The 12th Annual Meeting

STS *forum* 2015

Summary

October 4, 5 and 6, 2015
Kyoto, Japan

Science and Technology in Society *forum*

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Statement

1. The 12th Annual Meeting of the Science and Technology in Society *forum* took place from October 4 to 6, with the participation of over 1,000 global leaders in science and technology, policy, business and media from nearly 100 countries, regions and international organizations.
2. At the meeting, based on the recognition that the earth is becoming finite for the activities of humankind in the 21st century, participants reflected on how to strengthen the "lights" and control the "shadows" of science and technology. We considered the future of humanity and the sustainable development of society over a longer-term perspective, thinking of what the future will be like not just in twenty or thirty years' time, but over 100 or 500 years from now.
3. Based on discussions at this year's meeting, we would like to highlight the following viewpoints.

   A. *Energy and Environment*

   Over the long term, continued burning of fossil fuels will exact an unacceptable environmental cost and exhaust finite resources. We should have diverse energy sources for ensuring reliable and stable supply, and nuclear power should remain an important option, under the conditions of safety, security and non-proliferation.

   We also stressed the need to establish an international framework for effectively mitigating greenhouse gas emissions that includes all countries. We hope that our message will be reflected in the discussions at the United Nations Climate Change Conference (COP21) in December 2015 in Paris.

   B. *Innovation*

   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.

   We should strive to develop a coalition that includes the public and private sectors, academia, government and industry. Chief Technology Officers should become bridges between business and academia in the development of science and technology to nurture innovation. The ultimate source of major innovation is basic science, which has to be supported in both the public and private sectors.

   C. *ICT and Smart Cities*

   A global-level consensus on universal ICT rules is needed, as advanced utilization of ICT with improved security and privacy protection becomes essential for future human development. The merging of the internet with mobile telephony and other devices is transforming society and is helping developing countries and empowering women. The "Internet of Things" and use of "Big Data," as well as the emergence of AI and robotics, will also create new challenges and opportunities for society.

   More livable, humane, disaster-resilient and energy-efficient urban environments must be developed using science and technology. ICT in particular, through urban planning and better management systems, can help create "smart cities," to support the evolution of cities, peoples, values and cultures.

D. Global Health

Recently, research into iPS cells and genomics has been achieving breakthrough results in life sciences. By making these results fit for practical use, we should encourage further progress in personalized and preemptive medicine, in harmony with human health, safety and ethical issues. Scientific knowledge on nutrition should also be expanded for human welfare.

A new international system is required to improve collaboration among developed and developing countries and WHO for global health, especially for dealing with infectious disease pandemics.

E. Resource Conservation

The oceans and their deep currents are central to the climate and the management of greenhouse gas emissions. Better understanding of the oceans and the fresh waters of the earth is vital for developing effective sustainable development futures for humans. We must think of better ways to make efficient use of various kinds of resources with careful attention to prevent significant problems for society.

To produce the food necessary for humanity in the face of the increasing uncertainties of climate change will require better use of land and water and more adapted resilient crops deploying the best science, including the use of GMOs, which have been shown to be safe and can contribute much to improve the nutritious content of the food of the poor.

F. Cooperation in Science and Technology

The innovations in one part of the world should be linked to others that need them, thereby ensuring that sustainable solutions spread throughout the planet.

Supporting education, research and local entrepreneurship is essential for capacity-building in developing countries. Cooperation among industries focusing on science and technology in the global economy today is increasingly important, while global competition among industries is the key to encouraging innovation.

G. Science, Technology and Education

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.

The importance of STEM education should be highlighted. High-quality science programs should be developed to interest and inform the public about the role of science and technology in society. Emphasis on the education and empowerment of women would help enhance sustainable development.

4. This year, we held workshops in major cities Kuala Lumpur and Milan. We have also established an “STS *forum* Future Leaders’ Program” involving close to 80 active younger leaders for sustainable development of the forum. We will build on and expand the network we have established to further address the opportunities and challenges facing humanity.
5. We look forward to meeting here again next year. We agreed to hold the 13th Annual Meeting of the STS forum in Kyoto from Sunday, October 2 to Tuesday, October 4, 2016.

Day 1

Opening Plenary Session 100
Plenary Sessions 101, 103 (A-B)
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Opening Plenary Session 100: Science and Technology for the Future of Humankind

Session Chair

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

Speakers

Abe, Shinzo, Prime Minister, Government of Japan, JAPAN [Nationality: JAPAN]
Valls, Manuel, Prime Minister, Government of the French Republic, FRANCE [Nationality: FRANCE]
Wickremesinghe, Ranil, Prime Minister, Government of the Democratic Socialist Republic of Sri Lanka, SRI LANKA [Nationality: SRI LANKA]
Dvorkovich, Arkady, Deputy Prime Minister, Government of the Russian Federation, RUSSIA [Nationality: RUSSIA]
Holdren, John P., Assistant to the President for Science and Technology and Director of the White House Office of Science and Technology Policy (OSTP), Executive Office of the President (EOP) of the United States, U.S.A. [Nationality: U.S.A.]
Sakakibara, Sadayuki, Chairman, Keidanren (Japan Business Federation); Chief Senior Advisor, Chief Senior Counselor, Toray Industries, Inc., JAPAN [Nationality: JAPAN]

Opening Remarks

Mr. Koji Omi, Founder and Chairman of Science and Technology in Society *forum* (STS *forum*), opened the 12th Annual Meeting. First he welcomed the Japanese Prime Minister Shinzo Abe, Honorary Chairman of STS *forum*, and believed that his continued guidance would continue help ensure the achievement of STS *forum*'s goals.

While science and technology have improved the quality of our lives, they have also given rise to new issues such as global warming, information security. STS *forum* refers to these as the "lights and shadows" of science and technology. These must be addressed from a long-term perspective.

Mr. Omi then spoke about recent developments and timely issues in science and technology, such as advancements in medical research, including breakthroughs in iPS technology.

With regard to energy and resources, we need to recognize that resources are finite and must think about energy resources for 100 years into advance. Nuclear energy is one form

of renewable energy that also does not produce greenhouse gas emissions, we must also consider safety, reliability, and non-proliferation.

The Internet of Things is expected to make huge leaps in our quality of life. But at the same time we must control the negative impacts to ensure security and privacy.

Science and technology is also the key to solving some of the key issues we face. Science and technology issues affect all of us today, and must not be left to science and technology professionals alone. We must think of them as our own. At the same time, no one country alone can solve these issues and we must therefore work together. This is the fundamental concept of STS *forum* and the Annual Meeting.

For future generations, we must think about what we can do now to ensure a brighter future for mankind. STS *forum* is no longer merely a conference, but a movement for the betterment of humankind. The adoption of the UN Sustainable Development Goals are also welcome. It is hoped that the world leaders gathered here today will participate in STS *forum* in the spirit of noblesse oblige. Finally, Mr. Omi expressed his hope that the Annual Meeting would yield fruitful discussions and results.

The Prime Minister of Japan, Shinzo Abe, declared that Japan must contribute more actively to world peace and prosperity. To that end, Japan must leverage its expertise in science and technology as much as possible. Japan must become a hub for innovation. To do that, it must create eco-systems where knowledge gives rise to knowledge, and innovation gives rise to more innovation. This is one of the most important tasks for Japan over the next five years.

Prime Minister Abe then cited the example of innovation in cars. On the one hand, cars kill more than 1.2 million people per year in the world. At the same time, they are a great equalizer, democratizing people's movements. Their advantages should be shared by all. Japan has a mission to address the safety and reliability of cars using the technology it commands. Self-driving car technology is being developed in Japan. Two companies have emerged, ready to try out tests on public roads. Soon self-driving cars will be able to change lanes on the highway.

Of course, many challenges remain. Maps must first become dynamic, taking into account information such as traffic lights, road surfaces, pedestrian movement, and so forth. Cloud computing and sensor technology must also make further progress. Overall, open innovation must occur.

The creation of dynamic maps will create new eco-systems and give rise to new industries and services. Prime Minister Abe hoped that Japan would lead the pack globally in this regard. The manufacturing knowhow and technology in Japan will surely contribute to this end. Japan must also contribute to the internationalization of this technology. Prime Minister Abe declared that the age of the driving car would come very soon and said that driving cars would be widely available in Japan by 2020, the time of the Tokyo Olympic and Paralympic Games.

Prime Minister Abe also expressed the urgent need to foster more female leaders in science and technology. To that end, the Japanese government launched the "Riko (science and engineering) Challenge initiative," aimed at encouraging young women to take an interest in and potentially pursue a career in engineering fields.

In closing, Prime Minister Abe quoted 2001: A Space Odyssey, "any sufficiently advanced technology is indistinguishable from magic." As such he hoped to see a rise in "magicians" in the world, especially female "magicians" from Japan.

The Prime Minister of the French Republic, Manuel Valls, opened his remarks by praising Mr. Omi for his vision and commitment in establishing STS *forum*. France understands the importance of innovation to the country, and how it can ensure the country's continued competitiveness in the world.

The state has a major role to play in fostering research and innovation. That is why France has a system in place that is among the most conducive in the world to fostering innovation. More generally, it also encourages imagination and inventiveness.

Prime Minister Valls then touched upon emerging trends in science and technology. France hopes to seize all advantages of the digital age. At the same time France hopes to spread its benefits throughout society.

Energy transition is another important revolution. It is absolutely essential that the world secure sustainable energy supply. The negotiations at the 21st Conference of Parties in Paris are contributing to this end. Humankind and political leaders need to be aware of the devastating consequences of climate change. It is STS *forum* and other science and technology experts who have helped raised awareness among them. Science and technology are also the tools for addressing this.

It is therefore important to establish an international framework for addressing this issue. Rules must also be set to guide our actions, thus establishing freedom, imagination and innovation to be fully expressed. Prime Minister Valls therefore encouraged all entrepreneurs, scientists, political leaders to join forces, and establish commons standards. Finally he encouraged the participants to be bold and take risks for the betterment of mankind.

The Prime Minister of the Democratic Socialist Republic of Sri Lanka, Ranil Wickremesinghe, began by quoting William Churchill, "the empires of the future will be the empires of the mind." He followed up by saying that from seeing everyone gathered in the audience, he realized just how true this was. STS *forum* is indeed the World Economic Forum for science and technology, and Mr. Omi must be commended for his vision and devoted efforts.

Next Prime Minister Wickremesinghe spoke of Japan's postwar history, praising its peaceful development and support for developing nations. Furthermore, a strong Japan is needed for a strong Asia, and Japan's devotion to pursuing knowledge, particularly in science and technology, made it a much needed front-runner in the region, and a global leader in industrial innovation. Today East Asia is driving economic growth in the world. Economic growth and innovation have improved the quality of people's lives. However, the benefits of science and technology are not yet felt by all, particularly in South Asia, including Sri Lanka.

South Asia is forecast to be the most populous region in world in 2050 and harnesses great potential for growth. Therefore, the adoption of the UN Sustainable Development Goals has been a highly welcome development. Sri Lanka is an important turning point in its history and will seek to build a more inclusive society. It is important not only to bring together a divided people, but also to ensure that the benefits of science and technology are felt among them. The government must lay down the necessary infrastructure for people to realize their full potential. To that end, it considers a dynamic regional approach with international engagement to be the way forward.

Sri Lanka hopes that engaging in a science and technology partnership with Japan will help address the various issues the country faces, including through technology transfer, collaboration, and investment in next-generation infrastructure. Finally, Prime Minister Wickremesinghe encouraged participants to help the nations of South Asia to emerge from the shadows of their past and, through science and technology, create societies that are unfettered by oppression and where freedom of expression reign.

The Deputy Prime Minister of the Russian Federation, Arkady Dvorkovich, presented Russia's vision for the nation's science and technology. He believed that science and technology will make a profound contribution to long term sustainability and the resolution of negative developments around the world. Russia believes that its strong commitment to science and technology will contribute to global growth, as well as the development of Russia itself.

Russia considers development in the Asia-Pacific region to be of great importance to Russia and Japan is Russia's foremost partner in this regard. Russia also offers reasonable and comfortable investment conditions to all its potential partners from abroad. Moreover, Russia will work to ensure that the benefits of science and technology are widely felt in people's daily lives.

Deputy Prime Minister Dvorkovich then spoke about the areas of priority for Russia. The first is investment in agricultural assets. Russia is among the world leaders in terms of vast areas of land that are fit for agricultural cultivation. While genetically modified crops are not permitted by law in Russia, research in other areas of agricultural technologies are highly welcome. Energy is another priority. Nuclear power, which is seen as one of the best means currently of combatting climate change, is a major strength of Russia, as are other more traditional energy areas. Another area of priority, considering Russia's large size, is transport and communication technologies.

Deputy Prime Minister Dvorkovich then touched upon the Skolkovo Innovation Center, an eco-system for fostering high level research, and also applying that research to technologies and achieving innovation. In addition, Russia is also pursuing a new national technological initiative, to create completely new markets by the middle of the 21st century. In closing, Deputy Prime Minister Dvorkovich invited companies and universities from around the world to work with Russia on such innovation projects, expressing the Russian government's commitment to providing strong support for such international partners.

Dr. John Holdren, Science and Technology Advisor to President Obama and Director of the White House Office of Science and Technology Policy, began by conveying greetings to the participants in the Forum from President Obama, before turning to what society needed from science and technology, the impediments to meeting those needs, and some reasons for optimism that the impediments could be overcome.

At the national level, science and technology are essential for job creation and sustainable economic growth, improving public health, making energy technologies more affordable and environment-friendly, building preparedness and resilience against climate change, and strengthening national and homeland security. At the global level, as a collection of nations, we must fight pandemics worldwide, eliminate poverty, maintain the ecological integrity and productivity of the oceans, and prevent any use of weapons of mass destruction.

At the same time, Dr. Holdren noted that there were clearly many obstacles to the progress of science and technology and their effective application to society's needs. The first is inadequate understanding of the importance of investment in basic research, which helps sow the seeds for future innovation and applications. In some countries there has emerged misguided insistence by government officials that investments in basic research be justified by specific expected benefits or for the economy or national security. The second obstacle

is the unpredictable ups and downs of research funding that result from year-to-year budgeting and changes in governments. Thirdly, there are barriers to the transfer of discoveries in the lab to application in society such as lack of financing and lack of understanding of user needs by the innovator. Finally, many opportunities for scientific discovery and its application through technology to improve human well-being are missed because of inadequacies in all phases of STEM education, from getting kids interested in science, to providing high-quality instruction, to workforce training, to communicating about science and technology to decision-makers and the public.

On the other hand, Dr. Holdren identified a number of trends that pointed to improving prospects for bringing the fruits of science and technology to society. Partnerships are developing all over the world, between organizations, across different levels of government, between the public and private sectors, and between nations. Partnerships between government, industry, and academia help translate discoveries in labs to technologies that benefit society. Dr. Holdren noted that the United States was also becoming more aware of the importance of training PhD students and researchers on how to become successful tech entrepreneurs. Emphasis on advances at the intersections between different disciplines are also yielding exciting new results. For example, big data and big data analytics are poised to generate breakthroughs in many different research fields, including precision medicine. There has also been advancement in STEM education, to foster better science and technology education through active learning rather than lecture-based instruction. Additionally, efforts are being made to reach out to segments of society that have traditionally been underrepresented in STEM fields, such as women and minority populations.

Finally, Dr. Holdren expressed his optimism for the future and the promise presented by science and technology, and said that judging from the many people gathered in the room, he was surely not alone in this regard.

Dr. Sadayuki Sakakibara, Chairman, Keidanren, began by expressing his great honor and privilege to be speaking at STS *forum* for the seventh year in a row. He then cited some of the pressing issues facing the world such as energy sustainability and climate change. Nevertheless, Dr. Sakakibara was certain that humankind had the knowledge and wisdom to overcome these issues and create new values by innovation.

Speaking next on the role of Japanese industry, Dr. Sakakibara said that Japanese companies were expected to deliver the fruits of innovation to society, while also generating

employment through the provision of goods and services involving highly advanced technologies. However, efforts by private companies alone are not enough. He stressed that government support was needed, and that FIRST and ImPACT were effective programs to support cutting-edge research in Japan.

Then Dr. Sakakibara discussed the necessary conditions for groundbreaking innovation to occur. First he cited the importance of having a shared vision across government, industry and academia. There must also be linkage and balance between basic research, advanced research, and practical use. Partnership between entrepreneurs and service providers should also be fostered. Furthermore, there must be diversity in the field, including the involvement of more women and foreign nationals, as well as an enlarged role for young people, to foster open innovation. In closing Dr. Sakakibara expressed his belief that taking maximum advantage of the knowledge of STS *forum* and the pursuit innovation would contribute to the development of Japan and the world, and the fostering of co-prosperity for mankind.

To close the session Mr. Omi thanked the speakers for their insights and expressed his hope that the participants would engage in fruitful discussions over the next two and a half days.

Plenary Session 101: Energy and Environment

Session Chair

Holt, Jr., Rush D., Chief Executive Officer, American Association for the Advancement of Science (AAAS); former Member of U.S. House of Representatives (1999-2015), U.S.A. [Nationality: U.S.A.]

Speakers

Ueda, Takayuki, Vice-Minister for International Affairs, Ministry of Economy, Trade and Industry (METI), JAPAN [Nationality: JAPAN]

Kleiner, Matthias, President, Leibniz Association, GERMANY [Nationality: GERMANY]

Uchiyamada,Takeshi, Chairman of the Board, Toyota Motor Corporation, JAPAN [Nationality: JAPAN]

McBean, Gordon, President, International Council for Science (ICSU), FRANCE; Professor Emeritus, Geography, Institute for Catastrophic Loss Reduction, CANADA [Nationality: CANADA]

Opening Remarks

To open the session, Dr. Rush D. Holt, Jr. expressed his honor to serve as chair. He then introduced the activities of the American Association for the Advancement of Science, which include fostering communication between scientists and engineers, between the scientific community and society, science education, and public policy.

Moving onto the theme of the session, Dr. Holt highlighted the importance and timeliness of energy and environment as topics of discussion. It is interesting to note that this year marks 50 years since an American president and science advisory committee first issued an official warning about the dangers of global warming.

Scientists and policymakers must consider environment and energy both at the macro level and the micro level, while also addressing these issues at a variety of timescales. While engineers understand the different timescales at play very well, the public does not, and this must be better communicated to society. There needs to be more specificity and clarity about such timescales. For example, when society speaks of reducing dependence on fossil fuels, it is not clear by how much or when. In addition, while there is much talk of new technologies being developed that will change the game, these are, in reality, slow to emerge. Hybrid fracking may be groundbreaking, but it still took half a century to develop. Carbon capture and sequestration are still far from realization and application. Arctic oil development remains slow. The efforts of various countries to reduce fossil fuel dependency, though commendable, are still slow.

The basic energy picture is changing very slowly and it can be said that the glaciers themselves are moving faster than public policy and sentiment. All this does not take away from the efforts of researchers and policymakers to date, but it does highlight the fact that these efforts still remain inadequate for addressing the challenges that the world faces.

Vice-Minister Takayuki Ueda discussed climate change and energy policy in Japan, which are fields receiving increasing attention from society. The Great East Japan Earthquake and

nuclear accident forced Japan to reconsider its energy policy and mix. Japan had to rely more strongly on fossil fuels once again. Looking towards 2030, Japan's aim is to lower dependency on nuclear energy to the extent possible, by saving energy and increasing other renewable energy. Innovation will be one of the key factors for achieving these targets.

The 21st Conference of the Parties is also expected to be an important step towards tackling climate change. Japan submitted an ambitious target of reducing greenhouse gases by 26% by 2030, compared to 2013 levels. To achieve this, Japan will continue aggressively reducing emissions in the country. As part of the government's initiatives, Japan is hosting the Innovation for Cool Earth Forum, a conference focused on addressing climate change through innovation. Japan is also implementing joint credit mechanism initiatives to reduce emissions.

Finally Vice-Minister Ueda expressed his belief that STS *forum* was an excellent opportunity for the best minds in the world to come together to discuss cutting-edge science and technology and his hope that it would help elucidate solutions to problems faced around the world, particularly in the areas of energy and environment.

Prof. Matthias Kleiner stated that energy and environment were of the utmost importance for society. Increasingly, the world is becoming aware that we must take immediate action in this field. The nuclear disaster in Japan was a trigger for the final nuclear phase out by 2022 in Germany and the country's energy transition. As a result, greater renewable energy production is expected, supported by tax benefits.

Prof. Kleiner then discussed the work of the Leibniz Association. It is a highly interdisciplinary research institution that is committed to bringing the benefits of science and technology to society. Energy and climate change are important themes for the Leibniz Association as well and it will address the issue of Germany's energy transition from an interdisciplinary perspective. Technological innovations have a role to play in helping raise energy efficiency and reducing emissions, but these alone are not enough. Balancing technology and policy with public support will be key.

However, an independent study on Germany's energy transition lamented its progress, concluding that efforts need to be intensified to reduce greenhouse gas emission and raise energy efficiency. There are two targets, which are to reduce emissions by 80% and phase out of nuclear energy by 2022, and to raise the proportion of renewable energy to represent

18% of all energy consumption by 2020. Furthermore, the total cost burden of energy transition is not as exorbitant as public debates suggest.

