we need to analyze the genomes of humans, as well as the time cost. We must also maximize product efficacy. There are three concerns in this field, which are reducing the cost of diagnosis, the need for social systems such as insurance to ensure sustainability of the field, and the enhancement of the education system to raise public awareness and acceptance.

Prof. Nai-Cheng Yeh presented key messages from the sessions on innovation. The first session was on industrial innovation. There is general consensus that innovation is essential for economic viability of industries and companies, but there are many difficulties in actually successfully fostering industrial innovation. The importance of co-location of research in small areas, such as in the case of MIT, or industrial innovation parks, were also noted. Industry supports are important for promoting innovation and knowledge creation. There are also examples of industry fostering public-private partnership for innovation. Government support can be important, but too much support can drive away industrial and other private-sector participation. It is also necessary to maintain a delicate balance between pure and basic research, closed and open innovation, government intervention and market-driven innovation, disseminating knowledge and protecting intellectual property, and so forth.

The second session was on new materials and nanotechnology. New materials are key to address the issues faced by society. Key themes include the important connection between nano-science and issues of climate disruption, because nano-science can be the key to widespread usage of renewable energy, such as achieving better quantum efficiency in photovoltaic cells and contributing to energy storage in batteries. Additionally, carbon capture can be realized through the development of porous nano-materials, thereby making fossil fuels carbon neutral. At the same time, better conduits are needed to accelerate this process. Co-location between industry and research institutes are again one means of achieving this goal. Faculties of research institutions should also be encouraged to foster knowledge transfer. There are concerns with nano-materials, however, among which is toxicity, and sufficient attention must be paid to addressing this issue and minimizing potential hazards. It is also noted that advances in new materials need not be limited to nano-materials or meta-materials fabricated with nanotechnology. New composite materials with novel functionality can often have a big impact on applications, and should be encouraged.

The third session was on new manufacturing technologies. Manufacturing has traditionally been the main contributor to economic growth, but there are now growing calls for ensuring sustainable growth. The key is to find new harmonious means to achieve prosperity, while maintaining environmental sustainability. Vertical networks, as well as horizontal collaboration, are required. Collaboration between industry and academia was also highlighted. The chemical industry has not traditionally incorporated many novel technologies, but this is changing as new technologies are demanded for a variety of needs, including raising manufacturing efficiency. 3-D printing was also highlighted as a technology that could revolutionize manufacturing, generating a paradigm shift and offering more affordable manufacturing techniques to developing countries. On the other hand, there are also concerns about counterfeit products and intellectual property challenges. Future challenges in manufacturing include digitalization and the shortening of development timeframes, incorporation of big data, addressing manufacturing costs, and accounting for environmental sustainability via reducing, reusing and recycling. Finally, government must bring together diverse players to create higher value technologies, help offset the costs resulting from the shift of manufacturing paradigms, and supporting universities to educate students to meet the new challenges.

Dr. Sakarindr Bhumiratana presented the key messages from the concurrent sessions on education and capacity building. The first session was on collaboration among academia, industries, and government. It is only natural that the three areas work together, despite the different cultures and criteria for success. Each learns from the interaction, and enhances its practices to ensure the smoother delivery of science and technology to society. Through this process, universities have moved beyond research to sharing knowledge with society and creating innovative new industries. Newly energized scientists with novel ideas are also appearing. National boundaries are continuing to blur, allowing humankind to focus less on national

competitiveness, and more on issues such as equality and the environment.

The next session was on science and engineering education for the 21st century. In recent years, there has been a shift from teacher-centric education to learner-centric education. Technological platforms now serve to bring educational opportunities to more members of society, rather than act as a mere tool for teachers. There is, at the same time, a need to better educate students in science technology to foster a generation of policymakers with better understanding of these areas. Higher education should also adopt some of the management tools applied in the private sector, such as TQM.

The third session was on capacity building in developing countries. This is a problem that has existed for a long time. Developing countries are not only looking to move out of poverty, but also to eliminate wealth disparity. Therefore the focus must be paid on job development. They must also avoid the trappings of dependency. In line with the spirit of STS *forum*, practices to share technology with developing countries and this would surely accelerate the capacity building of these countries. Participants also called for international cooperation to develop technological capacity of developing countries and help them avoid the middle income trap. In addition, there is a need to foster the younger generation, and produce the young global leaders of tomorrow.