Finally, Prof. Kleiner reported that Germany's Federal Ministry of Education and Research recently launched a large program to support technical and social innovations for ensuring the country's successful energy transition. The program seeks to take an interdisciplinary and integrated approach, to bridge the gap between academic research and industrial application, and generate innovative products, a goal that is also shared by STS *forum*.

Mr. Takeshi Uchiyamada began by stating that last December saw the commercial release of Toyota's hydrogen-based fuel cell vehicle (FCV), Mirai. For FCVs to be widely adopted across society, the necessary infrastructure must be in place. While this will require time and money, FCVs represent a means of bettering society and their introduction is essential.

There are many advantages to hydrogen technology in cars, including the ease of producing hydrogen from sewage and other sources, its energy saving properties, the fact that it can be produced and sourced locally, and the fact that linking hydrogen sources to the power grid will help achieve a true low carbon society. Although renewable energy is finally taking off, their output is still unstable. Hydrogen technology and infrastructure can be used to store renewable energy for use later.

The Japanese government is engaged in research on technology for the production and transportation of hydrogen. The government also issued its roadmap for hydrogen technology and fuel cells, which calls for a transition to a hydrogen society by 2050. Many private companies have also joined in efforts to promote widespread use of hydrogen technology and make policy recommendations. Many private and public initiatives are already in the works for the 2020 Tokyo Olympic and Paralympic Games. It is hoped that collaboration among government, industry, and academia will make this a driving force for innovation.

In addition to the Mirai, Toyota is developing many other hydrogen vehicles. A number of major auto-manufacturers in Japan have already started working together. Through this and other efforts Toyota hoped to make a hydrogen-based society a reality and Mr. Uchiyamada stated his conviction that by tapping into the wisdom of humanity, and bringing government, industry, and academia circles together, it will be possible to overcome the great challenges faced by the world.

Prof. Gordon McBean talked about the integration of energy and environment towards the achievement of a sustainable world and began by explaining the activities of the International Council for Science, which seeks to use science and technology for the betterment of global societies. One of the key concepts for the Council is sustainability of development and the need to take a long-term view, looking many generations ahead. The biggest question with regard to energy, from a scientist's perspective is to understand energy usage projections for society into the future.

Prof. McBean then mentioned various international initiatives, such as the adoption of the UN Sustainable Development Goals, COP21, and the UN World Conference on Disaster Risk Reduction in Sendai. In particular, he highlighted the importance of having an integrated approach, and the role disaster risk reduction had to play when considering issues of sustainability.

Then Prof. McBean turned his attention to the Future Earth program, which is a cross-cutting initiative that seeks to address the issue of energy and environment from an inter-disciplinary and long-term perspective. In fact, in the recent restructuring of its Governing Council, STS *forum* was invited to become a member, as well as the Sustainability Network Solutions. The challenge of dealing with issues of sustainability requires gathering experts from different disciplines, which is no trivial task. Furthermore, it is also essential to engage civil society from the very beginning, to co-design, co-produce and co-deliver solutions, and STS *forum* represents just such an effort.

In closing, Prof. McBean informed that in the spirit of integration and public involvement, the International Council for Science, the International Social Science Council, and the International Council for Philosophy and Human Sciences had declared 2016 the International Year of Global Understanding.

Discussion

Dr. Holt asked the panelists about the role social and behavioral sciences could play in addressing energy and environment issues.

Prof. Kleiner believed that it was crucial that social sciences played a larger role in this regard. The technical problems for the technologies and solutions are often largely solved, but now the obstacles are social in nature. As such social innovation is needed. The role

of social science currently is to evaluate and criticize proposals, but it must now go further and propose solutions. At the same time natural sciences and engineering must reflect the views of social science more.

Prof. McBean commented on disaster risk reduction. One of the huge issues is how societies and governments evaluate risks and how they take action. Prof. McBean believed that the social sciences were now coming up with the solution, but the challenge is understanding how best to communicate these findings to society and educate people.

Mr. Uchiyamada highlighted the importance of social science for the betterment of society, particularly in relation to energy and environment. One of the key areas to which social science can contribute is to help foster a joint vision across all sectors and segments of society.

Vice-Minister Ueda believed that collaboration between natural science and social science was highly essential. Society is hoping for one single perfect technology, but, at least presently, this is not realistic. Energy is a very complex area. Nevertheless, there is enthusiasm among the public for addressing these issues.

Next Dr. Holt asked the panelists to elaborate on the difference between renewable energy and sustainable energy, and how the two ideas could be balanced.

Prof. McBean called for an integrated approach, balancing making the appropriate and necessary changes, while not necessarily ruling out any use of fossil fuels whatsoever. He stressed the importance of taking into account society, economies and a variety of other factors.

Prof. Kleiner recommended a systematic approach, stating that one must not just think about power supplies but also other aspects of energy consumption, such as transportation.

Dr. Holt commented that the idea of sustainability had a longer timeframe than the public currently seemed to be aware of.

Dr. Holt then made the point that the idea of reducing our dependence on fossil fuels had come to represent merely burning them more slowly. He asked if the panelists could see an end to the use of fossil fuels, and if the public fully understood the consequences.

Mr. Uchiyamada believed it was crucial to develop a CO_2-free society. For the automobile industry, FCV and electric vehicles represent potential solutions. Nevertheless, even now, even the process of producing electric cars leads to emissions, but it is hoped that in future, this will change.

Dr. Holt asked if hydrogen would be primarily important in cities, where emissions were highest, as opposed to countries as a whole.

Mr. Uchiyamada believed that it would be suitable and useful all over the world.

Prof. McBean commented that the individual issues must be looked at in an integrated manner. For example, it does not matter where CO_2 emissions are produced or reduced, as the particles all end up in the atmosphere where they will last for around 100 years and affect the whole world.

Prof. Kleiner thought that hydrogen would be vital to the energy system as whole transforming the way we use energy in our lives.

Vice-Minister Ueda informed that the goal of the Japanese government was to treat hydrogen as an equally important energy source to electricity. With regard to Dr. Holt's question about fossil fuel consumptions, Vice-Minister Ueda pointed out that fossil fuel consumption was actually increasing, not decreasing. One of the main reasons is the relative inexpensiveness of using sources such as coal. Rather than eliminating fossil fuels, it is important to increase the efficiency and cleanliness of their use.

Prof. McBean believed that the present dialogue was very significant for better understanding the issues of energy and environment, as well as all the factors at play and how they interact.

Mr. Uchiyamada said that looking back 100 years, the main form of transportation was by horse, illustrating the way in which innovation and science and technology can generate massive change. Nevertheless it is important for society to have shared vision for the future.

Prof. Kleiner believed that while science and technology had a crucial role to play in addressing the issues faced by the world, so too was that of governments and society.

Vice-Minister Ueda commented on the importance of nuclear energy for ensuring energy sustainability. However, nuclear energy is not perfect and more innovation is required to achieve the necessary improvements required of it.

Concurrent Session 102-A1: Shale Gas / Shale Oil Revolution

Session Chair

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

Speakers

Herberg, Mikkal E., Research Director, Energy Security Program, The National Bureau of Asian Research, U.S.A. [Nationality: U.S.A.]

Muraki, Shigeru, Executive Adviser, Tokyo Gas Co., Ltd., JAPAN [Nationality: JAPAN]

Swartz, Derrick, Vice-Chancellor, Nelson Mandela Metropolitan University, SOUTH AFRICA [Nationality: SOUTH AFRICA]

Toichi, Tsutomu, Senior Advisor for Research, The Institute of Energy Economics, Japan (IEEJ), JAPAN [Nationality: JAPAN]

Opening Remarks

The chair opened the session with an explanation of why shale gas deserves a whole session at the conference, given their differences from traditional oil and gas resources which are relatively rare and found trapped below impermeable layers, while shale gas resources are relatively widespread and which have become relatively easy to extract using a combination of technologies such as hydrofracking and horizontal drilling. Shale has so far been mostly exploited in the US, although there are substantial resources elsewhere. Shale gas now accounts for more than 30% of US production compared to conventional gas, and has resulted in the US importing much less crude oil, and even consideration of exporting of gas. Production of shale gas is economical, resulting in lower energy prices for the foreseeable future, but this also results in making other energy sources including renewable energies uneconomical.

For all of the advantages of shale gas there are drawbacks, including the industrialization of the countryside which raises tensions with the local communities, and there are concerns about the potential of contamination, leakage of gas and induced seismicity.

The chair highlighted the questions to be considered during the session, including expected growth in primary energy demand, the outlook for oil and gas supply, the role for shale and tight oil and gas, the role for new technologies, the economic implications, the global and local environmental implications, and the establishment of best practices and regulations. He then introduced the first panel speaker.

Panel Speakers

The first panel speaker noted that the crude oil price had collapsed, with one of the major driving factors on the supply side being the shale revolution. Cheap oil is good news in particular for non-oil producing countries, and the oil prices are likely to remain cheaper in the coming years. Natural gas is expected to have a lifetime of 230 years at current production levels based on current estimations, and therefore it could provide a buffer to enable us to develop alterative energies. However, the price of natural gas fluctuates considerably from country to country, and therefore may not provide a competitive alternative to coal. Also there need to be policies put in place to address climate change such as carbon taxes and carbon pricing.

The second panel speaker explained that in South Africa substantial deposits of shale gas had been found in a large region in south-central South Africa where water is scarce, and that this had raised the question of how to engage citizens, especially poor citizens, in the debates over shale gas extraction, and how to ensure that there is sufficient public education on the issue. He explained that South Africa is facing a crisis of energy due to lack of investment, and a new mixed model energy plan has been announced by the government. He stated that a university research project had been set up to examine the economic, social and environment issues, collect related data, and to make the data available to the public. There is a window of around a decade before extraction is likely to commence, during which data can be gathered on the state of the environment before extraction begins, and then monitoring can be conducted on the effects on water resources in the area, which are absolutely critical to the local population, as well as other changes in the local ecosystem. The project is already well underway in the first phase, and the second phase will look at how to best commercialize the resource if it is decided to go ahead with production to exploit the resource.

Discussion

A participant commented that it is interesting to separate out the problems for which we have solutions, and those that we do not have solutions for. Those that we have solutions for are earthquakes, which are generally caused by wastewater disposal and linked to the volume of wastewater disposal, water contaminations which can be prevented by following strictly and enforcing the codes for well construction. Fugitive gas is a case of tracking down the small percentage of wells that have fugitive gas problems. Problems which do not have solutions include scarcity of water in the region, where it may be necessary to look for water resources which would be disposed of anyway to employ for shale. Another is the climate change issue, where we need to ensure that shale is being used as a bridge to lead to renewable energies, rather than replacing renewable energies.

A participant suggested that a carbon tax or carbon pricing could be used to address this issue.

A participant stated that it is interesting that it has been so difficult to replicate the shale gas revolution that has been seen in the US.

A participant stated that householder mineral rights and the vast land spaces are some of the factors that have made the revolution possible in the US.

A participant stated that population densities were a huge barrier to shale gas development elsewhere, and also the flexible dynamics of the shale development market and the artistry involved make it less suited to large state enterprises.

A participant stated that in many places access to the gas grid would be prevented by the operator in order to protect their monopoly, preventing the market from working.

Panel Speakers

The third panel speaker stated that there would be a large impact on the Asian LNG and gas market, due to differences in pricing models, lack of destination clauses, and varied duration of contracts. However, he noted that financial products and technologies could be used to bring fixed pricing the Asian market, and that natural gas could become the most

reliable and affordable energy in the market. Demand in Japan will decrease as nuclear plants are restarted, but will rise again in the future as nuclear plants reach retirement age.

The fourth panel speaker explained that shale revolution has provided a huge boost the US economy, but that it is also boosting the economy elsewhere as affordable LNG is exported from the US in the coming years. This is looking like a sustainable shift, but he cautioned that there are many oil technologies at the higher end of the cost curve for which investment is drying up and therefore will not be there in the future, and as there is not large amount of spare supply in the market, the market could turn very quickly if supply reduces.

Discussion

A participant asked how the role of energy security affects the decision of countries to import gas, where for example for China and India importing LNG does not look likely.

It was noted that a good balance of energies is important, but suggested that the overall role of natural gas will increase.

It was noted that in India there is a nuclear program on the way, and also noted that exports from the US are out of the question for many countries that have not signed FTAs with the US. The shale industry is very capable of cutting costs to meet the prices in the market, but the industry is very highly leveraged, and there are many companies that have gone out of business. There is also the reemergence of Iran as an exporter, which will add a large amount of capacity back into to the oil market.

A participant noted that coal has a much larger resource pool, and that by using technologies available to reduce the emissions from coal this resource could return to become a central part of the market in the future. However, other participants pointed out that the high costs of cleaning up coal resulted in renewable energies looking economically attractive.

It was noted that the effect of cheap gas on development of nuclear and renewable energies only applied in the US, but that in countries that have to import gas the costs are much higher, and the impact would be different for each country.

A participant noted that the developments in battery storage would also be a major enabling technology for renewable energies.

A participant noted that if transmission and management of renewable energies is improved to national scale then the fluctuation issues can be overcome.

A participant noted that demand could be shifted to match production through smart technologies, as domestic water heating, for example, can be carried out at any time and stored until required.

A participant suggested that natural gas will continue to be used to overcome fluctuation in renewable energies. He noted that in Germany excess capacity of renewable energies is being used to produce hydrogen or methane, which is then supplied the natural gas pipelines. He also pointed out that ammonia is an interesting carrier, as it does not emit CO_2, and it is also being investigated for burning with coal to reduce CO_2 emissions.

A participant asked how the issue of carbon taxation could be addressed widely given the differences in economics and the resource situation in each country.

It was noted that there had recently been a difficult debate in the government in South Africa over the introduction of a carbon tax policy. The country is a currently facing a major challenge to meet climate change obligations while not affecting industry or jobs.

It was noted that there were mandates being introduced to use natural gas for vehicles in India, which could reduce emissions overall.

The chair pointed out that a study had shown that introduction of gas would not necessarily result in a reduction of human influence on climate, due to increased overall demand for gas due to the flexibility and also due to leaks.

A participant stated that gas has been positive overall, but accepted that more has to be done to address leaks, and that this is an issue with a larger number of wells, and also the risk of leaks if compressed natural gas is used in vehicles. He also pointed out that electric cars could be worse than hybrid cars in terms of overall emissions depending on the type of base load used in the country.

A participant noted that there was concern in the US government that exporting LNG would increase the domestic price of gas.

A participant noted that there is room to reduce the cost of shale gas through improving the transportation costs, which is still a significant part of the cost.

A participant noted that for tight gas and shale gas some of the cost benefits in the US are related to infrastructure such as existing pipelines.

A participant stated that the problem for shale in China is poor geology and the fact that most resources are on agricultural land.

A participant noted that during the same session the previous year a speaker had pointed out that there were seven factors that contributed to the US shale revolution – high quality reserves, the availability of data, the natural gas pipeline network, the free market system, mineral rights, government support, and finally entrepreneurial spirit and the dynamics of the industry.

A participant stated that there is a common misunderstanding in the economics of short cycle wells, in that companies are often paying back their loans on the wells in 8-12 months, and this is what is resulting in the rapid peak of the resources.

A participant noted that it is now possible to pinpoint even slow leaks using satellite.

A participant also noted that on the distribution side the technology exists to pinpoint the problems, and therefore there needs to be policy and enforcement put in place to solve the issue.

Concurrent Session 102-B1: Regenerative Medicine

Session Chair

Takahashi, Jun, Professor, Department of Clinical Application, Center for iPS Cell Research and Application, Kyoto University, JAPAN [Nationality: JAPAN]

Speakers

Hengartner, Michael O., President, University of Zurich (UZH), SWITZERLAND [Nationality: SWITZERLAND]

Izumo, Seigo, Global Head, Regenerative Medicine Unit, Takeda Pharmaceutical Company Limited, JAPAN [Nationality: JAPAN]

Kachintorn, Udom, President, Mahidol University, THAILAND [Nationality: THAILAND]

Liu, Edison T., President and CEO, The Jackson Laboratory, U.S.A. [Nationality: U.S.A.]

Yang, Hongjun (Harry), Director, Head of Personalized Healthcare and Biomarkers, AstraZeneca, CHINA [Nationality: U.S.A.]

Opening Remarks

The Chair opened the session by speaking on the role of cells as tools, and how they will have a tremendous effect on medical treatments. He outlined the key questions of the session, which were how industry and regenerative medicine will change each other, the effects of regenerative medicine on diseases and patients, and regulatory science and cell-based regenerative medicine. He then introduced his work at Kyoto University in this area.

The first speaker spoke about an initiative on research at the University of Zurich. He said that it is often difficult to apply research in practice, and outlined ways that the University is working in this area, such as skin for burn victims. He also spoke on synergy possibilities for regenerative medicine, such as combining robotics and stem cell technologies for artificial hearts. In addition, he mentioned finding funding for such initiatives, including the financial support of entrepreneurs. He closed by asking the participants for their input on the areas he outlined in his remarks.

The next speaker discussed the opportunities that cells present, including iPS cells. Currently, organ donors are limited but the number of patients who need organs continues to climb. Regenerative medicine represents an excellent way to address this problem. He also highlighted the cost-saving benefits that regenerative medicine can realize. As an aspect of this, he mentioned combinations of drugs and the climbing costs that are associated with them. If we can harness the ability of the body to fight diseases such as cancer, this will improve patient outcomes and reduce costs. In addition, immunosuppression causes lifetime risks of problems like infections, and we should try to make it a thing of the past with regenerative medicine. He concluded by mentioning the great hope that iPS cells represent, as well as safety issues and availability of different functions.

The third speaker spoke on clinical applications for patients, in which regenerative medicine is a game changer that offers solutions and hope for people. There has been a great deal of research on patients who were previously thought to be incurable. Better treatment and biological tools will be created, which will reduce costs.

The third speaker then highlighted stem cells, which can replace damaged, malfunctioning, or diseased cells. Stem cells are a powerful therapeutic tool for many chronic diseases, including diabetes, heart failure and degenerative nervous diseases. There are still issues to be addressed to advance the field and benefit patients, and the speaker stated his wish that these issues would be discussed during the session.

The fourth speaker introduced The Jackson Laboratory and its work toward solutions for disease. He outlined three areas: cell replacement therapy, targeting endogenous cells, and enhanced regenerative potential. One challenge of cell replacement therapy is tissue rejection and therefore autologous therapy will be the key.

The fourth speaker also addressed targeting tissue niches with small molecules, such as what has been successful in the cancer field with the immune checkpoint inhibitors. For cancer therapy, T cells have been given to patients with marginal benefit, but the new checkpoint inhibitors mobilize endogenous T cells. Another example is with myostatin inhibitors which bypass the need for transplantation of muscle stem cells. He then outlined other new, innovative approaches in these areas, such as blocking scarring tissues. The speaker concluded by speaking about identifying the genes involved in regeneration using advanced genetic tools at The Jackson Laboratory. Genomic tools have allowed the identification of specific gene components that enhance regeneration.

The last speaker discussed personalized healthcare system first, which has been the focus of extensive efforts and new trends. Certain drugs are needed for certain patients, i.e., targeted therapy. Thus, companion diagnostic tools are needed to define patients.

The speaker then spoke about next generation sequencing, which provides a tool to draw big data from patients. Under the conditions of protecting privacy, genomic data provides extremely useful information on diseases, and enables study of what causes disease and medicines that can be used to tackle the diseases. He also said it is essential to reach the world to tackle this large task, and called for all universities and companies to work together to change patients' lives. He concluded by stressing that the overarching goal of this area is helping patients.

Discussion

The first topic was on the relationship between industry and regenerative medicine, and how they will change each other. The Chair spoke on his main field of Parkinson's disease and treatment possibilities. He emphasized the importance of interaction between cells and drugs.

The session's first speaker stated that the industry is very aware that technology can change this area. Industry must develop services to help hospitals and patients. It is hard to predict when changes will happen, but industry should be pro-active. For this reason, he stated that he was not surprised to see so many industry representatives in the room.

The second speaker raised the question of targets, stating that cell therapy has changed these targets. The new paradigm is the cell, disease, and host, and this represents a fundamental way of thinking about disease. Another speaker posed a question about cell-based therapeutics as a different paradigm and the entrance of pharmaceutical companies. The second speaker affirmed that his company is interested in entering cell-based therapeutics. He then spoke about regulatory science and stressed its importance for sharing benefits and finding issues.

A participant from the industry side also confirmed that his company is pursuing new technologies, and then moved onto potential threats, such as checkpoint inhibitors. To some extent, the fate of the pharmaceutical industry is that there will always be a new technology that makes previous technologies obsolete. He also spoke on cell-based therapies and the difficulties and costs associated with them. He stated that it is not uncommon for the industry to be active in service aspects.

A second participant spoke on the importance of microbes. His example involved mice, and he stated that even if mice have the same genetic set-up, they have different responses to drugs, which is due to microbes. A third participant highlighted the importance of skeptical persons in companies, noting the results of cell-based therapeutics in clinical trials. He asked about results that have been observed for Parkinson's disease. The Chair stated that the situation for Parkinson's disease has improved, but more technology and research is needed. A speaker noted that there has been progress in iPS cell transplantation.

A participant from Kazakhstan spoke on the creation of stem cell libraries. A speaker then said that regenerative cell therapy should not only be available for certain people, and mentioned the example of cell sheets and their availability to other countries.