Dr. Joanna Rubinstein presented the key messages from the concurrent sessions on the theme of nature preservation. The first session focused on ocean and addressed the issue of biodiversity and conservation. Oceans are important for economies, life, and the hydrologic cycle. Failures to adequately address pressing issues of ocean acidification, pollution or overfishing, have to be addressed with innovative scientific and technological solutions. We must also find ways to better educate students and societies at large about these problems, and engage all the stakeholders. Some of the issues discussed included the importance of sharing of data among academia, governments and the private sector. For example, the problem of rapid melting of the ice caps in the Arctic requires concerted efforts to understand the causes, and developing solutions to mitigate and prevent this escalating problem. To do this we must share information, have better networks, and improve the collaboration with the private sector that owns much of the necessary data. In general, better governance at the global, regional, national and local level is needed.

The second session was on the theme of water. Discussion focused on the promotion of science and technology to address the issue of improving the efficiency of water use in different sectors. We face different water challenges at the global and the local level, especially in the distribution of water. The dry regions are becoming drier. With the majority of the world conflicts in the drylands, we urgently need to find ways of mitigating this problem. Among other pressing issues is the problem of water salination and of desalination, or costs of decontamination of water. The majority of water (~70%) is used for agriculture. The increased scarcity of water affects food security, which together with the growing world population further exacerbates the problem. Science and technology must focus on the development of solutions for more efficient water use for food production. Moreover, we have to recognize that most of these problems affect developing countries, which do not have access to the latest technologies available. Therefore it is also important to address the issue of technology transfer. Yet another problem constitutes water pricing. Instead of raising the price for larger volumes of use, water is often subsidized, leading to the waste of water and loss of groundwater. We must therefore examine ways for the public and private sectors to partner, and to develop better government policies, and better collaborate among the global, national and local levels. Big data analysis in partnership with the private sector will help, but other forms of support must also be developed to for improving efficiency of water use.

The third session was on adaptation to climate change. In recent years, the increase in incidents of extreme weather conditions has made more people aware of climate change, but it continues to remain an urgent educational problem. We need societies and governments to better understand causes and catastrophic consequences of climate change. We need to develop better, scientifically proven, climate change mitigation and adaptation strategies. The example was raised of the recent IPCC report stating that sea levels will rise 1 m by the end of century, whereas other scientific data indicates that the rise may actually reach 4 m. The consequences between the two scenarios will of course be very different. Therefore, more investment in research is required to generate more conclusive data. Additionally, the role of capital was discussed. For example, 90% of the world's capital does not take into account the risks of climate change. This provides new opportunities to engage the capital sector in addressing the climate change, which may offer novel approaches for dealing with the climate change issue. It was concluded that the problems of ocean, water and climate change are all interlinked. To effectively address these problems, we must improve ways of collaboration among the different scientific disciplines, governments and across different industry players.

Prof. Per Eriksson presented the key messages from the concurrent sessions on ICT. The first session was held on security for ICT. STS *forum* is about the lights and shadows of science and technology, and this is particularly true of ICT. There are many lights, but equally many shadows. 400 million data records were stolen this year alone. Google and Facebook provide services for free, but we pay in valuable data. The Internet is becoming increasingly complex and data is growing. It is estimated that the amount of data doubles every two years. We also have faster computers and better mobile devices, at increasingly low prices, leading to exponential growth of data.

The second session was on privacy for ICT. In this area we see encryption and at the same time indifference, especially among companies that prioritize speed to market. We also see terrorism and crime. The sharing of information is very important, especially for ensuring the free flow of data. Absolute security may be impossible, but we must nevertheless accelerate efforts to protect ourselves. It is estimated that 20% of data on the Internet is malware that seeks to attack our electronic devices. However, the main threat is internal and pertains to ethics. In this regard, better education is needed. We also need greater international agreements. As for privacy, we must handle private data, such as medical data carefully. For this we need not only regulation, but also greater understanding of the ethics involved. Overall there is a need for good interplay to balance security, privacy, and also economic growth. With the rise in incidents in which privacy or cybersecurity have been compromised, we will surely see a trend of growing awareness of the importance of cybersecurity. Participants also discussed a hypothetical scenario of a non-profit company that stores private data, but has no right to access that data without explicit permission from the owner of said data.