The Chair then asked the speakers to discuss robotics. One speaker explained the process of regenerating an organ from a part of the organ by growing a new organ and then switching out the organ in the patient. He said that in the future, operations in such areas would be provided and generated by companies.

Following this, a speaker compared autologous cells and allogenic cells, as well as replacement therapy and assist therapy. A second speaker asked about the regulation status of diagnostics and therapeutic drugs in the United States, stating that there are only guidelines that do not specifically define therapeutic products and their connection

to diagnostics. He stated that this is a new challenge. A third speaker stated that in Japan, there is a new law on cell therapy products, and the regulatory authority says that all patients must be in a registry for qualification, which decides whether products can stay in the market or not. A participant said that this law shows that Japan is leading in this area simply through the law's existence.

A participant from the Food and Drug Administration (FDA) of the United States responded to the previous speaker's call for collaboration with regulatory science, noting the combination of robotics and technologies and how they will interact with the body. There are many unanswered questions and the participation of all sectors is required in this area.

A speaker then asked the participants for their thoughts on the spread of cell therapeutics, including xenotransplantation. The participant from the FDA responded that he specializes in devices, and spoke on interdisciplinary areas including cell therapeutics at the FDA.

Following this, another participant highlighted costs, and compared scientific discovery to the evolution of personal computers. He said that at the moment, people want numerous electronic devices at low prices, but in medicine people want personalized solutions that come at very high prices. A high percentage of GDP in many countries is spent on healthcare, and there are often plateaus for the amount that governments are willing to spend. He stressed that it is important to make sure that costs are low so that therapies can reach billions of people. A speaker stated that pharmaceutical companies want to move in this direction and address the issue of cost, and mentioned examples such as small molecules.

A speaker asked about ethical and economic consequences, saying that regenerative medicine is enhancing the situation in the developed world where people now advance to increasingly older ages. He mentioned injecting the blood of young rats into old rats. An additional speaker expanded on the rat experiment and its study of memory and biochemical markers of youth.

The speaker then returned to the question of replacement versus support, and compared treating terminal diseases and healthspan. He said Japan is focused on cell-based therapies, asking about changes to the experimental design. An additional speaker stated that randomized trials cannot be used to prove everything. However, the previous speaker spoke up to give the example of bypass therapy.

A speaker stated that Japanese regulators have the viewpoint that therapy and devices are combined, and mentioned innovative surgeons and registries and their role in regenerative medicine issues. He noted the immense progress in imaging technique and labeling cells. The Chair added that efficacy depends on indication, and spoke on imaging technique and Parkinson's disease. A speaker then stated that he wanted to encourage individuals to be more creative. He gave the example of lung cancer patients in randomized trials, saying that the basket trial concept required statistical modeling. He said Japan is a leader in cell-based and complex technologies, but that we should think carefully about how to construct therapies. A speaker mentioned trials with specific endpoints, as well as safety and efficacy. The Chair elaborated on cell-based therapies, saying that Japan has a new category called regenerative cell products.

Following this, a participant spoke on efficiency from the mathematical point of view. There are many parameters that are used to look at diseases, and efficiency can be defined as how fast the key parameters which define the disease are changing the timeline. After measuring efficiency, we can compare difficult treatments. The participant gave the example of oncology diseases and how people who live in the US and Africa have different parameters.

Two participants then spoke on approval for cell-based therapies, and concluded that it will probably take 10 years instead of five years for cell-based therapies to achieve regulatory approval. A speaker mentioned recent approvals in Japan, such as the provisional approval for advanced heart therapy. In response to a question about myoblasts in heart therapy, the speaker explained the trials, saying that myoblasts were isolated and transplanted through open heart therapy. There were seven patients and six out of seven had a significant improvement in symptoms.

A second speaker pointed out that the previous speaker had raised an important distinction, which was that therapeutics undergoing trials are what he terms negative, but that the problem with regenerative medicine is that one starts with individuals with deficits, which are more difficult to measure. It is almost impossible to do such a trial on children because they have different levels of deficit of their neurological disorder. His group identified the time of age when recovery could take place, which was used for small molecules to prove that their therapy worked, and the human clinical trial was restructured. For cell-based therapeutics for regenerative medicine, we must measure the status of the entry of the subjects or we will see no benefits.

The second speaker then said that the positive results of the seven patients of the previously-mentioned trial were exciting, but somehow over time as the therapies were tried, they never really worked out. He said it is important to measure function of what deficit really is in order to stratify patients. The first speaker said that this was the point of the conditional approval by the Japanese regulators. The open heart surgery results he previously mentioned will be reviewed in five years.

A speaker then commented on cell-based regenerative medicine, stating that regenerative medicine has to do with developing completely new ways to treat diseases that are currently beyond repair. Regenerative medicine could be developed as personalized medicine, tailored to work especially for each patient. However, the current stem cell technology is time consuming and expensive, so we must ask if we can afford such treatments, or how to find a balance. Many companies and clinics are addressing this challenge. He also noted that there are still many questions to consider, such as if regenerative medicine means that people will no longer need to worry about behavior that leads to the diseases that regenerative medicine treats.

The Chair then asked the participants how medical systems will change. A speaker pointed out the three components of patients, industry, and government, but emphasized the importance of the patients. He said that although we must consider issues such as cost, we must put the patients first. He suggested that laboratories should also consider patients to be of utmost importance.

The Chair closed the session by stating that there are still various issues associated with cell-based therapeutics but suggested that we will have more solutions by the same time next year. A speaker voiced his excitement about new technologies, but noted the issue of national processes that either facilitate or block progress. He lauded the Japanese government for its dedication to advancing progress, and called for other governments to do the same.

Concurrent Session 102-C1: Industrial Innovation

Session Chair

Cantor, Brian, Vice-Chancellor, University of Bradford, U.K. [Nationality: U.K.]

Speakers

Amano, Hiroshi, Professor, Department of Electrical Engineering and Computer Science, Graduate School of Engineering; Director, Akasaki Research Center, Nagoya University, JAPAN [Nobel Laureate 2014] [Nationality: JAPAN]

Fleming, Graham, Chief Scientist and Chancellor's Principal for International Research Collaborations; Melvin Calvin Distinguished Professor, University of California Berkeley, U.S.A. [Nationality: U.S.A.]

Higashi, Tetsuro, President & CEO, Tokyo Electron Limited, JAPAN [Nationality: JAPAN]

Kinaret, Jari, Head of the Condensed Matter Theory Division, Department of Applied Physics, Chalmers University of Technology, SWEDEN [Nationality: SWEDEN]

McQuade, J. Michael, Senior Vice President, Science & Technology, United Technologies Corporation (UTC), U.S.A. [Nationality: U.S.A.]

Opening Remarks

The Chair opened 102-C1 Industrial Innovation by introducing himself and the speakers before introducing the discussion points for the sessions, which were:

1. What should national policy be to encourage industrial innovation?
2. What are new schemes to help startups cross the valley of death?
3. How can the relationship between large businesses and academia be re-invented?
4 What are the pros and cons of in-house R&D vs external innovation?

The Chair stated that pure and applied research had become increasingly important in recent years, due to the need to combat the growing variety of issues faced by the world. He added that universities were paramount both as institutions and in their training of young minds to helping understand these issues and overcoming them, and that the triple helix,

a tripartite collaboration between government, business and academia was essential for fostering innovation and a growing knowledge economy.

The first speaker opened his presentation by explaining that he would be addressing the importance of government, academia, and industry partnership, using his experience working in light emitting LEDs as an example. He explained that one of his mentors at Nagoya University had originally worked in industry, before moving to academia in order to continue his work on developing commercially viable light-emitting diodes. He explained that after numerous attempts, the university team was able to eventually overcome the issues which had originally prevented the commercialization of LEDs. He also emphasized the important role played by government officials who understood the importance of the fundamental achievements in research, and who helped promote collaboration between the two sectors. In conclusion, he once again re-emphasized the importance of industry/academia/government partnership to create major technologies.

The second speaker opened his presentation by explaining that he would broadly set his presentation around the topic of an ideal ecosystem for academia/industry/government collaboration. He began by asking aloud how innovation could be preserved, how inventors or companies could get over the valley of death, and how it could be ensured that the connections to innovation remain. He pointed out that these questions had been asked by innovators and creators for many years. Regarding academia, he emphasized the importance of looking at both the academic value of the research, while not forgetting the importance of basic research. Moving on, he stated his belief that governments should help define and maintain long-term views, and help enable tax policies around the world that value and do not severely inhibit research. In conclusion, he stated that the fundamental role of governments was to ensure that there were ample and effective communication networks between academia/government/industry collaborators.

The third speaker opened his presentation by explaining the background of the graphene flagship project in Europe. He explained that the goal of the flagship was to create disruptive technology changes. Speaking on the importance of fundamental research, he also pointed out that it was important to recognize the major hurdle of bringing technologies and findings from the lab to industry. He also noted that benefits would need to be beneficial across an academia/industry/government relationship, and that value chains would be an important factor in creating such connections. He concluded his presentation by stating that a multi-lateral cooperation between different industries would be required to pass over the valley of death and create lasting and effective products, services, and technologies.

The fourth speaker opened his presentation by giving a brief introduction of his company and its services/products. He stated that his company had created an R&D scheme to ensure that they stayed at the forefront of their industry. As part of this R&D scheme, he explained that they had a venture capital arm that looked for promising opportunities, businesses, and technologies that could contribute to the business. He added that the scheme also boasted an extensive R&D network with professors and universities around the world. In conclusion, he stated that as a result of their open collaborative approach to their business, the company had saved many resources on development and research, leading to lower risk and increased profits.

The fifth speaker opened his presentation by explaining that he would speak about the relationship between large companies and universities in terms of long-term strategic goals involving multiple partners on both sides. He explained that such relationships could result in a broader range of benefits for both sides, as opposed to those relationships based on short-term goals or outlooks. He acknowledged that some of the challenges would include getting high level representatives from both sides to buy into the projects, and creating a system with dedicated leadership, which was capable of evolving and communicating effectively. Moving on, he emphasized that there were many areas lacking traditional market drivers that could benefit from innovation with a combination of philanthropic support and university and industry research. Finally, before concluding his presentation, he briefly introduced the Berkeley in-house accelerator, which had been created in order to further support the innovative businesses and ideas generated by their students and alumni.

Discussion

A representative from the first group stated that they discussed the need for stable policies across administrations; the role of governments in bridging the gap between raw

technologies and industry; maximizing collaborations and minimizing frictions in collaborative work between industry, academia, and government; obstacles related to risk and conflicting time tables; the importance of risk sharing schemes; and structure agreements and relations to help build trust between academia and industry.

A representative from the second group stated that they discussed fundamental research; the importance of sharing goals and supporting fundamental research for industry/academia relationships; the transitions in university/industry relationships away from linear technology transfer models towards longer term and multi-sided relationships; the shift in focus from income to impact from universities' points of view; focusing on collaborations in terms of outcomes rather than outputs, in terms of broader societal outputs instead of individual outputs; the critical need for human resources, and the question of how you access the best and brightest talent in order to develop human resources for broader innovation and ecosystems.

A representative from the third group stated that they discussed the need for long-term partnerships between industry and academia; the differences in experiences between countries in terms of industry/academia relationships; and the long-term benefits that industry/academia relationships can result in, in terms of products, services, and producing better and more skilled human resources.

A representative from the fourth group stated that they discussed the role of matching fund requirements by government grant programs, and encouraging universities to find people interested in the commercial sector to help leverage funds in particular areas; acceleration programs and the difficulty of finding the right people to choose who should be put in acceleration programs; and evaluating the ROI by university support and via feasibility, research, and productization.

A representative from the fifth group stated that they had discussed partnerships; how to bring out innovation from large organizations and maximize IP output; various university technology licensing issues; support for innovation and connecting university and industry innovation with one another; the need for more consistent international IP recognition; increasing length of access to IP rights by making sure they are granted earlier; and the fact that shorter IP lifetimes would lead to faster innovation.

Concurrent Session 102-D1: Ocean

Session Chair

Henocque, Yves, Senior Adviser, Maritime Policy and Integrated Coastal and Ocean Management, French Research Institute for Exploitation of the Sea (IFREMER), FRANCE [Nationality: FRANCE]

Speakers

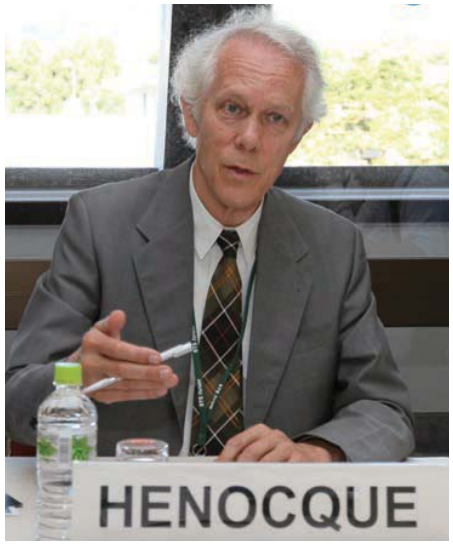
Delaney, John R., Principal Investigator and Director, Regional Scale Nodes Program, Professor of Oceanography; Jerome M. Paros Endowed Chair in Sensor Networks, University of Washington, U.S.A. [Nationality: U.S.A.]

Higuchi, Kiyoshi, Technical Counselor, Japan Aerospace Exploration Agency (JAXA); President, International Astronautical Federation, JAPAN [Nationality: JAPAN]

Miloslavich, Patricia, Project Officer - Biology and Ecosystem Panel GOOS, Australian Institute of Marine Science – Australia, Universidad Simon Bolivar – Venezuela, AUSTRALIA [Nationality: VENEZUELA]

Rahul, Sharma, Chief Scientist and Project Leader, Geological Oceanography Division, CSIR—National Institute of Oceanography, INDIA [Nationality: INDIA]

Shirayama, Yoshihisa, Executive Director of Research, Japan Agency for Marine-Earth Science and Technology (JAMSTEC), JAPAN [Nationality: JAPAN]



Opening Remarks

The chair began the session by setting out the goal of discussing the deep sea and the ocean ecosystem. Among the Sustainable Development Goals of the UN General Assembly, number 14 concerns the ocean. One indicator of the progress toward these goals would be the systemic management and protection of marine ecosystems. The focus of the participants as marine scientists should be on putting efforts such as Ocean Day, which will be a part of the upcoming COP-21, on the agenda in order to remind policy makers of the ocean's significance and how much of it remains to be explored.

The first speaker introduced his thoughts on the relationship between science and technology in marine science in particular. His personal study focuses on nematodes, a topic largely ignored beyond his field. These microscopic worms make up a huge worldwide

biomass, but are invisible to the human eye. However, they, and other unseen bacteria, form the basis of the ocean ecosystem.

Such biodiversity is not easily seen, but is very complicated. Science needs to create a holistic system for understanding these ecosystems. There are several ways in which they can be examined. For example, genetic analysis of seawater or sediment can provide a short-term understanding of the current state of ocean biodiversity. We can develop, based on that understanding, a way to sustainably and effectively utilize ocean ecosystems.

Our current global ecosystem cannot sustain 8 billion people, a growth we will soon face. Technological advancement is necessary in order to fully utilize all the resources the ocean offers us.

The second speaker made reference to his several decades spent exploring the ocean. Why, he asked, do we explore? There is increasing demand for the land-mining of minerals, but existing sources are becoming overdrawn. We must now turn to the deep sea for the mining of resources, and we need technological advancements, as well as a consideration of their potential harms and challenges, in order to access these resources.

A great supply of resources exists in the deep ocean, able to provide millions of tons of vital metals, which are fast depleting and are used in many alloys, including those used in electronics. But these metals lie beyond the exclusive economic zone, meaning that no country can be held responsible for the pollution and other environmental consequences that may arise from mining them. Nevertheless, these sources will inevitably have to be tapped in the future.

He explained that several deep-sea minerals such as polymetallic nodules, hydrothermal sulfides and ferromanganese crusts are considered to be alternative sources of strategic metals such as Cu, Ni, Co, Pb, Zn, and Cd, and of fast depleting land-based minerals, and added that several entities are claiming vast tracts of seafloor under the UN Law of the Sea for the exclusive rights for exploration and future mining. There are now as many as 22 parties who have been allocated deep-sea locations for potential mining. Since many of these deposits lie in international waters beyond national jurisdiction, the International Seabed Authority (ISA) has formulated a mining code that includes environmental guidelines. Several technological challenges exist in establishing deep-sea mining, among them the creation of an eco-friendly mining method, on-site power generation and processing,

and real-time monitoring of environmental impact. However, this does not necessarily mean that we should not utilize these resources, but that it should be done in a judicious way. In specific cases, certain private companies with deep-sea mining technology are also approaching less developed countries (who do not have the necessary know-how) requesting them to 'sponsor' their application to ISA. Hence the necessary policies need to be laid down for ensuring proper compliance to regulations and liability in case of a lapse or mishap.

The third speaker stated that, as the ocean is now more than ever becoming the life-support system of the earth, we must recognize how much we rely upon it. But this reliance is extremely complex and challenging to understand. Ships, satellites, underwater vehicles, etc. have all been used to study the ocean. But few have been advanced enough to provide scientists with real-time information.

Japan, Canada, the United States of America, and several other countries have been deploying fiber-optic networks in the ocean, making possible global and real-time access to the data collected by their monitoring devices. These monitoring devices can be redeployed to observe natural events, such as storms and volcanic eruptions, or to record data such as fish stock measurements and whale migrations.

Technology has granted oceanography new eyes, endowing science with new abilities and new views on the world that can be utilized to humanity's benefit.

The fourth speaker spoke about her work at GOOS (the Global Ocean Observing System). GOOS is organized in three panels: physics and climate; biology, chemistry, and carbon; and biology and ecosystems. GOOS is now seeking to determine what biological factors regarding the ocean should be observed long-term and on a global scale. Efforts are being made to discern from international conventions the specific societal needs for ocean observation, and how the necessary observation can be employed. New initiatives are also being linked with existing initiatives already in progress.

The ocean is huge, and needs to be explored further. What must happen, especially in light of the ocean resource exploitation that will soon occur globally, is that there must be an international agreement on the specific variables to be measured via ocean monitoring, and the development of technologies that will make this monitoring more efficient.

The fifth speaker asked the participants what they supposed the link would be between his work in space and the other speakers' work in the ocean. He wanted to point out why a link between the two is now more attractive than ever. Both the ocean and space form a type of final frontier, and we as a society need science and technology in order to address them.

The most important question, for him, was the origin of life: did it arise from the ocean, or from space? To completely understand life on earth, for example in terms of climate change, we must also understand space and the ocean. The ocean is a decisive factor in the status of the earth's environment, and satellite data from space, including global modelling, allows us to study the ocean. But without on-the-ground examination, data collected via observations from space cannot be implemented.

In addition, understanding the origins of life in the ocean may help us understand the possibility of life on other planets. And, like the ocean, space may be our next step in resource acquisition. Integrated knowledge and technology will be vital in both of these endeavors.

Discussion

After dividing for discussion, representatives from among the participants reported on the topics covered by each group.

The first representative reported that his group had discussed several important topics, including the need to maximize the use of new technologies in order to examine changes in climate, population, etc. Addressing data and information, the necessity of providing real-time information to consumers in particular had been stressed. Data must also contribute constructively to the management of the ocean. Additional discussion had taken place on providing fora for bringing together scientists and the public, a particular role of GOOS. Marine scientists must also have access to multiple levels of skills and society, including policy-makers, in order to make the real, urgent needs of the global community known. Dramatic change is taking place in ocean ecosystems, and inadequate monitoring and control of human activities in the ocean is exacerbating this. For example, fishing and deep-sea mining use may in the future greatly affect not just the ocean, but also each other. International collaboration will play an important role in mitigating this.

The next representative reported that his group had had a highly polarized discussion about the future of deep-sea mining. While it was recognized that there is a realistic need for further resource access, the matter of how this could be appropriately managed internationally remained an issue. The biological effects of deep-sea mining had also been discussed, as well as the question of to what extent we can realistically understand its potential environmental impact.

The representative from the third group reflected on four main topics; the lack of knowledge about the deeper ocean; the need to act on issues affecting the ocean now, even without understanding it fully; the need to develop knowledge into new dimensions; and, lastly, the need to discuss these issues with the public in an easily understandable manner.
A question arose as to whether any entrepreneurial opportunities might exist in deep-sea exploration, in response to which the examples of the possible pharmaceutical use of chemicals found in deep-sea organisms and the photosynthetic capabilities of other ocean organisms that might be applicable for use in fuels were provided.

Another representative stated that his group's discussion had stressed the importance of ocean monitoring, as well as of adjusting the targets of that monitoring in order to address public needs. Excellent technology for this exists, as had been discussed earlier in the session, but the next step will be the cultivation of the ability to integrate and use this new data. In light of upcoming deep-sea resource exploitation, great concern was expressed over the safety of these new technologies and the ability and cost of technology to manage potential resulting pollution was questioned. Pollution caused by single parties in these

cases could quickly become a global issue. On a positive note, the increased installment of technology for mining on the ocean floor also means increased opportunities for the installation of deep-sea monitoring equipment.