The third session was on big data. Big data has allowed us to better understand a diverse range of fields from climate, to medicine, to language. Universities have therefore begun expanding curricula on data management. Overall, it is important to raise awareness of the lights and shadows in ICT. Part of the responsibility lies with educators, but ethics are also required, as is information sharing and interaction across the public and private sectors.

Next, Prof. Dr. Robbert Dijkgraaf reported on international relations in science and technology. The first session was on S&T diplomacy and international collaboration. Diplomacy in a simple sense is the pursuit of national interests and science, and technology has played role in this regard. Of course, another aspect of diplomacy is the interplay between regions, in areas such as sustainability and mutual growth. Science and technology cannot also contribute to these goals. The long-term payoff of science and technology is therefore obvious. It is important to note that the language of science is very clear, whereas the language of diplomacy is more flexible.

The next session was on competition and cooperation among global industries. Competition is essential for innovation, but increasingly there is a key need for greater collaboration. Greater demand for innovation, higher costs, and greater need for interdisciplinarity has led to increasing need for collaboration by different players across sectors and countries. At the same time barriers do exist, such as intellectual property. Setting standards can be conducive to collaboration. Legal and tax concerns must also be worked out. It was also pointed out that in addition to government, academia, and industry, the customer can also play a role in collaboration and innovation.

The third session was on responsible public dialogue in science and technology. The border between science and society has become more flexible and is shifting. Drivers include technological progress, media, and enhanced education. Therefore there is a need for greater dialogue. In fact, better understanding and engagement from society for science and technology is needed to allow society to make informed decisions about technology. Science must be seen as an essential part of our culture. There are terrific opportunities and social media and mobile devices are key platforms for this. We are now in the age of "open science," "science 2.0," or "citizen science." It is also promising to see the emergence of young scientists who are not only highly technically proficient, but are also adept at and eager to engage with other stakeholders in society.

Dr. Masuo Aizawa presented the key messages from the concurrent sessions on human habitat. The first session was on smart cities. Prosperity and technological development can now be achieved by all countries. However, this has also intensified competition. Science and technology have, on one hand, exacerbated issues such as climate change; but at the same time offer means for a brighter future. One such idea is smart communities that can transform societies. One successful example was

presented from Singapore, which demonstrates the possibilities of big data, and the ability to make any society "smart." Kashiwanoha was also highlighted as a smart city in Japan, which combines robotics and ICT. Similar efforts have been pursued in Fukushima, a region that was irrevocably damaged by the 3.11 disaster. A smart city must also encompass job creation and must engage industry.

The second session covered efficient use of global resources. The issue of resources cannot be solved by any one country or actor alone. On the supply side, industrial initiatives include research on simple chemicals as alternative fuels, such as hydrogen fuel and hydrogen fuel cars. Citizens should also be given a voice, and governments must acknowledge citizens' opinions and act according to the interests of society.

The last session was on social innovation for sustainability. Microfinance and fair trade were presented as examples. Social innovation pervades all aspects of our lives, and we must be more open to these ideas to avoid compromising our future. Social change for addressing the needs of aging society were also discussed. Maintaining a good quality of life requires innovation and the accumulation of knowledge. Innovation arises from experimentation, and we must encourage different and novel ways of thinking. Universities have a role to play in this regard. From industry's perspective, it is essential that we define what "sustainability" means, so that industry can make more focused efforts to develop technologies that contribute to sustainability.

Prof. Ichiro Daigo reported on the discussions of the Future Leaders group. Prof. Daigo introduced the members of the group before presenting the lessons they had learned. The group held discussions on research and innovation, research budgets, education, and a multitude of other societies. Science and technology have brought us both lights and shadows. The shadows apply to global issues in climate change, health and other challenges. However, we can work towards overcoming these challenges now. STS *forum* is unique in the fact that it brings together leading members from government, industry and academia, so that we can work together on these issues. However, discussion must also include the public. Citizens' desire for a better quality of life has to be accounted for. When looking to the long-term, discussions have looked at the timeframe of decades, but we must make plans for hundreds of years into the future. When looking ahead that far into the future, we must also maintain a focus on basic and applied research.

Closing Plenary Session 302:
How Do We Move Forward to Maintain Sustainability for the Future of Humankind?

His Imperial Highness The Crown Prince of Japan

Session Chair

Charles O. Holliday Jr., Chairman of the Board, Bank of America Corporation, U.S.A.

Speakers

Paul Nurse, President, The Royal Society, U.K. [Nobel Laureate 2001]
Naledi Grace Mandisa Pandor, Minister of Science and Technology, South Africa
Koji Omi, Founder and Chairman, Science and Technology in Society *forum* (STS *forum*), Japan

Mr. Charles O. Holliday Jr. opened the closing session of the 11th annual meeting of the STS *forum*. He welcomed His Imperial Highness The Crown Prince, and thanked him for his attendance and precious time.

His Imperial Highness' speech is as follows.

"Excellencies,
Distinguished participants,
Ladies and gentlemen,
I am very pleased that the 11th Annual Meeting of the Science and Technology in Society *forum* has been successfully concluded after fruitful discussion over the past three days among esteemed participants from all over the world.

This is the fourth time I have attended this conference since its establishment in 2004. I appreciate the significance of the lively discussion over the last 10 years on various issues related to the so-called "lights" and "shadows" of science and technology, as well as sustainability for the future of humanity. I would like to express my deep respect for all the efforts made by those dedicated to this forum.

This forum covers urgent issues facing humanity such as environmental problems, including responses to climate change, energy use and global health. In order to cope with these issues, the international community is now required to hold multidimensional discussion on the shape of society in the future and advance international cooperation on such important topics as building global networks and establishing rules. From this viewpoint, it becomes more important than ever for experts in various fields from all over the world to address these urgent issues by creating interdisciplinary networks.

In thinking of the future of humankind, it is important to discuss the issues, including the environment, energy, food and water, from a longer-term perspective, not just 20 or 30 years from now, for the sake of everyone living on our planet, beyond mere national borders. Let me express my heartfelt wish that global leaders will continue their efforts to bring their wisdom together and search for the best way to make the most of science and technology for the future of our earth and the sustainable development of humankind.

In conclusion, I would like to renew my sincere wish that this annual forum here in Kyoto will further contribute to the sound advancement of science and technology and the future of humanity.
Thank you for your attention."

Following the speech of His Imperial Highness The Crown Prince, Mr. Holliday took up the theme of balancing the short-term and long-term considerations of economic growth, and the long-term sustainability of our planet. Some consider the two to be trade-offs, but that is simply not the case. Both are possible at the same time. One concern is the cost of growing the economy in a sustainable way. It will in fact cost more to grow the economy in a more sustainable way. Nevertheless, this is an excellent investment for the future of humanity. However, there is one fundamental assumption: that science and technology continues to advance, and that policymakers will make the best use of these advancements.

Mr. Holliday then highlighted three key points. First, fossil fuels will play a role in the next 15 years, but we can make use of technologies such as carbon capture to mitigate the negative effects. Secondly, finance has not been creative enough and taken enough risks in promoting sustainable growth. However, green bonds and other sustainable investments are continuing to gain support. Finally, energy efficiency is critical for achieving the goals of sustainable economic growth.

Sir Paul Nurse discussed trust in science. To ensure science brings about a sustainable future for mankind requires trust from society, and a healthy relationship between science and society. We need a democracy in science for coping with complex problems faced by science. Scientists must therefore be open and honest, being transparent in their work and sharing the data they have gained in the course of their research. It is also important to declare support from industry and non-profit organizations.

Scientists have to be rigorous, and be both honest and skeptical. They must withstand pressures to produce results for career advancement. This is best combatted with a healthy culture of science for the pursuit for truth. Advances in science are not linear. Much work is based on hypotheses that may later be found incorrect. But there is no shame in this, provided the work was conducted in an honest way.

Greater understanding for scientific process, not scientific facts, in education is also a must. The media must also be more responsible in its reporting of scientific research. Scientists must also be fully engaged in the public regarding what is being done and why, and what data is significant and what is not. This can only be achieved through bidirectional dialogue.