Lastly, the final representative discussed the matter of oceanic governance and its extremely fragmented nature. How can this governance be changed, and what kind of governance does the ocean need? Education will be vital, particularly in terms of bringing this knowledge to students and the public. New technology, such as the fiber-optic network, could play an active role in this and help build a global understanding of issues affecting the ocean. The final point raised was how oceanography, a field still unfinished in its development and not widely understood, can still be fully discussed. The creation of a single reporting system for oceanic data was suggested. In speeding up this process, much will depend on collaboration between scientific entities. Networks are being formed, and are being utilized on both a global and a local level.

A final statement was made by the third speaker, suggesting that new figures in oceanography should be encouraged to think broadly and long-term in order to fully comprehend the massive scale of the ocean as a field of study. The chair thanked the speaker for his statement, and added that, just as the ocean is boundless, so scientific cooperation and responsibility should be similarly international.

Concurrent Session 102-E1: S&T Diplomacy and International Collaboration

Session Chair

Durongkaveroj, Pichet, Minister of Science and Technology of Thailand, THAILAND [Nationality: THAILAND]

Speakers

Katsura, Makoto, Ambassador for Science and Technology Cooperation, Ministry of Foreign Affairs, JAPAN [Nationality: JAPAN]

Lerman, Zafra Margolin, President, Malta Conferences Foundation, U.S.A. [Nationality: ISRAEL]

Littlewood, Peter B., Director (President, Uchicago Argonne, LLC), Argonne National Laboratory, U.S.A. [Nationality: U.K.]

Schlegel, Flavia, Assistant Director General for Natural Sciences, (UNESCO) United Nations Educational, Scientific and Cultural Organization, FRANCE [Nationality: SWITZERLAND]

Turekian, Vaughan C., Science and Technology Adviser to the Secretary of State, U.S. Department of State, U.S.A. [Nationality: U.S.A.]

Remarks

The Chair began by introducing himself as the chair of the session, and also introduced each invited speaker. During the last three meetings of STS *forum*, he said, a number of useful ideas were discussed on the subject of Scientific and Technological Diplomacy and International Collaboration. For example, there has been discussion on diplomacy and international cooperation as a way to tackle regional or global challenges, such as Ebola and global warming, or as a way to handle the large-scale projects that demand a large amount of financial resources, such as the European Organization for Nuclear Research (CERN) and Synchrotron-Light For Experimental Science And Applications In The Middle East (SESAME). In addition, cooperation in science and technology is a way to deepen diplomatic relations among countries, with an emphasis on North-South collaboration.

The Chair then introduced some institutions that facilitate such collaboration. In 2008, the American Association for the Advancement of Science (AAAS) established its center for science and diplomacy, and allowed for scientific communities to examine how their research can benefit society. The UK-based Royal Society developed similar programs, with a focus on strengthening ties between scientific communities and policy makers.

Science diplomacy is another key factor, with large-scale multi-national initiatives such as CERN and SESAME not only leading to ground-breaking scientific research, but also to increased linkages and exchanges between scientists from all over the world. Science for the welfare of developing countries is also something that should not be overlooked.

He closed his introductory remarks by expressing his hopes for a frank and fruitful discussion.

The first speaker began by describing science diplomacy as a type of diplomacy which can succeed where other kinds of diplomacy fail. She described the Malta Conferences Foundation, which gathers scientists from fifteen countries in the Middle East – including Bahrain, Egypt, Jordan, the Palestinian National Authority, Iraq, Iran, and others. This conference offers a multinational forum where scientists safely and freely identify unique opportunities for cooperation to meet scientific and technological challenges of the region. Many scientists from these countries would not otherwise have opportunities to meet face-to-face, because diplomatic relations are challenging.

These scientists work together on issues that affect all countries in the Middle East, such as solar energy, science and technology education at all levels, and water and air quality. She expressed the fact that if only one country in the Middle East cannot and will not endeavor to improve its air quality, then this will have an adverse effect on all neighboring countries in the region. Water is another extremely important issue in the Middle East that she mentioned. Many of the countries do not have enough water for their population, and Gaza does not have any clean drinking water. Only collaboration between the countries in the region will guarantee clean drinking water for everybody. Through this program, scientists work together to overcome the chasms of distrust and intolerance and develop friendship in addition to cooperation and collaborations surrounding these issues.

The conference has become a powerful force for peace on the world stage, she said, and the next meeting, to be held in Morocco in November 2015, will be the seventh. She ended by again stressing the importance of deep and far-reaching science diplomacy, both

regionally and throughout the world in order to establish peaceful links across otherwise hostile borders.

The next speaker expressed an interest in the intersection between science, technology and foreign policy. He suggested that participants think of the past as prologue – in the past, even in times of great political tension, such as the Cold War, there has been considerable scientific collaboration and exchange transcending those borders.

The connections that institutions provide are critical in allowing for these collaborations, he continued. Governments are sharing a growing recognition that collaboration is essential in tackling the issues and challenges which face modern society. He mentioned that the U.S. State Department is investing considerable resources in nationalizing scientific and technological research. According to him, in May, a high-level meeting convened by the Ministry of Foreign Affairs, attended by many representatives from all over the world, resulted in the establishment and appointment of a Science and Technology Adviser to the Ministry of Foreign Affairs. These are just two examples of foreign ministries beginning to emphasize science and science diplomacy.

This trend also points to an evolution in foreign affairs, away from scientific competition and towards collaboration. Science diplomacy must consider how to adapt to the changing challenges that the world faces, and the evolving needs of society.

The next speaker started by reminding the participants that the most important science diplomacy institutions of the 20th century– CERN, SESAME or Malta Foundation – where all initiated by UNESCO. For the 21st Century, science diplomacy continues to play an essential role, especially in the context of recently adopted Agenda 2030. To move from relevance to impact, we should be active in the following domains: outreach, action and monitoring.

She underlined the importance of raising awareness about science diplomacy in the minds of the decision-makers. It is necessary to create venues and opportunities for scientific collaboration, where individuals from all over the world can gather together without consideration of their political affiliation. Investment is also important to ensure that outreach is effective and far-reaching, both on the level of collaboration as well as with respect to capacity building. It is important to “enlarge the family,” she said.

In order to convince decision-makers to politically and financially support science diplomacy, she suggested to share with them success stories and propose new concrete projects. Good communication skills between scientific leaders and decision-makers is therefore crucial, but not always easy because of their very different approaches. She then outlined various initiatives and networks which improve communication and strategy planning between scientists.

Finally, she stated that monitoring is important. Observing the progress and challenges of large-scale worldwide initiatives could yield data and other information which can be used to create a set of standards to apply to future projects.

The next speaker began by outlining his responsibilities for bilateral scientific cooperation. Japan has S&T Agreements with 46 countries and the EU, under which Joint Committees between the two governments provide unique opportunities to collaborate and identify areas of future cooperation.

He then shared some of Japan’s approaches on science diplomacy, which recognizes science and technology as indispensable in finding solutions to global issues such as environment, energy, disaster prevention and infectious disease.

The combination of ODA and science diplomacy began with a program called Science and Technology Research Partnership for Sustainable Development (SATREPS). Through this scheme, for example, Japanese researchers are collaborating to provide support in both

scientific development and policy making for rainfall monitoring systems in Thailand, and to improve the breed of rice in Kenya and Viet Nam.

Then, he introduced a program in which the Japan International Cooperation Agency (JICA) supports the introduction of products and know-how by Japanese private companies to address socio-economic challenges of developing countries, including medical issues in Central and South America.

The final speaker began by introducing his work at Argonne National Laboratory in the United States, which has many resources that can be used by researchers from all over the world. He said it is an example of a large, modern laboratory facility which contributes to building scientific communities as well as facilitating cutting-edge research.

The relationship between scientists and states is complex, he reminded the participants. The reason that a state supports scientists is often that science can be used for economic and infrastructure expansion, as well as the development of defense and military capabilities.

However, he also introduced some examples of scientific collaboration that reached across borders. The U.K. Royal Society was founded in the 16th century after the reinstatement of the monarchy after the Civil War. The Royal Society was established as a way for the monarchy to consolidate the scientists and technologists in the country in one venue, thereby ensuring the appropriateness of projects, and observing their progress and results. A number of members of the Royal Society at this time were from Holland, and Holland was at war with the UK. Another example of this would be the Manhattan Project, which welcomed scientists from all over the world at a politically sensitive time.

To work globally, he concluded, it is important to work transparently, without emphasizing nationality, which can lead to greater collaboration on a larger scale.

The Chair then opened the floor to discussion.

Discussion

After forty minutes of lively discussion, the Chair reconvened the session, and invited each group to share a summary of their discussion.

The first group discussed the Malta Conference, and other conferences which gather young people from geographically and politically diverse locations. One participant added that it has been found that problems are effectively addressed through the creativity and ingenuity of young people.

The next group, with a presenter from Lesotho, discussed the need of involving Africa in science diplomacy, to ensure that the developments can benefit countries in Africa, as well as those in other countries and regions of the world.

The next group shared their discussion on sharing lessons learned from science and technology development, and how to find a win-win situation in using science diplomacy to build bridges between countries with different interests. They also discussed how to use science and diplomacy in developing countries or smaller countries with fewer resources.

The next group pointed out that research is initiated in countries by strong individuals or organizations, and identifying the true topics of interest is of key importance. Also, they considered the question of what kind of scientist profile would be the most beneficial to world society. For example, there was debate about whether an engineer-scientist would be the best, or a scientist with a foundation in medicine.

The next group discussed the meaning and dimensions of scientific diplomacy, specifically the gaps where people could work together more effectively. One issue was a discussion of the roles the private sector should play, and how to balance the ramifications of research and the tenor of policy discussion to be able to manage public perception and limit the potentially negative involvement of lobbyists.

The final group discussed some major global undertakings which have been successful, including the International Space Station and others, and the lessons that could be learned from them. They discussed the possibility of taking a more holistic approach to collaboration.

The Chair drew the session to a close.

Concurrent Session 102-F1: Science and Engineering Education

Session Chair

Gutfreund, Hanoch, Executive Committee Chairperson, Israel Science Foundation; Former President, The Hebrew University of Jerusalem, ISRAEL [Nationality: ISRAEL]

Speakers

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

Dannetun, Helen, Vice-Chancellor, Linköping University (LiU), SWEDEN [Nationality: SWEDEN]

Hashimoto, Shuji, Vice President, Waseda University, JAPAN [Nationlity: JAPAN]

Marcus, Roy, Chairperson of the Council, MEC, University of Johannesburg, SOUTH AFRICA [Nationality: SOUTH AFRICA]

Yamagiwa, Juichi, President, Kyoto University, JAPAN [Nationality: JAPAN]

Opening Remarks

The chair opened the session by emphasizing that science and technology are at the core of STS *forum* and are at the core of the many challenges we face today. However, science and technology also provide solutions to these challenges. The timespan between scientific progress and its application is getting shorter and shorter and the rate of change is increasing more rapidly. For example, not too long ago, the focus was on hybrid cars, but now self-driving cars are the object of attention. Such rapid changes must have an effect on how we train young people to be able to cope with such developments. They should be able to adapt and readapt to such changes. Also, science needs to cooperate with social sciences and the humanities to understand and affect how society accepts and adapts to these changes. The main challenge of present day education is to train young people. Thus, teaching and training young people in an interdisciplinary way is of paramount importance. Furthermore, they need to be taught how to apply the facts they

learn in a beneficial way to society. The chair then gave the floor to the speakers and asked them to give their opening remarks.

The first speaker pointed out that ICT usage is important and needs to be emphasized so that the next generation can overcome future challenges. Many future challenges will cover many disciplines, so multidisciplinary knowledge and skills will be necessary. MOOCs will also play a role in this regard as they bring about more global interconnectedness. Many people from diverse backgrounds can interconnect via the internet and share their thoughts and ideas. It is difficult for teachers to evaluate individual students in large classes, therefore peer review between students is important in MOOCs. An exchange of ideas and thoughts will happen within this cyber education and create many positive effects. In addition, the sharing of educational contents will be another positive effect to make a curriculum tuned for individual learners. This can change the methodology of science because students will learn to think with a global mindset when they address global challenges.

The second speaker first said that from the point of view of many universities, engineering makes a massive contribution to the quality of life and is the only true wealth creation profession. However, he expressed concern that engineering education has not kept pace with the escalating rate of change in science and technology. The questions that needs to be considered are the large scale global failures, such as Volkswagen's recent recall of millions of cars, and the concerns about the relevance of current engineer development programs. Universities have failed to address current problems because they are reactive and not proactive. Universities have often been blamed for not teaching students proper skills and for producing students who require at least three years of postgraduate training before they become 'useful' employees. However, the fault lies more with those dictating the rules of the profession in terms of regulation and accreditation. We therefore have to look at how we can reorder engineering programs at universities to address these new challenges. This can be accomplished through Project Based Learning allowing students to have more first-hand experiences instead of having them just attend lectures. Many medical departments have done this recently and it is a good model to follow because such experiences offer students real life experiences and access to professionals.

The third speaker opened her remarks by stating that at her university, problem-based learning happens. Due to this, the engineer students that go on to professional work after graduation are often well received by the business community. The speaker then stressed the importance of engineers and asked how we can better encourage young people to

consider engineering careers. Results from surveys that ask if young people are interested in engineering have often yielded very poor results and unfortunately, this was especially true for women in the Nordic countries and Japan. The basics of engineering in all fields are the foundations that are needed in educational programs. These foundations, combined with today's technological tools, are what society needs to makes good engineers. In addition, developing good social skills in engineers is another essential aspect that needs to be addressed. This can be accomplished by further cooperation with the humanities and social sciences.

The fourth speaker spoke on the relation between knowledge and the engineering profession. For a long time, subjects such as quantum physics were viewed as too abstract to be taught in combination with the skills needed to become an engineer. Now a number of economic sectors rely on these types of physics. Therefore, a new approach to the appropriate basics is needed, and we should not be shy about teaching more abstract subjects to future engineers. Not categorizing the knowledge is key. Just to give another example: the enhanced relevance of mathematics in a number of economic sectors makes mathematicians more valued and in demand in many businesses as companies develop higher profiles in their targets of hiring mathematicians. Big data, statistics, and ICT are directly relevant in many areas of engineering in new ways and lead to new business models and areas. It is also important that students be exposed early enough to real life activities (internships in companies, labs) beyond what they study in their majors. This is currently being emphasized with great success in some leading universities.

The fifth speaker spoke about his educational experiences at Kyoto University. Kyoto University has long protected the tradition of frank and open dialogue. This has fostered creativity and new ideas. In addition to this freedom, multidisciplinary approaches are vital to generating innovative ideas. The speaker raised the Academic Alpine Club at Kyoto University as an example of a club that realized the values of freedom and multidisciplinary approaches. It was a club that brought together professors and students together from a variety of fields and studies. Furthermore, students were encouraged to research things outside their field and to collect data by following their intuition and curiosity. He then stated that field work requires more intercultural communication than ever before. When conducting field work abroad, Kyoto University students and native collaborators cooperate in collecting data. In turn, Kyoto University invites these collaborators to conduct research in Kyoto. Improving field work by adopting this global approach will bring about a new understanding of humanity in the future.

Discussion

One participant stated that the methodology of science and technology is changing. The ways young people use phones and computers are examples of this. Due to this, we have to keep up with this rate of change in our teaching methods. The methods of teaching at his university have begun to adapt to this change. Teamwork and interdisciplinary focuses are being augmented. The participant also emphasized the importance of reaching out to young children in primary schools.

The next participant stated that the way we teach science and math is an important thing to emphasize. We need to move away from fact-based learning and move towards hands-on learning. By doing so, students will develop critical thinking skills.

One participant raised a question about the skills of teachers and professors and asked how they can improve their craft. Another participant answered that further dialogue is needed to address this. They also stated that in the Swedish system, a professor's merit is not measured by the number of papers they publish, but importance is also placed on demonstrating pedagogical skills as well.

Another participant asked how the ratings system should be addressed as the current system doesn't cope with it very well. Another participant answered that professors need to show the progress in teaching ability. Methods such as student evaluations can be used to accomplish this.

The following participant spoke on university institutions. Many people are convinced that current university systems are stable, but looking at the rate of change in the systems of private institutions, that is unlikely.

The next participant called upon the other participants to challenge how we currently do business. The participant stated that we should focus on improving students' interactions with each other. It was brought up that this interdisciplinary method does currently exist to some extent. One participant teaches a lab class that uses this interdisciplinary method. However, it was then brought up that faculty members often use their sabbaticals to interact with similar people and do not learn new things. New textbooks and new training for the teachers are also necessary.

Another participant asked how we can better attract students to science. Old methods that used to work are no longer applicable in modern society. One solution is an expanding system of education off-site from universities.

It was also brought up that the language we use to speak to students is a powerful way to approach them. They way academics speak to each other is not appropriate for addressing students and attracting them to science and technology. Most young current students do not report good experiences with science and technology in the classroom and we need to address these problems at a younger age.

One participant stated that there are few western societies that give enough importance to primary schools. Looking at the evolution of universities throughout history, it has been shown that they can survive, but we do not give enough attention to primary education.

Soft skills were also brought up as important. The gap between social science and science is too great. By decreasing this gap, engineering skills will be improved.

It was also brought up that English and the ability to communicate should be a fundamental skill for future scientists to develop.

One participant mentioned that we are currently working graduate students too hard and that we need to encourage students to take more leisure time. A balanced life is what makes a great scientist.

One participant stated that it is often said that due to MOOCs, universities are becoming more irrelevant. If we continue to teach the way we have in the past, this will become true. Improving just the technology in the classroom is not the solution. Teaching critical thinking and combining social sciences are what will save universities. However, another participant mentioned that the quality of MOOCs is not always good.

The chair then invited the speakers to make some closing remarks.

The first speaker spoke on the importance of the internet in the modern age and how we need to teach students to use it.

The second speaker stated that students often confuse scientific and biased knowledge on the internet. He stated that students need to be taught how avoid manipulative data on the internet.

The third speaker concluded that we need engineers who can collaborate with others and who are creative. Also, science needs to be taught earlier at primary schools.

The fourth speaker stated that the comments today displayed a reactive, rather than a proactive attitude from many universities.

The fifth speaker compared people who listen to CDs but go to live concerts to MOOCs and universities and concluded that here is always a need for real life learning.

Concurrent Session 102-G1:
Smart Cities – Urban Design & Development

Session Chair

Rübig, Paul, Chairman, Science and Technology Options Assessment (STOA); Member, European Parliament, BELGIUM [Nationality: AUSTRIA]

Speakers

Ahrend, Christine, Vice President, presidency, Berlin University of Technology (TU Berlin), GERMANY [Nationality: GERMANY]

Belmans, Ronnie, Professor, Department of Electrical Engineering, Energy Institute, Katholieke Universiteit Leuven; Executive Director, Global Smart Grid Federation, BELGIUM [Nationality: BELGIUM]

Khiatani, Manohar, Deputy Group CEO, Ascendas-Singbridge Pte Ltd; President & Group CEO, Ascendas Pte Ltd, SINGAPORE [Nationality: SINGAPORE]

Onishi, Takashi, President, Science Council of Japan (SCJ), JAPAN [Nationality: JAPAN]

Takeuchi, Kazuhiko, Senior Vice-Rector, Rector's office, United Nations University (UNU); Assistant Secretary-General of UN, JAPAN [Nationality: JAPAN]

Tyler, Nick, Pro-Vice Provost, University College London (UCL), U.K. [Nationality: U.K.]

Opening Remarks

The chair welcomed everyone to the Concurrent Session on Smart Cities – Urban Design & Development – and touched upon the various scientific definitions of smart cities, particularly by the European Commission – "Cities whose knowledge, economy, and governance is being progressively driven by innovation, creativity, and entrepreneurship, and in which regional technologies can be used to efficiently and effectively run cities and services provided by them." He then commented on how smart cities reduce costs and resource consumption, enhance the quality and performance of services, as well as further engaging with citizens; emphasized the implementation of security; and led the introductions of each of the speakers.

The first speaker introduced two approaches to smart cities; one, the rational development of urban cities to help infrastructure run smoothly and effectively; and two, the use of ICT which would contribute significantly to a system. He provided an example in the energy sector, where Japan introduced dynamic pricing, low carbon models, and smart infrastructure systems. He then spoke of ISOs which will be used to clarify what a smart city is and emphasize ways to evaluate them, and to evaluate both the supply and demand sides when developing systems.

The second speaker stated that cities were more like people, and that cities fail because they have failed the people. If a city suits the people and gives them benefit, the city will succeed. To be smart, a city must be smart about understanding its people. Looking at successful cities, the key seems to be to have a high level overarching long-term vision. The ownership of a vision is at the moment left to politicians. However, this is weak in terms of its development because once a political party changes, the vision will also change. We need to create visions with a better - and more scientific - method than this. He then stated his views on what a smart city should achieve, which included being a courteous city where mutual respect between people was prioritized. The city would have activities that are inclusive, and a public space that feels like it belongs to the people, where it is aesthetically attractive and accessible. The city also delivers positive health outcomes; and is a city that can evolve with its people. He then commented on understanding how people interact with the environment, and on a smart city's design and operation.

The third speaker commented on smart eco-cities, mainly focused on sustainable urban development. He stated that the UN MDGs were focused on eradicating poverty and sustainability concerns in developing countries. However, global goals were also developed for both developing and developed countries. He then highlighted how smart cities would impact the environment, create energy efficiency, mitigate climate change, and build resilience to disaster. The third speaker then noted how smart cities would also benefit aging societies, which is increasingly becoming a concern.

The fourth speaker emphasized that renewable energy needs space and thus careful planning and increased efficiency was needed. He then brought up topics on whether energy generation or demand would drive the other, to what effect data management and the Internet of Things (IoT) would be vital to the system, how the views between the utility and the consumer would have to change, and how storage would also play a vital role.

The fifth speaker emphasized that urbanization was a global megatrend of our time and cities that thrive will be those which adopt appropriate technology and a holistic approach towards development. He elaborated that people moved to cities in order to have a higher quality of life, and a key factor in achieving that was to have good quality jobs. Hence, a smart city is one that combines smart physical infrastructure with smart social and economic policies to achieve smart growth. People have to be at the centre of the equation, and smart technology is a means to creating good jobs and fulfilling lives. He continued that in terms of infrastructure, a smart city should have a few key elements, i.e., efficient transport and mobility, robust energy systems powered by smart grids, clean and reliable water and sanitation, and a safe environment. The core of the smart city is IoT, an expanding network of Internet enabled devices that talk to each other. He emphasized that local context would also be critical, as the development in one country may be quite different from another.

The sixth speaker gave her thoughts on the players developing the process that were taking the challenges to fulfill new functions and requirements of smart cities. She also stated that innovative technologies would dictate social transformations and that information and communications technologies would link processes from different fields. She then noted the development of smartphones, big data, concerns on privacy, as well as security issues.

Discussion

The third speaker questioned the creation of a multi-level governance system in the establishment of a smart city. The second speaker replied that it was a different perspective from public-private partnership, as by default it does not involve the people. People must be involved in how utilities are delivered, how planning and transport systems are designed and delivered, explicitly within the process.

The first speaker questioned how to develop a smart city with a declining and aging population and how technological applications would be able to help. The third speaker answered that the elderly would benefit from living in a compact smart city where services and needs were located in close proximity and easily accessible.

The sixth speaker questioned short and long term strategies to involve the participation of consumers and how to change functions of government, administrations, and of the science community. The second speaker stated that shrinking cities would have different demographic profiles, and that we should be using this opportunity to ask how the citizens

would want to use the space in the community, thinking about how their lives would change in a smaller community, and recognizing how that demographic shift would affect the different areas in one's life course, particularly in education and healthcare. The fourth speaker commented that outlooks on life between age generations would have to be emphasized and that products would have to be developed accordingly.

The fourth speaker brought up shared economies, questioning if we see similar effects in cities, and if it was just a short-term trend or a long-term change. The fifth speaker replied that new trends that he saw through the use of IoT was how to optimize space and discovering new sources of revenue, and stated that the shared economy was here to stay. The second speaker added that telecommuting hasn't really taken off like everyone thought when the Internet was first developed. However, work was being done during transport. The chair then commented on developments of autonomous driving, views on health from the perspective of the young and the elderly, the effects of IoT, and stated that we should be thinking about our current demands and the demands of future generations.

The fifth speaker commented on how smart cities could adopt a holistic approach to develop industry, create good jobs and attract talent. The combination of efficient infrastructure and talent pool will encourage businesses to set up and expand their operations, thereby creating a virtuous cycle providing sustainable economic growth. He also commented that as a developer, his key drivers for incorporating smart technologies are energy efficiency, higher productivity, and better customer service.

The third speaker noted recognizing the full framework of cities, including finances and governance; how we can implement the realization of smart cities through political will or institutional arrangements; and how the Asian population was facing various challenges and opportunities.

The second speaker summarized democracies and tyranny in small places, saying that it is important to facilitate younger people to be more involved and make greater contributions to democracy in order to change the political landscape; realizing the needs of cities in order to develop goals; getting governments to realize that the population would also be able to have a voice in making development decisions; and how to deal with problems in cities that already exist and to use technology as a servant rather than the master so that it responds to identified problems to change cities that would be better in the future.

The first speaker described that, due to the diversity among participants at their table, their definitions of smart cities were open to discussion, adding that smart education and the mitigating of disparities in the use of smart technologies was important.

The sixth speaker commented on how citizens should be involved and how responsibilities should be divided among stakeholders, emphasizing that there should be a balance in the development of technical trends so that the culture, society, and technology could develop together.

The fourth speaker highlighted the need for an integrated approach to a city's development, having an all-inclusive design, having all technologies accounted for from the beginning, as well as recognizing what the demands from the population were.

The chair thanked everyone for the lively debate, wished everyone a nice stay during the rest of their time at the STS *forum*, and concluded the Concurrent Session of Smart Cities – Urban Design & Development.

Plenary Session 103A: Research and Innovation

Session Chair

Fuchs, Alain, President, French National Centre for Scientific Research (CNRS), FRANCE [Nationality: FRANCE]

Speakers

Al-Salem, Nabeel H., Executive Director of Outreach & Communications, QF Research & Development, Qatar Foundation, QATAR [Nationality: QATAR]

Repik, Alexey Evgenievich, President, Delovaya Rossiya (Business Russia), National Public Organization, RUSSIA [Nationality: RUSSIA]

Matsumoto, Hiroshi, President, RIKEN, JAPAN [Nationality: JAPAN]

Walport, Mark, UK Government Chief Scientific Adviser, Government Office for Science, U.K. [Nationality: U.K.]

Schütte, Georg B., State Secretary, Federal Ministry of Education and Research, GERMANY [Nationality: GERMANY]

Lindpaintner, Klaus, Chief Scientific Officer, Thermo Fisher Scientific, U.S.A. [Nationality: AUSTRIA]

Opening Remarks

Prof. Alain Fuchs opened the session and outlined the various themes for discussion. He began by talking about how many solutions to the problems faced by society came in the form of technology. In fact, these days it is impossible to address the problems of society without societal involvement, but to what extent should civil society be involved in debates about science and technology. In addition, for every challenge the degree of risk changes. Another theme is the under-appreciated efforts of industry to advancing science and technology, as well as its ability to foster a safe environment for innovation.

Dr. Nabeel H. Al-Salem believed that a country's prosperity depended on the sustainability of its economic, human and social development. The requirements differ by country, and in Qatar's case, the country's idea of prosperity is driven by its vision to transition from a

Carbon-based economy to a knowledge-based one. To that end, the country has identified its top research grand challenges, which are water security, energy security, cyber security, and healthcare, all interdisciplinary fields.

The political will of the country and resource capacity are great strengths in carrying these out. However, the country also faces a real shortage of human resources with the necessary skills. Therefore, Qatar is seeking to attract researchers and other talented human resources from around the world. In addition, the country is also strengthening efforts to raise public appreciation and awareness of the importance of science and technology and is committed to creating a sustainable society through science and technology.

To begin, Mr. Alexey Evgenievich Repik cited the many pressing challenges that threaten the world. No country can solve these by themselves, nor any one sector. Instead, there needs to be collaboration among entrepreneurs, researchers, government, and civil society.

While many exciting developments in science and technology research and innovation are emerging, misinformed public opinion, outdated government policies, and limited funding models for research, represent some of the major barriers preventing scientific discoveries from reaching members of society. These must be overcome.

Moreover, rather than pursuing the current approach of reactive regulation, there needs to be a shift towards more proactive regulation, which creates proper incentives for the development of innovation. This can be done on national levels, but more importantly, there must be harmonization at the global level, which can be achieved through dialogue at international fora such as STS *forum*.

Prof. Hiroshi Matsumoto stated that innovation was not something that was made, but something that happened. As such, the role of universities and research institutions is to serve as the rich soil from which seeds of innovation can grow. It is crucial that researchers perform their own research on their own vision of an ideal society, with a broad perspective of the respective fields. Innovation cannot occur if researchers only focus on their immediate research interests. They must step outside their laboratories and develop a broad perspective of society and gain knowledge from other scientific fields.

Next Prof. Matsumoto explained how science and technology offered both great potential but also great risks. There are “lights” and there are “shadows.” Japan itself faces many significant challenges where science and technology can play a role, including the aging of its society, as well as the problems brought to light following the nuclear accident in Fukushima. To tackle these issues, academic research must be integrated into society.

Sir Mark Walport stated that innovation in and of itself could be neither good nor bad. Rather, the question is how we use innovation. It is therefore important to hold in-depth discussions to ensure we get the most out of innovation, including using innovation to address pressing global issues. Citing the example of self-driving cars, Sir Mark noted that while the technology was largely in place, the necessary regulations were not. Therefore, in addition to technology, public debate must be held.

However, to foster productive debates, there needs to be clarity, particularly regarding the difference between hazards and risks, which are often treated as one and the same. Hazards, if properly managed, pose no risk. Another communication issue is that discussions about science are often conflated with discussions about values. Furthermore, discussions about technology are often general, when they should be specific to be useful. Sir Mark also spoke about the need to manage the unexpected outcomes of innovation.

To sum up his remarks, Sir Mark stated that innovation was badly needed and that it was not only science and technology professionals who should decide on innovation policy, but all of society.

Dr. Georg B. Schütte spoke about the German innovation strategy launched in 2006 and which entered its 3rd phase in 2014, citing some of the lessons his country had learned. Germany has set a new focus on society rather than technology. It has succeeded in setting a new course for its innovation agenda, away from the traditional orientation on technological

development and instead focusing on grand societal challenges. This is also supported by financial allocation. Secondly, the German government learned the importance of taking a broad-based strategic approach which systematically takes the entire innovation chain into consideration and which also involves the public. Thirdly, Germany learned the importance of networking and the fact that government-industry-academia collaboration is key to success.

Dr. Schütte also spoke of how Germany was facing a number of major national issues that can be surmounted only through a joint approach to innovation: demographic change, industrial change, and the international competition for the world's best minds. In light of these, German has set six key goals, which are digitalization, sustainable economy and energy, innovative workplace, healthy living, intelligent mobility and homeland security.

More broadly, the German government is also focused on fostering an environment that is conducive to innovation. To that end, the government has set up regional leading edge clusters that are engaged in open and organic innovation. It has also introduced efforts to introduce industry into academia.

Dr. Schütte also explained how the German government valued scientific evidence and the public in its decision-making, citing the example of fracking. With regard to fracking the German government's policy is that funding will be provided for fracking research at individual fracking sites, only if there are companies willing to collaborate in the research, and if there is a process in place for engaging the local community and allowing them to look into the research. Funding is also provided for independent researchers who consult citizens, so that society can ask the proper questions of the scientists and companies.

Finally, while each country had its own model for innovation, Dr. Schütte encouraged different countries to hold in-depth discussions to identify differences in approach and learn from each other's experiences.

Prof. Klaus Lindpaintner pointed out the role that what he referred to as the "enabling industry" plays with regard to facilitating innovation on a number of levels. It actually provides the analytical tools essential for monitoring and maintaining a healthy and safe environment in which we can lead our lives and innovate. Then, it provides the tools that all scientists need to carry out their innovative work. And last, the enabling industry itself is engaged in continuous innovation to further improve the tools it provides to the scientific community.

He then spoke about Thermo Fisher Scientific's approach to technological innovation. R&D is by nature risky and costly. While during the initial ideation phase the process clearly needs to be open to ensure high quality ideas, the company has started implementing lean principles from an early stage of the design and R&D process.

Prof. Lindpaintner then spoke about the two types of innovation, which are continuous innovation and disruptive, breakthrough innovation. The former builds on existing value and 90% of Thermo Fisher Scientific's R&D is devoted to this. The latter form of innovation is disruptive to society and markets, and there is therefore often reluctance to pursue it. Disruptive innovation only occurs when "outside-the-box" thinking takes place. It needs fostering and encouragement, and if companies miss the opportunity presented by disruptive innovation, it can be fatal.

Prof. Lindpaintner also discussed how Thermo Fisher Scientific had set up an internal "venture capital fund" for soliciting proposals for innovation from within the company. As a rule, any proposal must be supported by more than one business unit, and also by scientists, to ensure they are addressing customer needs while also being scientifically valid. This has proven to be a success, not only in fostering innovation, but also in changing the nature of innovation and cooperation within the company.

Finally, Prof. Lindpaintner finished his remarks by expressing Thermo Fisher Scientific's dual goals of providing the tools that allow others to innovate, while also empowering itself to innovate, helping to make the world a healthier, safer, and cleaner place.

Discussion

First the participants discussed the best means of achieving a more holistic and integrated approach to research and innovation. Prof. Lindpaintner spoke about the metaphor of silos, which was usually treated as a negative example. However, he believed that to some extent silos were needed for good R&D. They prevent distraction and allow researchers to focus on what they do best. However, from time to time, the silos need to open up for more multidisciplinary discussions and collaboration.

Sir Mark believed the key was communication between scientists and innovators, and also discussion with the customer.

Prof. Matsumoto explained that in Japan, universities, due to their large number, played a significant role in basic research, while research institutes worked more on applied science and application. The two play complementary roles. However, the relationship between the two is still somewhat weak, especially as many researchers at universities are more interested in pursuing their own area of immediate interest. To foster innovation, this culture must change. Industrial involvement would also be welcome.

A representative from Oman asked about the national strategy in Germany, and the benefits of orienting research and innovation towards society. Dr. Schütte explained that Germany was shifting away from the old approach whereby scientists created technology, and the public simply accepted it. Germany is trying to involve the public from the agenda-setting stage. This is also true of the decision to phase out nuclear energy in Germany.

Mr. Repik commented that to ensure that innovation was actually practical, it was essential to understand the perspective of the customer and the market. Ultimately, the customer is key.

Dr. Al-Salem explained that in Qatar, the challenge was a lack of any diversified private sector that connects academia and industry. Therefore, the government is the main funder for R&D, and faces the challenge of trying to create an integrated value chain all the way from discovery to value creation.

Plenary Session 103B: The Role of Universities

Session Chair

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

Speakers

Mandon, Thierry, Minister of State for Higher Education and Research, Ministry of National Education, Higher Education and Research, FRANCE [Nationality: FRANCE]

Knutsson, Helene Hellmark, Minister for Higher Education and Research, Ministry of Education and Research, Government Offices of Sweden, SWEDEN [Nationality: SWEDEN]

Shimomura, Hakubun, Minister of Education, Culture, Sports, Science and Technology (MEXT), JAPAN [Nationality: JAPAN]

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

Mishima, Yoshinao, President, Tokyo Institute of Technology, JAPAN [Nationality: JAPAN]

Chuchottaworn, Pailin, Chairperson, Vidyasirimedhi Institute of Science and Technology (VISTEC) and Kamnoetvidya Science Academy (KVIS), THAILAND [Nationality: THAILAND]

Opening Remarks

Prof. Torsten Nils Wiesel opened the session by stating that universities today are creating new knowledge, even as the conditions and the structure of universities have changed. Universities are adapting new technology, which has led to the alteration of education. These very rapid changes are due to the digital revolution, which affects almost every aspect of our lives. He then posited questions to the speakers, asking how universities can do a better job in developing critical thinking and entrepreneurial skills, adapting to disruptive technological changes, increasing gender equality, and addressing and accommodating the volatility, complexity, and uncertainty that businesses and nations are facing.

Prof. Wiesel then stated that societies must find better ways to care for all people and provide access to education for everyone. There are many factors that limit access to higher education in the world, and it is expected that new technology will help in eliminating these factors. Prof. Wiesel also noted the importance of including women and minorities in education. He said that some countries have failed in this aspect, noting that certain well-qualified individuals have not had access to education.

Universities in the 21st century will continue to play a vital role in providing for society's needs. They also have a responsibility to produce thoughtful and well-informed citizens, which calls for a crafted balance between general and specialist education.

His Excellency Mr. Thierry Mandon began by asking the question, "What are universities for?" He then gave several answers, saying that universities are contributors to innovation, supporters of international business and investment, and agents of social justice. He noted that innovation is predominantly a business process and that the role of universities is to contribute to the environment of innovation. Universities should recognize their support capacity, and this in turn should be recognized and supported by governments. Useful research values curiosity and genius, and universities provide a natural space for engagement and development. His Excellency Mr. Mandon concluded by outlining the values of France in this area, including academic freedom and the importance of the responsibility of the state to provide large and equal access to knowledge and skills.

Her Excellency Ms. Helene Hellmark Knutsson said that Sweden prides itself on being a knowledge society and that its global competitiveness depends on the country's use of new technology. Thus, Sweden invests in supporting innovation, which also helps find solutions to global problems. She then highlighted the importance of sharing innovation.

Her Excellency Ms. Knutsson next spoke on women, and the high percentage of women in the workforce in Sweden. However, there is still a large difference in the number of men and women who pursue higher education in science. She said we must take a hard look at our society and evaluate the gender portraits of different professions. Greater diversity will also lead to better research. She said that gender equality is vital for Sweden's place as an innovative country, and also is necessary for true democratic rights for all. She then outlined initiatives in Sweden that address the problem, such as integrating all universities and funding.

She concluded by touching on socioeconomic background, noting that people with parents who enroll in higher education are more likely to enter higher education themselves. It is vital to ensure equal education for all.

His Excellency Mr. Hakubun Shimomura began by discussing Abenomics, which is showing definite results. The creation of new industries is essential as an aspect of this. 65% of elementary school students who entered school in 2011 will eventually be employed in jobs that do not currently exist. He also pointed out that many current jobs will simply vanish and become computerized. Thus, the ability to solve problems is essential and reform of all levels of education as well as the entrance exam system is needed to address this. The Ministry of Education, Culture, Sports, Science and Technology (MEXT) has recently developed a strategy for national universities, which focuses on strengthening their management capabilities. This will allow them to maximize their functions for knowledge-based societies. MEXT expects that each university will transform itself, and contribute to scholarship and the creation of innovation.

The second topic mentioned by His Excellency Mr. Shimomura was reform in science and technology. Results of research must be applied to return the benefits to society, which will spur the creation of new industries. There are three areas of strategic importance: transformation through artificial intelligence for an ultra-smart society, overcoming disease with iPS cells, and innovation in energy conservation. This will lead to a virtuous cycle of innovation, and providing support for young innovators is essential. Through

these efforts, the Government of Japan is using Abenomics to support innovation and contribute to all of humankind.

The Honourable Mr. Chuan Poh Lim opened by sharing Singapore's experiences in driving reform at universities, noting the importance of change for students who must adapt to a rapidly changing world and need the appropriate skill sets. He explained changes in pedagogy in areas such as emphasizing team-based learning.

The Honourable Mr. Lim explained his experience in opening a medical university in Singapore, saying he only agreed to do it after meeting the university leaders and confirming that they were dedicated to a new approach. They understood the need to fundamentally transform healthcare due to changes. They were also concerned with giving students skills to deal with changing conditions, such as the ability to interact easily with other doctors due to the new change of doctors often having to engage with each other to treat patients. In addition, he stated that it is important to recognize care for patients as healthcare, and not "sick care." He also highlighted online learning, which then leads to team-based learning and discussion and then to the application of each student's education to real-world scenarios.

Prof. Yoshinao Mishima stated that the most important role of universities, as well as the session, was education reform. Industry is now calling for education to change. University students often only focus on meeting graduation requirements and finding jobs for a stable life. However, it is important that universities guide students to be innovators in a rapidly changing world, and they should teach students to be creators and leaders in technology. Young people must gain multiple abilities, including entrepreneurship. The key to realizing this is changing the mindset of university staff.

Dr. Pailin Chuchottaworn introduced his work in Thailand and PTT Public Company Limited. He noted that he was the only speaker who was not from Europe. He then spoke about fostering new knowledge that will lead to innovation, and outlined KVIS's work in linking students and industry. He pointed out that it is important to use school curricula to equip students to handle the world, and that students can even be involved in the curriculum planning process itself. They should also receive guidance from industry and organizations such as the STS *forum*. Universities should be places where positive qualities are instilled in students, and industry will be gratified to have such students. A student's grades are only one indicator of their progress, and it is important to consider the individual to prepare him

or her for working and entrepreneurship. He said that PPT is working its hardest in Thailand and asked that others to join them.

Prof. Wiesel then stressed that universities want to change and recognize the effects of new areas such as the internet and new technology. It is important that they care for all students. He requested that an audience member give his or her thoughts on this matter. A participant from a university in Kazakhstan volunteered, noting the importance of distinguishing between good research and good teachers. He pointed out that good science and technology does not necessarily lead to good education. Dr. Mishima responded by saying that spending more time on education will not lead to a lesser quality of innovation and research.

A participant from the floor asked if there is a need to reform how we assess research productivity because it has enormous implications for the quality of education and universities. Prof. Wiesel said it was important to train teachers to enable them to reach all people.

A participant then asked the panel to speak on encouraging critical thinking. Her Excellency Ms. Knutsson stated that it is important to see students as carriers of new knowledge and critical thinking as they are the ones who will innovate society and companies, and that we must thus invest in education and ensure that they receive the necessary support. The Honourable Mr. Lim noted that we must look at the overall picture of education, and that we must consider how we can improve at each next level. A participant from the floor closed the session by stating that general education is essential to develop critical thinking in students.