However, there are many that can undermine trust in science. There are many cases where politicians, media, and others can distort or cherry-pick scientific data and arguments to support their own religious, political, or ideological beliefs. Those who continue to seek to undermine science must be most strongly countered. Another grave threat is contrarians and skeptics. However, there is a lesson to be learned by scientists. They must be the ones who are most skeptical about their own scientific findings. Science must also contribute to society and produce sustainable benefits to humankind. However, this is not possible without trust in science, and to achieve this we must train scientists to gain trust and fully engage the rest of society.

Her Excellency Mrs. Naledia Grace Mandisa Pandor began by stating that the participation by representatives from South Africa in the STS *forum* provided valuable guidance for the country. South Africa has learned lessons from Japan and others about funding research and protecting intellectual property rights. South Africa has continued to raise basic research funding, and has encouraged the transformation of universities so that they are no longer isolated from industry. Intellectual property legislation has also been introduced. At the same time, South Africa is also promoting science and technology for addressing the pressing issues that face the world.

It is essential that we understand all the challenges and rapid changes facing the world, because we live in a globalized world, and our problems are our neighbors' problems. Tuberculosis and HIV are on the rise again in regions previously considered safe, for example. More than ever we need global solidarity. We need to confront the rising inequality that we face in our world. This is most evident in the discrepancies in affordable healthcare. We must also leverage the new prominence of the interface between science and society, and the prominence this enjoys in public discourse. Novel forms of public partnership have begun to emerge, as well as new North-South cooperation. Improving the instruments of science also enjoys a prominent position on agendas of national governments around the world.

Another key challenge is sustainable development. This goal cannot be achieved without extensive collaboration.

Regional cooperation in science and technology has to be prioritized. Furthermore, international partnerships must be co-owned by all constituents to the partnership. The North-South donor-recipient paradigm is now a thing of the past.

Her Excellency Mrs. Pandor then discussed the Four Square Kilometer Array project in South Africa. This will be the first example of large-scale scientific infrastructure on the African continent. Investment in projects such as these have attracted the attention of distinguished astronomers from around the world. The scientific achievements of researchers from African universities have also risen in prominence. It is hoped that an international treaty organization will be ready next year. The partnership between nine African countries in this project should also be celebrated.

Her Excellency Mrs. Pandor also discussed science and technology innovation in Africa. South Africa understands the importance of international collaboration. For this it is essential to build the science and technology capacity of other African countries, in collaboration with partners from around the world. Her Excellency Mrs. Pandor cited the holding Science, Technology and Innovation for South Africa (STISA), which will address a variety of globally relevant science and technology themes.

In closing, Her Excellency Mrs. Pandor stated that we lived in an ever more fragile world. However, she was confident that with the right political will, it would be possible to pursue science and technology in a manner that made a real difference for all of humanity.

The final speaker was Mr. Koji Omi, the founder and chairman of the STS *forum*. Mr. Omi began thanking all the participants for making the 11th annual meeting a great success. He expressed his belief that the STS *forum* had grown from a conference to a global movement. Mr. Omi expressed his commitment to continue to develop STS *forum* as a platform for addressing science and technology issues for future generations. It is nevertheless important for all parties to continue to connect science and technology and society more enthusiastically than ever before.

Mr. Omi then presented highlights from the official statement of the 11th annual meeting of the STS *forum*. Nuclear power will continue to play an important role for the future. We should also note that iPS cells have high potential to achieve breakthrough technologies for cures. Additionally, it is important to strengthen the capacity of the world to deal with diseases such as Ebola. In ICT, security and privacy are vital for the future, and we need universal international rules. In addition, collaboration between government, academia and industry are vital for further growth and innovation. In the past human society treated the earth as infinite, but we have now come to realize that the world is finite for us. We must therefore protect the environment and ensure sufficient energy, food, and other resources for future generations. At the same time, we must not forget that humankind is part of nature, and we must live in harmony with nature.

In closing, Mr. Omi believed that participants from around the world had discussed their shared concerns as members of humankind to achieve sustainability and innovation over the 11 years of the meeting's existence. Thanks to these efforts, the STS *forum* has begun producing tangible results in the world. To further expand activities, workshops will be held in cities around the world, including Beijing, Berlin, and Kuala Lumpur. Finally, Mr. Omi said he looked forward to seeing the participants again next year to hold fruitful discussion and pave the way for future generations.

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