Concurrent Session 104-A2: Challenges and Solutions for New and Renewable Energies

Session Chair

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

Speakers

Brechet, Yves, High Commissioner for atomic energy, Commissariat à l'énergie atomique et aux énergies alternatives (CEA), FRANCE [Nationality: FRANCE]

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

Gupta, Hulas Rahul, Managing Director, IndoSolar Ltd, INDIA [Nationality: BRITISH INDIAN OCEAN TERRITORY]

Kuniyoshi, Hiroshi, Executive Director, New Energy and Industrial Technology Development Organization (NEDO), JAPAN [Nationality: JAPAN]

Tanguy, Philippe A., Corporate Vice President, International Scientific Development, Scientific Division, Total S.A., GERMANY [Nationality: CANADA]

Opening Remarks

The Chair opened the session, introducing the panel speakers.

The first panel speaker reminded the participants that around 85% of world energy supply is from fossil fuels, and that in order to increase the share of renewable energies there are technology issues, systemic issues and materials issues. In order to match supply and demand, there are technological issues and societal issues, but storage will be a very important solution to this issue. Regarding materials, he pointed out that renewable energies are not as renewable as supposed, because they use other resources for construction and machinery involved in renewable energy generation. He noted that it is possible to calculate a material intensity index for each energy, and the consumption of materials have to be included in consideration of renewable energy selection.

The second panel speaker pointed out that Germany and France take very different approaches to renewable energies, but agreed that recycling technology must be improved. He noted that in the energy system there are lots of cross-sectoral interactions and interdependencies, and that individual approaches can have many unintended and unanticipated consequences, and therefore a holistic approach must be taken.

He noted that addressing the climate issue is the ultimate aim, but that this is only effective if they result in global changes. The current European Emissions Trading Scheme (ETS) could serve as a lever for a globally coordinated approach, and can be extended to additional sectors and developed to encourage innovation. The difficulty is in identifying which power sources are preferable from a systemic viewpoint. There are many different possible variants that emerge, but they have some common themes across all scenarios, such as the importance of wind and photovoltaics, and that fossil fuels will continue to play an important role in the short and medium term.

The third panel speaker noted that renewable energies will be central to the energy mix going forward, and noted that the rapid acceleration of emissions during the recent decades would have catastrophic effects. He noted that there are artificially low prices for solar, and unless the financial viability is corrected it may not be possible for these manufacturing plants to continue production in the future.

The fourth panel speaker noted that we need a broader, holistic approach to renewable energies, and more coordinated actions worldwide. The new constraints being faced is the limitations of connectivity to the power grid to connect all of the planned renewable energies, and strengthening of the power grid to cope with fluctuations is a pressing issue. Demand response could also be an important approach to tackling this issue. The appropriate grand design for the next generation of the electricity supply must be considered, but this requires a broad mixture of people with different skills and knowledge. It is hoped that discussions will continue at the ICEF forum, and be transferred into actions toward COP21.

The fifth panel speaker noted that climate change policies focus on net emission reduction, adaptation to climate change and energy security of supply. The EU has set a target of reduction of 40% from 1990 levels, and in order to achieve this objective, mobility must become much more efficient. Energy efficiency in mobility is multi-faceted. There are two approaches: technology progress for individual vehicles, such as reducing weight and deploying more efficient motorization/fuels, and a new paradigm at the system level such

as making traffic flow smarter, enhancing multimodal transportation and switching freight transport from trucks to trains. Implementation requires political will, public acceptance, and innovation. There is also a need to have business models which are profitable and resilient to exogenous shocks.

Discussion Outcomes

Table 1

The main point discussed was the need for tremendous resources to transfer to alternative energies, and that increased recycling of resources would be required. Nevertheless, there has been a large buildup of alternative energy and large investment. It was felt that nuclear is not a long-term solution, and therefore the consideration would be on distribution of money, as most of the shift to renewable energies is driven by subsidies, which may be necessary but may not build a sustainable industry that produces the sustainable technologies.

The question was raised of whether a falling cost curve for storage technologies could be achieved, and it was agreed that more investment and research would be required.

Table 2

It was felt that even with an increased share of renewable energies there would still be a reliance on fossil fuels, and this would require dealing with the problem of emissions. For the transport sector there will be a need to convert to lower-emission forms of transport. In developing countries there must be a sustainable and accessible way to achieve a sustainable energy mix.

Table 3

There is a need for a portfolio approach to generation in many nations. There is also a need for relatively uniform subsidies to avoid regional distortions in the energy market. Existing grids will need to be rebuilt to increase the inclusion of renewable energies beyond a certain point.

Table 4

It was noted that in a competitive economy, increasing costs undermines competitiveness. Hydrogen production from fossil fuels will result in large amounts of emissions, and therefore production of hydrogen should only be considered using renewable energies. The main recent revolution in energy has been fracking, and solar photovoltaic also has potential if solutions are found to maintaining efficiency with panel cleaning and storage of the energy produced. There was consensus that the price of oil will determine the pace of the shift to alterative energies.

Table 5

In the transportation sector, the ideal fuel must be considered as a variety of fuels in the system as a whole, rather than trying to identify one single fuel that fits every situation. Overall system efficiency must be considered from well to wheel. For electric cars the future efficiency of the electric supply grid also needs to be taken into consideration.

Open Discussion

A participant asked for clarification on the issue raised regarding photovoltaic industry raised by Table 1. It was reiterated that the cost reduction curve for solar is artificially low, and unsustainable, resulting in a lack of R&D and innovation.

A participant stated that when assessing any new installations they are considered on an economic basis and social basis, but there is also the survival view, which must be incorporated into the cost calculations.

A participant suggested using the word incentives rather than subsidies, as subsidies have a bad connotation as they are often given to fossil fuels.

The science around climate change is not completely established, and nuclear must still be considered, and the high costs of renewable energies also need to be considered.

It was pointed out that the most recent 5th IPCC Report said that the rate of increase in temperature is now threefold higher, and it is clear to see the effects on the earth.

The Chair summarized the discussions and pointed out that the session agreed on some challenges for new and renewable energies. Some of them were 1) Economical and political (decarbonization incentive, support more R&D on renewable energy, and less subsidies to fossil fuels), 2) Public acceptance, 3) Environmental acceptable (nothing is like zero emission), and 4) Cost model (business model that was comfortable and resilient).

It was emphasized that it was not easy to reduce CO_2 emission. For example, to produce renewable energy such as fuel cells, PV, and batteries also needed materials that will release CO_2. At the moment there was no master plan for clean energy, but there was a need for transformation of energy. Fossil fuel would be used only for a short time, and it would be soon renewable energy to be used in the long term.

It was noted that there was no sufficient financial support to develop further renewable energy (including improving current technology). Thus, financial support for R&D of renewable energy was needed. It was also obvious that it was not easy to connect electricity produced by renewable energy sources to the power grid. A strong power grid (smart grid) was needed. Also, energy storage was important, and to fulfill these needs, broad perspective, global cooperation and action, and more committed investment were needed. In terms of mobility, two demands: 1) mobility efficiency (including energy downsizing and efficiency) and 2) type of transformation of energy mix were important, and immediate actions needed to be done to fulfill these demands.

The Chair asked the participants to step back and look at the renewable energy issues in a more comprehensive way. He felt strongly the need to work hard together on these challenges to provide solutions, noting that there is no silver bullet to overcome the challenges and energy issues must be considered holistically, and brought the session to a close.

Concurrent 104-B2: Food and Nutrition

Session Chair

Hacker, Jörg, President, German Academy of Sciences Leopoldina, GERMANY [Nationality: GERMANY]

Speakers

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

Izumori, Ken, Professor emeritus, Kagawa University, JAPAN [Nationality: JAPAN]

Kimura, Takeshi, Member of the Board & Corporate Vice President, Management of R&D, Intellectual Property Department, Ajinomoto Co., Inc., JAPAN [Nationality: JAPAN]

Suematsu, Makoto, President, Japan Agency for Medical Research and Development (AMED), JAPAN [Nationality: JAPAN]

Opening Remarks

The Chair opened the session by introducing the speakers. He then quoted the First Global Nutrition Report, saying that good nutrition is essential for human wellbeing and affects people at all stages of their lives. He pointed out that safe food is not yet available for one third of the population. Food and nutrition must also meet global concerns, such as climate change, and there are various issues associated with food production. The Chair also spoke on the Sustainable Development Goals (SDGs), including food security. These goals can only be achieved if interconnected factors are addressed together, such as livelihood and employment, access to infrastructure, food security, and greater equality. The Chair's second point was on new technologies in the food and nutrition field, including GMOs.

The first speaker outlined his work at the Japan Agency for Medical Research and Development (AMED). He said his organization is very interested in the SDGs, and stated his personal interest in genome editing, which is in a grey zone in terms of regulation. He

also mentioned plant breeding, saying that it leads to indistinct boundaries regarding the regulation of GMOs.

The second speaker stated that every year, millions of young children die from malnutrition. Those children who survive suffer from inadequate brain development, stunted growth, and issues that lead to problems such as diabetes, cancer, and stroke. Good nutrition is a fundamental driver of a wide range of developmental goals and we must consider addressing malnutrition as a top goal.

The second speaker then stated that on the one hand, we have a wealth of information on maternal and child nutrition. On the other hand, we are challenged by the aging population, and more research is required on the elderly to provide them with a better quality of life at the end of their lives. In addition, reducing poverty is only one aspect of addressing nutrition, and they are actually quite different issues. An example is that although some people live in poverty, they have access to food and it is instead a lack of access to education that means that they cannot apply this knowledge for their nutrition. The speaker stressed again that the problem is not poverty, but education, and especially emphasized the importance of improving STEM education.

The second speaker then spoke on achieving a sustainable food future, emphasizing closing the food and nutrition gap, the economic gap, and protecting the environment. Science can provide solutions for this balancing act, and policies are also vital. Global partnerships, including intergovernmental cooperation, are essential. No one solution alone can create a sustainable future and close the gap, and we all must work together to rid the world of malnutrition.

The third speaker spoke on the private sector and nutrition, saying that companies can bring about benefits with shared goals with society. For example, Ajinomoto has worked with the government of Ghana to improve nutrition. He said that it is not possible to help in this area through aid alone, and that it is essential to foster business models and entrepreneurs who can work to achieve nutrition goals. He pointed out that there needs to be less resistance toward industry participation in public-private partnerships. An example of a positive partnership was the UK government's work with companies to reduce salt content in food.

The third speaker concluded by speaking on technology, and specifically GMO technology. He noted that there is a problem with public backlash, and that more education is

necessary. In addition, some companies, in advertising the lack of GMOs in their products, have contributed to the negative public perception of GMOs. It is essential to shape public perceptions when introducing technology.

Following this, the fourth speaker explained his background in biotechnology, focusing on rare sugars. Only small quantities of rare sugars exist in nature, and the speaker outlined his work in producing rare sugars.

The fifth speaker discussed the need to increase food production. One example he raised is that there is increased demand for meat, and in turn there is a need for more feed for livestock, in the context of climate change and its effect on water. Another problem is the development of antimicrobial resistant bacteria due to the misuse of antibiotics in livestock production.

One solution to the need to produce more food lies in GMOs. However, another solution can be found in the sea: seaweed. Seaweed is well-known in Asia, and there is great potential for science and technology to develop seaweed cultivation. Seaweed contains nutritional ingredients (as proteins) and functional molecules (as rare sugars) that can help to reduce the use of antibiotics in livestock. We must improve the research in this field of algae, and OLMIX is active in this goal.

The final speaker also spoke on the importance of public reactions to biotechnology, and stated that it is essential to explain that biotechnology is not against nature. He stressed that it is important to talk about solutions that biotechnology can provide, including helping poor farmers.

Discussion

The rapporteur for the first group explained that the group addressed nutrition issues in Africa, and also spoke on his own work there. He said it was important to help African farmers solve their nutrition issues by themselves, using such methods as the traditional practice of cultivating spirulina.

The second group spoke on education and the roles it can play in solving the problems of poverty, inequality, and the distribution of food. The group proposed using STEM education to bring technology to people who need it, including farmers in rural areas. This will also help create better food regulation, and will address the need for better food science and study of how food affects the human body. The Chair asked about the model of implementing education, and the rapporteur of the second group said the group had not discussed this but that government should play a large role.

The third group, which included participants from three continents, debated GMOs. From a scientific point of view, there is quite a lot of information on GMOs but there is still a very biased public perception against them. Thus, it is important to emphasize the benefits that GMOs can bring, and not just the technology itself. By focusing on benefits, people will understand that GMOs can help them and will realize that they are not just a government initiative aimed at saving money. There is also no real definition of what sustainable development is, and events such as the STS *forum* are excellent opportunities to share ideas and knowledge. The rapporteur also said that it is important to tackle the anti-science movement that is developing, including an anti-science attitude in the field of nutrition.

The next group spoke on rare sugars and the importance of such supplements for health benefits. A speaker explained that rare sugars can also act as ecological pesticides. The group then moved on to GMOs, suggesting that it is best to focus on alternatives such as better agricultural techniques. The table was not necessarily against GMOs, but understood the reality of the negative public perception of GMOs.

The final group also focused on GMOs, and agreed that it is important to address public fears of GMOs and instead publicize their benefits. The rapporteur stated that it was important to compare genetically modified foods with foods that are seen as "natural," giving the example of carcinogens in celery.

Concurrent Session 104-C2: Future Nanomaterials

Session Chair

Yeh, Nai-Chang, Professor of Physics and Co-Director of Kavli Nanoscience Institute, California Institute of Technology (CALTECH), U.S.A. [Nationality: U.S.A.]

Speakers

Ahmad, Rezal Khairi, Chief Executive Officer, NanoMalaysia Berhad, MALAYSIA [Nationality: MALAYSIA]

Bengtsson, Stefan, President and CEO, Chalmers University of Technology, SWEDEN [Nationality: SWEDEN]

D'Iorio, Marie, Executive Director, National Institute for Nanotechnology; Assistant Vice-President Research (Nanotechnology) and Professor of Physics, University of Alberta, CANADA [Nationality: CANADA]

Mason, Thomas, Laboratory Director, Oak Ridge National Laboratory (ORNL), U.S.A. [Nationality: U.S.A.]

Ushioda, Sukekatsu, President, National Institute for Materials Science (NIMS), JAPAN [Nationality: JAPAN]

Opening Remarks

The Chair opened 104-C2 Future Nanomaterials by introducing herself and the speakers before giving a brief opening statement on modern nanotechnology. She stated that to-date, nanomaterials had found applications in a wide range of technological fronts, including in manufacturing, electronics, memory storage, information and computation technology, medicine, and other areas. She added that generally speaking, nanomaterials were developed by design through nanofabrication of meta-materials, self-assembly of nanostructures, nano-systems such as two-dimensional thin films, and natural processes among other means. In conclusion of her statement, she stated that the development of future nanomaterials to meet societal needs and global challenges would require not only multidisciplinary fundamental research efforts but academia-industry-government collaboration as well.

Before moving to the second presenter, she asked that all participants consider the following two questions during the discussion phase of the session:

1. What are the most important nanomaterials?
2. What are the best technical and societal approaches for advancing nanomaterials?

The first speaker opened her presentation by stating that working across disciplines would place nanomaterials at the heart of sustaining humans for centuries to come. She commented that nanotechnologies would eventually be further imbedded in agriculture, manufacturing, transportation, energy, and healthcare among other sectors. She added that researchers had much to learn from nature's nanomaterials, processes, and materials. Moving on, she explained that the discussion of materials was also about imbedding nanomaterials, bringing up examples related to irrigation, diagnostics, and infrastructure to illustrate her point. Finally, before concluding her statement, she stated that the future of nanomaterials would depend on a healthy ecosystem that supports policy, regulation, and collaborative research.

The second speaker opened his presentation by introducing Chalmers University of Technology and the research conducted there. In explaining about the activities of his university, he introduced two projects. The first project introduced was the European Graphene Flagship Project, which was tasked with bringing together academic and industrial researchers to take graphene from the realm of academic laboratories into European society in a duration of 10 years. The second project described by him was to investigate and innovate new products for the forest industry beyond paper, pulp, and cardboard. He added that it would be key to integrate various scientific disciplines in order to reach goals, and that the university would need to consider upscale and commercialization itself. In conclusion of his presentation, he noted that the projects had led to a number of approaches for the university in terms of the innovation systems and the way they worked together with industry. He explained that some of those approaches included the need to further consolidate infrastructure and the need to restructure the method of work with one of their largest industry collaborators.

The third speaker opened his presentation by explaining that when the NNI – the National Nanotechnology Initiative in the US – was initially formed in 1999, the focus of the initiative was to circumvent the end of Moore's Law. He noted that recently, signs of the slow down had been manifesting itself. Pointing out that major economic growth had been driven by successive performance enhancements in computational performance, he wondered aloud how this issue would be addressed. One potential solution, he commented, could be

control at the nanoscale level, adding that many more instances of controlling functionality by controlling function and dynamics on the nanoscale were being discovered. In terms of exciting future areas in nanotechnology, he brought up new capabilities in nanoscale imaging as one example. In conclusion of his statement, he stated that the ability to take insight from the application of data analytics to new imaging techniques in order to guide the creation of real materials was proof that the future of nanomaterials was ripe with opportunity.

The fourth speaker opened his presentation by introducing the National Institute for Materials Science (NIMS). He introduced a center run by the Institute called International Center for Materials Nanoarchitectonics (MANA), which utilized a bottom up approach to build materials out of atoms and molecules. He then introduced several materials developed by the program including artificially assembling nanopores amongst others. He concluded his statement by stating his hope that materials informatics in developing new materials would be less dependent on traditional approaches.

The fifth speaker opened his presentation by introducing NanoMalaysia Berhad, and explaining that the institute had a very specific focus on only developing economically viable products in the short-term. As a result, he explained, the focus of NanoMalaysia Berhad was on graphene utilization in rubber, plastics, energy storage, nanofluids, and in terms of exploiting the conductivity of graphene through conductive inks. He then explained the delivery framework, adding that the institute would follow the process from beginning to end to ensure that it ran smoothly.

Discussion

A representative from the first group stated that they had discussed and collectively come up with three challenges for nanomaterials. The first challenge was a lack of methods to manipulate materials at the nano-level; the second challenge was in terms of the actual manufacturing of nanomaterials and making the process more cost-effective, efficient, reproducible, and scalable; and finally, improving the environmental and health impact of creating nanoparticles.

A representative from the second group stated that they discussed whether the future of nanomaterials would be greatly advanced due to deterministic design or creativity; the exciting applications of nanomaterials as related to the Internet of Things (IoT); nanomaterials as related to wearable technology; how nanomaterials may transform traditional

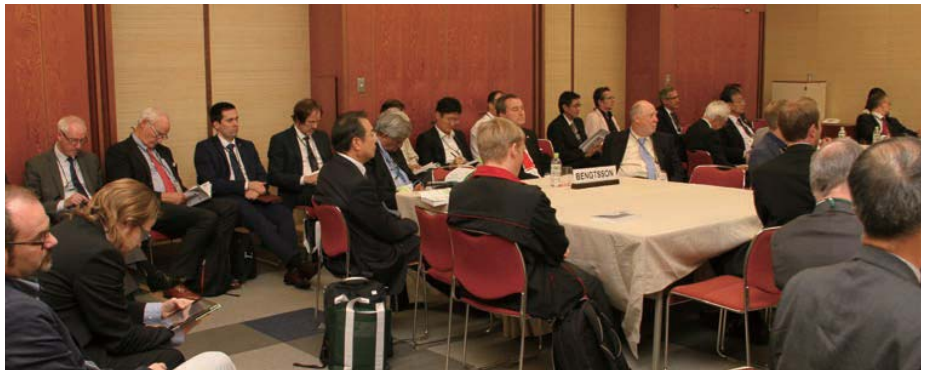
industries; the negative environmental aspects of nanomaterial waste; how nanorobots could be created and regulated; and the need to create a manufacturing process for nanomaterials that is compatible with current manufacturing processes.

A representative from the third group stated that they discussed societies' viewpoints on nanomaterials; the importance of investigating health issues related to nanomaterials; recycling nanomaterials; nanophotonics; bio-inspired computing; nanosensors; and societies' expectations of nanomaterials and managing those expectations.

A representative from the fourth group stated that they discussed how to store energy and use nanomaterials in batteries and avoid degradation; energy density and ways in which solar power could be converted to gas using nanomaterials; creating lighter weight metals and plastics to be used in cars and other products using nanomaterials; and applications of nanomaterials in medicine.

A representative from the fifth group stated that they discussed the diversity of different applications of nanomaterials in various materials including as replacement of magnetics, polymers, medicine, quantum key distribution and quantum computation, and normal in waste water treatment.

In the final round of open discussions, the importance of archiving and disseminating the data and pertinent information of nanomaterials for something like a "materials genome" initiative was brought up as a potentially effective means to expedite the development of future functionalized nanomaterials.



Concurrent Session 104-D2: Water

Session Chair

Al-Hinai, Hilal Ali, Secretary General, The Research Council (TRC), OMAN [Nationality: OMAN]

Speakers

Eggen, Rik I.L., Deputy Director, Swiss Federal Institute of Aquatic Science and Technology (Eawag), SWITZERLAND [Nationality: SWITZERLAND]

Kabat, Pavel, Director General and Chief Executive Officer, International Institute for Applied Systems Analysis (IIASA), AUSTRIA [Nationality: NETHERLANDS]

Kennel, Charles F., Distinguished Professor and Director Emeritus, Scripps Institution of Oceanography, University of California, San Diego (UCSD), U.S.A. [Nationality: U.S.A.]

Nguyen, Van-Thanh-Van, Chair, Department of Civil Engineering and Applied Mechanics; Director, Brace Centre for Water Resources Management; Professor, Endowed Brace Chair Professor in Civil Engineering, McGill University, CANADA [Nationality: CANADA]

Oki, Taikan, Professor, Institute of Industrial Science, The University of Tokyo, JAPAN [Nationality: JAPAN]

Santo, Masaji, Senior Vice President, Division COO, Infrastructure Business Division, Mitsubishi Corporation, JAPAN [Nationality: JAPAN]

Opening Remarks

The chair commenced the session with a call for wide-ranging conversation, as water is a topic that effects and relates to a variety of fields. For example, water spans the sectors of energy and ecology, food and health. On the energy front, the debate surrounding fracking and water safety continues. Health-wise, there is the need to provide sanitation and access to clean water across all societies. He drew particular attention to the neglect of water in the progress of scientific and technological development.

The chair provided the example of water distribution in times of disaster, such as during the flooding in Pakistan or the

tsunami in Fukushima. Water is a primary and necessary resource for disaster-stricken areas, while also being one of the most difficult to transport and distribute. Why has technology not addressed this crucial inefficiency, and why is water not drawing the necessary developmental energy and attention? As a society, we need to think about how our money and resources are being used in the supply of clean water, and where our current system falls short.

The first speaker pointed out that, while he was not a water expert, he felt certain that highlighting the history of water issues in the state of California would provide the participants with an idea of the necessity of their work. It was the development of a water-distribution infrastructure in California that led to the state's initial population boom. However, to this day the state has altered constantly and unpredictably between drought and flood, an effect of the cycling between El Niño and La Niña years.

Until now, a vast system of reservoirs in California has captured snowmelt produced in the mountains and retained it for distribution throughout the state in times of drought. However, rainfall in California has been drastically decreasing, with 2014 being one of the worst years of drought in the state's history. Groundwater loss has now exceeded the amount of water retained from mountain runoff. A large-scale reduction in water use was ordered in the state, and was in fact achieved. However, the state of drought has continued unabated. While in the past California's water use and supply was matched to the cycle between El Niño and La Niña years, this system is no longer reliable, and the water supply can no longer be predicted. This has prompted a change in the understanding of water management in California, emphasizing greater use of technology, conservation, and the use of desalination processing. Each region in the state will now have to develop its own water management structure. While this drastic weather change cannot be directly linked to climate change, a similar upheaval in the water supply is expected to continue in the future.

The second speaker expressed frustration regarding the state of global progress in terms of water reform. While the same topics are repeatedly discussed in political and scientific forums, no progress on global water issues, such as those affecting India, has been made. Furthermore, even as discussion of groundwater and salinity issues has slowed, no technology to suggest other solutions has been developed.

Efficiency, transportation, and water storage have all been continual issues. None of these matters have been progressed on, even those that were thought to have already been solved. People have forgotten the importance of investing in the future of infrastructure.

The third speaker spoke about water issues in low- and middle-income countries. Advancements are not being made fast enough on issues such as sanitation and distribution. However, an additional topic which needs to be addressed and yet remains off the global agenda is chemical pollution.

As the manufacturing of chemicals has increased, it has been located primarily in lower- and middle-income countries. People in these countries are less aware of how to handle these chemicals, and are often ignorant of the health and environmental side effects. While we are generally knowledgeable about how chemicals such as insecticides and pharmaceuticals affect the environment, we are not as knowledgeable about how chemical pollution affects humans. Human intake of chemical pollutants occurs via direct exposure but also largely through water and food. This issue needs to be addressed as part of a political agenda in order to raise awareness and create ways to avoid this type of pollution.

Currently, measures to address chemical pollution take place in a "wait-and-see" situation, where solutions are only found after the pollution has already occurred. New technologies should be developed and innovations utilized to address these issues before they occur. Furthermore, the provision of education and information in countries where chemical manufacturing as well as increased usage takes place is vital, both in terms of how to handle chemicals and how these chemicals affect them. Lastly, local and global data on how this pollution is affecting environmental and human health will be needed in order to stir people to action.

The fourth speaker addressed the problem of urban water management in the context of climate change from an engineering perspective. Whenever studies are carried out on the impact of climate change, output from global climate models cannot effectively reproduce the details of climate conditions at the scale of a small urban area. There is great political pressure to account for climate change effects in the management of urban water systems, and much money could be spent to minimize the risks of failures in these systems. Hence, there is a great need to develop improved climate simulation models and the necessary downscaling tools for linking global (or regional) climate predictions to urban hydrologic processes at appropriately high spatial and temporal resolutions. The main challenge would be to predict

accurately the future variability of urban hydrologic processes (such as temperature, rainfall, and runoff) at the scale of the urban area in the context of climate change in order to build suitable scenarios for the operation and management of urban water systems.

The fifth speaker spoke on the concept of the water footprint, defined as a metric that quantifies the potential environmental impacts related to water. What the water footprint endeavors to record is the potential environmental impact of the use and production of items using water. However, the environmental impact of the usage of water varies according to geographical and temporal factors (global location, season, etc.). The consumption of a liter of water in a dry country in summer would, for example, have a different environmental impact than a liter of water consumed in a wet country during a more temperate season.

Another aspect of the water footprint the speaker wished to emphasize was the quantitative and qualitative nature of the environmental impact of water consumption. He encouraged participants to consider how the environmental effect of water usage in terms of amount differs according to the context in which it occurs, and to think about how the idea of the water footprint might be further developed in order to measure that usage in a uniform manner.

The sixth speaker spoke about Mitsubishi's role in the global water business activities. He introduced a specific case from Australia, where a subsidiary company of Mitsubishi operates many water plants, in relation to a water recycling scheme for vineyards in order to utilize water resources usually split between drinking water and food production. Australia suffers from many periods of drought. South Australia is simultaneously one of the driest regions in Australia and a famous fruit producer, particularly of grapes for wine production. The speaker explained how wine production is one of the most water-reliant industries in the South Australian region. Water supply significantly effects vineyards' income, altering the taste and quality of their products.

Vineyard owners in a particular region of Southern Australia jointly proposed to local governments that their vineyards would take in all recycled water from the local treatment plants, and in exchange would construct a pipeline to deliver the recycled water from the treatment plants to their vineyards. There are three significant benefits to this mechanism. Firstly, vineyard owners now have a steady water supply during periods of drought. Secondly, the mechanism expands water supply to areas where there was no water in past, allowing vineyards to increase their production. Lastly, local authorities now have

a fixed customer willing to pay for water produced from their recycling plant, rather than simply discharging it into the ocean. This is not only environmentally but also economically sustainable, and addresses a solution for the splitting of water resources between drinking and food production.

Discussion

After dividing into groups for breakout sessions, representatives were elected to briefly explain the contents of their group's discussion to the other participants.

The first representative provided a few words on the essential humanity at risk in issues regarding water access. His group had proposed reuse as the world's most viable option for sustainable water supply, while acknowledging global issues of transport, storage, and data collection.

The next representative also expressed frustration as a scientist at seeing other scientists not progressing their studies to actual, applicable stages. Only a small fraction of the global economy would be needed provide significant support toward solving water issues, but this sort of economic contribution yet to be seen. There also exist countries that have succeeded in the adaptation of water technology, such as Israel, who has gone from water "needer" to exporter. Perhaps, rather than being a science and technology problem, what prolongs

problems regarding water supply is largely a policy issue, where even the steps available are not being taken.

A third representative stated that his group had addressed the issue of scale, particularly in terms of measurement. For example, when measuring the scale of climate change, the larger the scale of the study, the harder it is to measure. It is very difficult to discuss the issue of climate change when scientists can only discuss the issue based on the scale they themselves can observe. We as humans tend to believe what we see, so a physical process must be developed to uniformly measure factors involved in climate change, such as rainfall, etc. This is where engineers and water scientists can collaborate in creating a common system of measurement.

The final representative mentioned the challenges of promoting water as a priority for scientific and technological development, citing a lack of data. While much data is available locally, it is lacking on a regional and global scale. He also reported that the sharing of data itself is often an issue, one which could be facilitated by ICT. Lastly, innovation within the water sector is limited by lack of funding. Governments should secure the basic fund requirements necessary to facilitate research. Political will is very important in achieving that. He stressed the role of the scientific community in integrating an understanding of the potential water impact into any government planning system, helping to involve politicians in the issue and to draw their interest.

Concurrent Session 104-E2: Competition and Cooperation among Global Industries

Session Chair

Blanco Mendoza, Herminio, Founder and Chief Executive Officer, Soluciones Estrategicas S.C., MEXICO [Nationality: MEXICO]

Speakers

Johnson, Ray O., Executive Director, QxBranch; former Senior Vice President and Chief Technology Officer, Lockheed Martin Corporation, U.S.A. [Nationality: U.S.A.]

Kojima, Keiji, Vice president and Executive Officer, CTO, President & CEO, Research & Development Group, Hitachi, Ltd., JAPAN [Nationality: JAPAN]

Marshall, Larry, Chief Executive, Commonwealth Scientific and Industrial Research Organisation (CSIRO), AUSTRALIA [Nationality: AUSTRALIA]

Williams, Keith E., President and Chief Executive Officer, Underwriters Laboratories Inc., U.S.A. [Nationality: U.S.A.]

Opening Remarks

The Chair opened the session by focusing the discussion on points where cooperation among global industries could be enhanced. He gave the example that the makers of the electric car Tesla released its patents so that other companies could use them to compete. The European Institute for Innovation & Technology (EIT) has also endeavored to create frameworks to spread technological collaboration.

The first speaker noted the parallels between the topics explored in this session and the CTO Luncheon held earlier in the day. Collaboration among industries is key, but there are many challenges to overcome. For example, cooperation and collaboration are difficult if the industries are similar – but easier when there are less common products or customer bases which could be disrupted. One possible way to address this challenge would be to involve academia and the public sector more effectively in research and development projects. The

government in the United States has been especially helpful in helping to finance high-risk, high-reward projects, he noted.

The digital environment offers an invaluable opportunity for people to collaborate with those with whom they would not have much contact with normally.

The next speaker noted that "co-opetition," a term coined by FIRST Robotics, is a useful touchstone for this discussion because both cooperation and competition are crucial.

Standards are a challenge to overcome, because too stringent ones can sometimes kill an industry, but they can also promote cooperation. There are three types of standards. First are process standards, such as ISO standards, which dictate the materials that make up a product and the process involved in making it. Second, performance standards tell one how a product should perform. Finally, prescriptive standards, based on legal or industrial prescriptions, such as Wi-Fi, can create industries. Initially, standards are born in a spirit of collaboration – collaboration is a prerequisite for creating standards – but ultimately lead to competition and innovation once companies begin to make products or services based on the standards. As prosaic as standards can sometimes be, they can lead to improved public safety. Finally, developing standards for the Internet of Things (IoT) is a major issue which will require participation from academia and industry, specifically related to cybersecurity.

The next speaker described how the various challenges facing society are not only becoming increasingly complex but also global in scale and changing by the moment. Many companies have risen to the challenge, including Hitachi. Given the scale and growing scope of the societal issues, however, it is no longer feasible for just one company of even one industry sector to tackle the issues alone, and global collaboration must be sought not only in technology but across the entire value chain. Hitachi is addressing this challenge through customer-driven "Social Innovation Business" working with regional stakeholders to co-create solutions based on a shared vision.

The next speaker remarked that Australia has an innovation dilemma –people often confuse invention with innovation. Innovation drives productivity and jobs and creates new markets and industries, literally creating value from nothing, based on inventions and new ideas. Investors often find a lower risk path is to invest in incremental innovation, copying a successful innovation from another country (especially the US) and replicating it in their domestic market. This is a problem because jobs, productivity and value creation come from new to the world through innovation not replication. Universities and Research Institutes are great inventors, but compete too much in research. Universities rank themselves on citations and publications, i.e., inventions; Research Agencies should rank themselves on value delivery and impact. Agencies should reposition themselves to collaborate with universities to deliver the universities' inventions to industry where they can create value (and become innovation), and thereby transform competition into "co-opetition."

Discussion

A participant touched on the significance of quantum computing – while some aspects like coherence and superposition are quite technical, the basic gist of quantum computing is that it can complete multiple calculations simultaneously. The difference between calculating eight things sequentially versus simultaneously is negligible, he said, but when one considers the resources required to handle 1090 functions simultaneously versus sequentially, the difference in speed and efficiency is clear. It will make extremely complex computations more feasible and less expensive to do. The world is full of problems that are too complex to deal with at the current stage of computing, but not with quantum computing. Quantum computing can enable the creation of new industries.

Another participant added that quantum encryption is un-crackable, and this is part of the reason that scientists are collaborating all over the world at an unprecedented rate.

There was a response that as the world changes and industries evolve, many companies discover new competitors as they expand into new industries. With these new competitors, there are new opportunities for collaboration.

Another participant noticed that the Earth is on the verge of a massive explosion of new knowledge as various digital and bio-platforms emerge, but standards are still used as tariff-free trade barriers and impediments to innovation and free commerce. She added that collaboration on cybersecurity is of the utmost urgency. There is a financial incentive to collaboration, which may seem counterintuitive as competition has been emphasized so heavily. Early-evolving industries are extremely crowded, and there may be room for a marker-clearing product. Many companies sell "black boxes" whose purpose and specific market is ambiguous.

A participant from the UK answered that the Darwinism of the market is something which should not be overlooked. Standards are important because they create a base-line for the industry and ensure customer safety – and standards should come from the market. At the same time, the governments of the world should be friendly to innovation, and play a role in sending a signal to the market and letting it compete.

The Darwinism of the market is also informed by market and government responses to accidents and incidents, because they ultimately lead to customer knowledge about products and confidence in using new technology. If we understand the risks, we can make the public safe and educated – that is the link between standards and collaboration.

Another participant proposed that we do not understand or truly grasp the pace of innovation.

There was agreement to this proposal. Regarding cybersecurity and standards, a participant noted that the US established a safe place for companies to disclose and share knowledge about intrusions and security breaches. The instinct many regulators have is to punish those who produce products that are vulnerable to cyber-attacks, but this will prevent information sharing and disclosure and when we keep silent and do not share, the black hats win.

A participant from India noted that the population in his country is massive – over 1 billion, and it is very important to push simple innovation, to be able to harmonize it across all economic and social classes and make it accessible.

In response, a participant noted a project he was involved in, a web platform called "http://indiainnovates.in/," whose stated purpose is to recognize that innovation comes from anywhere, and provides a network for such innovators to share their ideas. It runs a competition, where ten winners have the opportunity to travel to Silicon Valley and conduct exchanges.

Another individual added that he has been impressed with the Indian Government's use of technology in recent years – including thumb-print scanners than enabled at low cost digital bank accounts for every Indian citizen.

A participant said that innovation benefiting India must come from India. He gave some examples from East Asia, such as Japan and South Korea, where innovation was born after hardship and war, and driven by major brands such as Sony and Panasonic in Japan, and Samsung and LG in South Korea. He also touched on China, which had once been "the world's low-cost factory," but the Government and citizens are starting to recognize the importance of innovation to the digital economy.

It was pointed out that one innovation driver that is often overlooked is high profile events such as crises, disasters and international events. The example of the Great East Japan Earthquake in 2011 was given, and the collaboration in Fukushima recovery efforts. It was also mentioned that cybersecurity is very important to Japan as the 2020 Tokyo Olympic Games and Paralympic Games in Tokyo approach and the potential vulnerabilities begin to emerge.

A participant responded that there are two kinds of cyber-crimes – terroristic cyber-crime, and that which is motivated by profit or corporate espionage. One of the reasons that cyber-crimes are so threatening is that criminals have considerable time to methodically plan and execute their plan – whereas bank robbers, for example, must be in and out within 30 seconds.

A participant added that cyber-attacks as robbery is only one aspect of cyber-crime – it is important not to overlook cyber-attacks as the actions of nation states. It is often difficult to define the damage of such cyber-attacks. Often, people know something is stolen, but they do not know its value.

In response, a participant added that another opportunity for collaboration and competition is the global move away from paper-based currency towards electronic currency such as Google Pay or Apple Pay. He mentioned that it is possible that by the end of the decade, some countries may eliminate paper currency altogether. In Sweden, over 90% of transactions are handled electronically. Electronic currency is a rapidly growing market. One of the possible dynamics is that it is harder to make transactions on the black market.

A participant agreed that electronic currency has major potential as an opportunity for collaboration. He reminded the participants that the Visa credit card brand began as a co-op, looking to tackle the difficult problem of security in non-cash payments. Electronic payments have a considerable potential to remove much of the friction from financial transactions, if they are indeed completely secure.

The Chair closed the session, thanking all the speakers for their participation.

Concurrent Session 104-F2: Bridging Science and Technology with Society and Politics

Session Chair

Imura, Hiroo, Professor Emeritus, Kyoto University, JAPAN [Nationality: JAPAN]

Speakers

Asenjo, Juan A., President, Chilean Academy of Sciences, CHILE [Nationality: CHILE]
Diderichsen, Børge, Vice President, R&D Outreach, Novo Nordisk, DENMARK [Nationality: DENMARK]
Gluckman, Peter David, Prime Minister's Chief Science Advisor, Office of the Prime Minister of New Zealand, NEW ZEALAND [Nationality: NEW ZEALAND]
Keiser, Rebecca, Head, Office of International Science and Engineering, National Science Foundation (NSF), U.S.A. [Nationality: U.S.A.]
Moratti, Letizia Brichetto Arnaboldi, Co-founder, San Patrignano Foundation; former Mayor of Milano; former Minister of Education, Universities and Scientific Research, ITALY [Nationality: ITALY]

Opening Remarks

The chair began the session by stating that due to the rapid rate of change in science and technology, the scientific community is increasingly being called upon to deal with a large number of issues. These can range from short-term solutions to an ebola outbreak to combating the long-term effects of climate change. He then addressed the Great East Japan Earthquake in 2011 and stated that the role of scientific community in advising to policymakers failed in this case because the advisory system was too complex. In such emergency situations, science needs to play a better role in the future. The chair then showed opinion polls concerning nuclear systems in Japan and how they have changed over time. Due to the legacy of the A-bomb, many Japanese people were initially reluctant to use nuclear power, but fears of climate change made them more open to the idea. After 2011, the situation began to change and has not recovered until now. This

is a very difficult issue due to its complexity. There are too many dangers in nuclear power. Yet, the alternatives are currently not adequate so a mix of the two or more is needed. Addressing these issues will be a challenge at all levels and help from the social or behavioral sciences is needed. He then invited the participants to make their opening remarks.

The first speaker spoke on her work experience and her interest in science enterprises. The increasing mistrust of science by the public is an issue and many are pointing to public ignorance as the cause of this mistrust. Yet, when a recent questionnaire for the public asked questions about scientific facts, the average person got 75% of the questions right. On the other hand, only 40% of the respondents demonstrated an understanding of the scientific process. This highlights that there is a lack of understanding about how we perceive science. We can't blame the public, however, as people only act naturally to protect themselves. An example of this is the misperception that vaccines have a link to autism. Science is not a satisfying answer to many because it leads to more questions than answers. We can do more to help scientists convey the meaning of their research to the public. The number of women and underrepresented groups in science is low and science needs to look like the majority of people in the world. Further work must be done in communicating the processes in research and creating more transparency.

The second speaker stated that his role is to help the public understand science and to serve as a scientific advisor to the government. In both of these situations, trust needs to be built as one can't help the public or the government if there is no trust. There needs to be a comprehensive approach to science. Yet, there needs to be different approaches for different situations. For example, a crisis needs a faster approach and reaction than a policy decision. To maintain trust between scientists and the outside, there should be a high level of independence. Furthermore, science should be honest rather than pushing for a specific position or agenda. There is a paradox because people trust and do not trust science. People have trouble coping with the rate of change in technology and communication often comes too late in the development cycle. The community needs to be engaged much earlier in the discussion to foster trust.

The third speaker spoke on health and drug use and stated that those who use drugs are at high risk for diseases such as HIV and hepatitis C. However, the causes of drug use remain unknown and further studies are needed. Science needs to be the method to discover the root of this problem and all scientific disciplines must integrate to give the best solution. With regard to outcome, science can once again play an important role. It needs to focus

more on drug use recovery. There should be more studies on long-term abstinence and more open and transparent discussions need to be held to address this. Science can reach civil society and communicate the results, outcomes, and the best solutions. At the UN next year there will be a special session at the General Assembly on drugs to better address this problem and improve global health.

The fourth speaker stated he would speak on his experiences in Chile and how they relate to the current challenges in science. The Chilean Academy of Sciences carried out a study in 1989 which came to the conclusion that Chile needed a Ministry of Science and Technology to tackle issues in science and technology. Later, in 2012, while the speaker was President, the Chilean Academy of Sciences carried out a study for a whole year with the participation of a large group of members of the Academy; it did a study to analyze and develop potential programs that should be carried out to improve science. It also came to the conclusion that while science and technology in Chile are of a very high quality, the number of scientists is low and Chile only invests 0.5% of its GDP in science and technology.

The project made eight proposals to address these solutions and proposed initiatives that would have a big impact on education, regional development, and national strategic problems, such as energy and water. These proposals would imply increasing the investment in Science and Technology by 0.4% in the GDP in 4 to 5 years. The Congress of the Future, which takes place every January, sponsored by the Chilean Senate and the Chilean Academy of Sciences, has played an important role in informing the general public on science. The Science for the Development of Chile Commission, by request of the President of Chile,

prepared a study that addressed the future of science in Chile and recommended increasing investment and the creation of a Ministry of Science and Technology. He concluded that development of stronger science education programs in schools and developing programs to help science were needed for the future.

The fifth speaker spoke about the gap between the general public and scientific experts on scientific issues. Science and technology are indispensable in solving the challenges humanity faces. However, especially in regard to medicine and biotechnology, further work needs to be done in terms of communication. For example, it is important to better communicate with the public that developing new innovative medicines is a costly and time consuming process. The speaker then spoke of two key target groups, the patients, and the policy makers. For the policy makers and civil servants, the closer you bring them to the labs and research processes, the more they will understand science. This creates an indispensable sense of trust that will lead to better policies. A forum with the general public is needed as ordinary people who can express their opinions and concerns to the scientific community will have a better sense of trust. The speaker's organization also builds trust and involves patients in the research priorities. This creates a strong sense of confidence in the patients. Young people also need to become more literate in science and the more hands-on and face-to-face experiences for them the better.

Discussion

One speaker stated that her breakout group spoke extensively on science education and its difference from science literacy. The group also came to the conclusion that critical thinking needs to be improved in science education. The group also discussed a few success stories. One success story was in Malaysia and involved science ambassadors who give advice to locals in rural areas on how to deal with floods. There is another program in Malaysia that invites ordinary people to have tea with scientists. This was done to humanize scientists and build confidence.

The next participant spoke on the broad range of issues in science and on Fukushima and the need to reflect and learn from the communication problems that occurred. Understandable communication will be the key for science and technology because when dealing with policy makers, we need to have the ability to communicate. When scientists know and don't know something, we need to get policy makers to not only focus on the unknown aspects of science.

The next participant spoke on the contribution of scientists to public policy and how to integrate their findings into something valuable. Specifically, how do we get former drug users integrated into society? The answer is to get scientists to work with social scientists on this and give them funding. Another issue is putting science into UN goals as a way of capitalizing on the successes of scientists, thus giving them more legitimacy.

The next participant spoke on attracting more people to science. A Ph.D. shouldn't be looked down upon and scientists need to be shown as human. The mass media often portrays scientists as odd, but scientists need to put themselves out there. Good female scientist role models are needed as well. In addition, connections with local communities needs to be improved.

The next participant talked about scientific literacy. Some people in the participant's group thought it was getting better and others thought it was getting worse. Scientists need to learn to better communicate with each other and the outside. Parents and teachers need to be encouraged to take a more active role in engaging children in science. The scientific process should also be taught much more early on.

The chair concluded the session by stating that the core points discussed in the session were the importance of education and communication strategies and skills.

Concurrent Session 104-G2: Smart Cities – Quality of Life

Session Chair

Rubinstein, Ellis, President and Chief Executive Officer, The New York Academy of Sciences (NYAS), U.S.A. [Nationality: U.S.A.]

Speakers

Akiyama, Hiroko, Professor, Institute of Gerontology, University of Tokyo, JAPAN [Nationality: JAPAN]
Feller, Gordon, Director, Cisco Systems, U.S.A. [Nationality: U.S.A.]
Komiyama, Hiroshi, Chairman of the Institute, Mitsubishi Research Institute, Inc., JAPAN [Nationality: JAPAN]
Petit, Antoine, CEO, Inria (Institut National de Recherche en Informatique et en Automatique), FRANCE [Nationality: FRANCE]
Rossant, John, Founder and Chairman, New Cities Foundation, SWITZERLAND [Nationality: U.S.A.]
Cheng, Vincent, Director, Building Sustainability Group, ARUP, HONG KONG [Nationality: HONG KONG]

Opening Remarks

The chair welcomed all first time participants to the STS *forum* and all participants to the Concurrent Session on Smart Cities – Quality of Life. He highlighted that how cities evolve will affect how the world will evolve, and that the opportunity for us to improve the world through cities was very large. He commented on the wonderful group of experts who gave their perspectives and brought up interesting ideas, and encouraged participants to try to touch on the real world that we see, both the exciting elements as well as the challenges with actual anecdotal discussion of the different things that are going on as opposed to just theory. He then provided the agenda for the session, and gave the first speaker the floor.

The first speaker commented on the science of city data and tapping into the wealth that comes from the data that can enrich cities but that hasn't been seen. He stated that cities were the living laboratory for where the physical and the digital were converging, and that it was a multi-billion dollar business. He highlighted the use of sensors in city assets, stating the effects on the way we work, the way we travel, our work-life balance, and the way we interact with the government. He continued that the Internet of Things (IoT) was things generating data, changing the business process, and changing the way people operate. As cities become activated and their assets become better utilized, cities can reduce their cost of operating and possibly increase their revenue.

The second speaker spoke about his personal experience in Japan encountering many issues in childcare, noting that children in Tokyo could not experience nature, problems with work-life balance, and narrow spaces in housing. He also brought up the issue of Japan's birth rate, which seemed to improve when efficiency was also improved, citing examples of telecommuting and the use of the Internet, commuting to Tokyo via bullet train, and developments in towns and rural areas of nearby cities.

The third speaker defined smart cities as a city that provided a good quality of life, and emphasized that a smart city should not only be connected and digital but also participatory. He commented on IoT, low power consumption devices, and the issue of security and privacy. He concluded by stating that it was our responsibility to turn our cities into

smarter cities, that new technologies have to find uses in order to be implemented, and that a strong involvement of policymakers was needed.

The fourth speaker shared that smart cities could improve quality of life by solving problems, such as through effectively utilizing communication, creating hope to let the younger generation innovate in the future, and improving the engagement of people. He noted that governments were recently more willing to release data so the public could use the information to improve mechanisms, and that the development of ISOs were beneficial.

The fifth speaker started off by highlighting challenges in an aging society. In 2030, one-third of Japan's population will be 65 or older, and this will greatly affect social security as well as the national economy. The elderly are also generally living longer and healthier, and are willing to work until the age of 70 or even longer. She noted that the fertility rate must be raised but that it is a long-term goal. She emphasized that healthy aging, lifelong learning, flexible schemes of employment, and technological innovation for men and women at all ages, and technological innovation for an age-friendly work environment were all important aspects in managing an aging society.

The sixth speaker shared that his organization helps shape a better urban future for all by promoting and fostering innovation, noted his interest in Japanese cities, and agreed with Prime Minister Abe's comments on the vital importance of building innovative ecosystems. The sixth speaker described three intersecting megatrends, including the creation of more sustainable models of life, historically unprecedented urbanization, and a tidal wave of game-changing new technologies, such as IoT and Cloud computing, leading to the creation of a real meta-sector of urban technology or Urban Tech. These technologies include renewable energy, mobility, smart homes, on-demand services, safety, and multi-modal transportation. In order to really reach its full potential, these new and emerging technologies are dependent on dynamic and innovative ecosystems in which governments, finance, industry, and society can work together to create open regulatory environments where innovation can really thrive. He also noted that global cities would be competing in unprecedented ways for global talent and to maintain their competitive edge. He concluded that he was very hopeful. In New York, for example, there are now thousands of startups in New York focusing on urban tech, and that startups affecting cities will remain the most interesting space for generations to come.

The chair then called on a guest speaker to comment on the subject of monitoring cities through the use of microbiomes.

The guest speaker commented that generally when collecting data, one wants to look at methods with broader coverage, good granularity, and that are non-permissive. Of two projects in New York City, the Microbiome Project looks at the microbiomes in our bodies that are constantly shedding which can be used to tell us about our nutrition, general health, drug use, and ethnicity. The sewers are a great collector of this material and the use of genomics should lead to interesting results. The second project was on the notion of passive, synoptic, persistent coverage – cheap sensors on the top of buildings in a city, able to watch thousands of buildings at once. This would collect data such as on light, heat, or plumes.

Discussion

The chair summarized that two of the most successful smart cities were Singapore and Songdo, but that compared to Barcelona where there was huge enthusiasm, now you have government changes and a group of people running the city who have never run a city before. He questioned what the challenges were in running smart cities and how IoT addresses those areas. He also noted the unique perspective on the continuum for rural and suburban cities being an important factor that is sometimes forgotten. He added that a really smart city could actually enrich the life of the people in the suburbs or in rural areas, and questioned the potential of what could be possible if IoT was utilized in early child development.

The first speaker commented on the density of human activity, a future state where we have greener electronics, and what the desired futures for a smart city were. He emphasized that the transition to a smart city was a green dilemma, and that there was hope that the science and technology agenda could be sharpened instead of remaking and rewiring legacy cities. He also noted the development of cities on oceans where 70% of the planet was underutilized.

The second speaker mentioned that smart cities were people based, that education on all the new technologies was a concern, and that we could get to a point where diversity and age were irrelevant.

The third speaker commented on the issue of insurance and healthcare, the economic models of cities, the construction of buildings in cities that already exist, and mobility within cities.

The fourth speaker summarized that city infrastructure had to be easy to use to improve quality of life, particularly for entry and exit; and that cities were commonly rated based on the success of enterprises, but that his concern was on all the data being concentrated in a handful of enterprises. His final point was on people moving into cities, but that manufacturing could be moved out and decentralized instead.

The fifth speaker highlighted the demographic changes in the labor force, the cultural response to labor force changes not being the same in all regions, and other concerns such as with pensions and mental health.

The sixth speaker noted the importance of more equitable cities and the potential dangers of smart cities, the potential rise of inequality, how to avoid a dystopian or Orwellian future where everything is observed and information is collected, the possibility of data being used as an instrument of oppression, and the theme of change itself.

The chair emphasized that a particularly promising area where a transformational change for the population could occur was in healthcare. He added that, in the world today, 50% of people over the age of 80 will have dementia, and that combined with the number of single child families such as in China will lead to a health disaster of incredible proportion if we don't have aging friendly cities with technology that allows those over the age of 80 to be at home as long as they can. The chair then briefly commented on the case study of collective action in Cincinnati where every area of society came together to come up with a plan to use data, thanked everyone for the rich conversation and excitement, and concluded the Concurrent Session on Smart Cities – Quality of Life.

Day 2

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

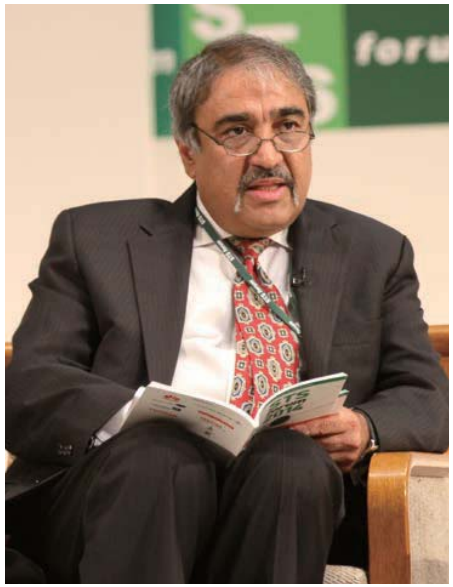
Plenary Session 200: Society Changed by ICT —Security and Privacy— (Dialogue among Political Leaders, Scientists and Industrialists)

Session Chair

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

Speakers

Serageldin, Ismail, Director, Library of Alexandria, EGYPT [Nationality: EGYPT]
Yamanishi, Kenichiro, Chairman, Mitsubishi Electric Corporation, JAPAN [Nationality: JAPAN]
Romine, Charles H., Director, Information Technology Laboratory, National Institute of Standards and Technology (NIST), U.S.A. [Nationality: U.S.A.]
Koanantakool, Thaweesak, President, National Science and Technology Development Agency (NSTDA), THAILAND [Nationality: THAILAND]
Saito, William H., Vice Chairman, Palo Alto Networks, K.K., JAPAN; Special Advisor - IT, S&T, Cyber Security, Cabinet Office, Government of Japan, JAPAN [Nationality: JAPAN]



Opening Remarks

Opening the session, Prof. Pradeep K. Khosla outlined the themes for discussion. Firstly, ICT has brought about revolutionary changes to many traditional industries. Another theme is how open and transparent collaboration in industry, government and academia can effectively foster ICT breakthroughs. The discussion will also cover the evolution of ICT from local proprietary systems to global networks. ICT has also disrupted industries and created new norms of living. To illustrate the power of ICT, Prof. Khosla cited the examples of Alibaba, Airbnb, Uber, and Facebook, which were all the largest companies in their respective fields, despite owning zero inventory. ICT has also fostered democratization and empowered a greater portion of society. Finally, Prof. Khosla explained that the two fundamental questions to be addressed by the session

would be how to deal with the vast amounts of data being generated and how to ensure data security.

Dr. Ismail Serageldin began by talking about how, through ICT, knowledge was becoming a complex living organism, that would require new modes of thinking to interact with it. At the same time, ICT also poses new challenges that we have never faced before. Specifically, Dr. Serageldin highlighted six dimensions of ICT, which were the increasingly blurred boundaries between human and machines, the rapidly expanding field of big data, the vast expansion of connectivity between people, connectivity between people and their environments, greater connectivity between machines, and artificial intelligence. Nevertheless, Dr. Serageldin reminded that we must not lose sight of real-world problems such as poverty, and the power of ICT and other science and technology must be supplemented by insights from social scientists.

In closing, Dr. Serageldin declared that the world was seeing the dawn of a new age, which had created a new world in which humans lived in an environment where the creation of knowledge was a thing of joy, and the sharing of knowledge a thing of beauty.

Mr. Kenichiro Yamanishi discussed the strategy for addressing the “lights” and “shadows” in urban development, with a focus on advances in ICT. First, urban development has brought about many challenges such as rising energy consumption, traffic congestion, and serious environmental issues. Natural disasters represent even larger risks as cities grow in size. ICT can contribute to urban progress, while also addressing its challenges. It will expand the boundaries of what is capable by human society. The Internet of Things (IoT) offers great promise, but we must address the issues of security and privacy that it raises.

Public awareness of these concerns, as well as carefully-considered regulation is also required. Governments have a responsibility to accelerate development of the necessary regulation, and to reach out and collaborate with industry.

Lastly, Mr. Yamanishi provided an overview of the efforts of Mitsubishi Electric to promote cybersecurity. The company has developed encryption technologies that have been deployed royalty-free via international standardization, and it remains committed to continuing R&D efforts in cybersecurity technology.

Dr. Charles H. Romine spoke about the role of the National Institute of Standards and Technology (NIST) and its collaborations with industry and academia. To begin, he touched upon the advent of IoT, which was seemingly inevitable. Dr. Romine likened it to the emergence of cloud computing, which posed similar concerns, such as loss of control and data insecurity. However, for cloud computing, much like IoT, the advantages are so compelling that they significantly outweigh the initial concerns. Nevertheless, it is a fact that alongside these advantages, new challenges and threats exist that must be addressed.

In this regard, NIST was instructed to work with industry on a set of voluntary guidelines for private sector companies that owned critical infrastructure to improve their cybersecurity. The many workshops held with industrial participants has helped galvanize much of the insight from companies, and the aforementioned framework is gaining traction. In addition, as another means of engaging industry, NIST has established the National Cybersecurity Center of Excellence. Furthermore, NIST is involved in educational efforts such as the National Initiative for Cybersecurity Education. Additionally, NIST houses the program office for the National Strategy for Trusted Identities in Cyberspace.

Overall, it is essential to have a larger more vibrant workforce capable of understanding cybersecurity issues. Nevertheless, we must not forget that end-users are human beings, who will behave as such, and usability is an important factor that cannot be ignored.

Dr. Thaweesak Koanantakool discussed the “lights” and “shadows” of ICT. On the one hand, society enjoys the benefits of the convergence of information and communication technology, as well the benefits of their interaction with other fields. These include the proliferation of small and convenient electronic devices in our daily lives, the power of social media to connect people across society, “smarter” facets of everyday life thanks to IoT, among others.

On the other hand, our interaction with ICT also produces vast amounts of data about our personal lives and habits that are sent and kept by service providers. Furthermore, government agencies such as the NSA track data about individuals. This can be used for a good cause and ensuring our security, but it can also be used in more harmful ways, such as spying on opponents for political benefits, which can lead to cyber war.

Dr. Koanantakool suggested that society may need innovation that allows private data to be stored in devices that are off-line to the public and completely controlled by the owner. Furthermore, social network users should be given the right to completely delete their own data, which is kept and apparently owned by the provider.

In this regard, government and industry have a responsibility to harness the benefits of ICT and ensure that it reaches as much of the population as it can, while also taking steps to mitigate any harmful effects. Every nation must enhance its own structure for dealing with such issues, and, at the same time, as these are technologies and issues that transcend national borders, there must be international collaboration as well.

Mr. William H. Saito began by citing the three "M's" that represented the most destructive forces in the world. The first is "Markets," the second "Mother Nature," and the third is "Moore's Law," which posits the exponential growth of technology. Mr. Saito focused on Moore's Law, and cited specific impacts on society, such as the rapid proliferation of communication technology and plummeting prices thereof, ever larger and ever cheaper data storage, and the increase in the average number of sensors on devices.

Next Mr. Saito spoke about another paradigm shift, as represented by the five "D's." These are Disruption, Demonetization, Democratization, Digitization, and Dematerialization. This is creating new forms of engagement, such as crowd-sourcing and the ability to solve

hard problems together, gamification, crowd-funding for entrepreneurial activities, and the sharing economy.

ICT has changed how we work, study and play. At the same time, however, it also poses challenges for humanity. For example, it creates challenges in education, in that ICT renders existing job types redundant. There is also the issue of hackers. In this regard, Mr. Saito introduced the acronym "ABCD," which stood for atomic, biological, chemical, and now, the newest and most dangerous form of weaponry, digital. There has been a transition from the age of the Cold War to now the Code War. Furthermore, though cyberattacks were originally logic-based, they can now result in physical attacks.

Next, Mr. Saito explained that, on the one hand, cybersecurity was highly multi-stakeholder and spanned many disciplines, which was why it was essential that it be discussed at venues like STS *forum*. On the other hand, cybersecurity is fundamentally a simple concept. It basically involves balancing the three sides of a triangle, which are security, usability and cost. Unfortunately, there is always a trade-off between the three. Logically, it is therefore not possible to have perfect security, and societies should instead strive for resilience.

To end his remarks, Mr. Saito concluded that this was no longer the age of the Internet-economy, rather the Internet has now become the economy. Cybersecurity is the fundamental enabling technology to the Internet and is what made the Internet a viable and serious business tool. For societies and economies to continue to develop, they must make advances not just in ICT but also in security.

Discussion

Prof. Khosla first asked the panelists to compare open source and proprietary systems and determine which was more beneficial.

Dr. Romine believed the more appropriate question to consider was how the software was being developed. More specifically, are the principles well-defined and do they prevent the introduction of known vulnerabilities? That being said, Dr. Romine thought that both open source and proprietary systems were able to foster innovation. The real issue occurs when software development lacks discipline and principles.

Prof. Khosla then asked the panelists to elaborate on the threat of cyberattacks resulting in physical attacks.

Mr. Saito stated that cybersecurity was increasingly being used for physical attacks. For example, during the NATO bombings in Libya, the radar systems were taken down using cyberattacks first, before the warplanes were flown in. More generally, the destruction of computers and power generators via cyberattacks is becoming increasingly commonplace.

Dr. Serageldin pointed out that in the past the more information was shared about a nation's arsenal, the more this served as a deterrent. Now, however, the opposite is true, and nations seek to hide information about their cyberattack capabilities. As such, traditional tools of diplomacy are no longer effective when it comes to Code War.

Prof. Khosla then asked the panelists to comment on the nature of privacy.

Dr. Koanantakool believed that privacy no longer existed, and private data were now owned by many different service providers and also governments.

Next Prof. Khosla invited questions from the audience. The first question concerned how to create regulatory framework for things like weaponized artificial intelligence and autonomous weapons.

Dr. Serageldin talked about how researchers were exploring the idea of ethical programming for such weapons. In fact, contrary to what one might expect, there may be some advantage to taking the human element out. For example, because of the bonding that occurs between soldiers, a study showed that 47% of soldiers surveyed said they would not turn in a colleague that they knew had killed civilian.

Mr. Saito recommended that as a first step, the international community must collaborate and share information, and understand that this was a common good.

The next question concerned Moore's Law. The exponential advancement of technology once drove the economy and job creation, but if that is no longer the case, how should human society respond?

Dr. Romine cautioned that this was not a zero-sum game and was confident that innovation driven by ICT and IoT would continue to fuel the creation of new jobs. The issue is not job creation but the distribution of jobs.

Dr. Serageldin agreed, pointing out that while ICT led to job destruction, it also fostered the creation of new types of job. The real issue is in keeping up with the unprecedented rate at which ICT has been advancing. However, Dr. Serageldin was confident that this issue would be overcome.

Dr. Koanantakool believed that there was much pressure for job transformation through ICT in countries all over the world, as some displaced workers may not be able to find a new job. While ICT created wealth and shifted wealth distribution by democratizing users, there are nonetheless some people who are still left behind the digital divide. It is up to governments to lead efforts to address this.

Another question was raised regarding how governments could encourage industry to play a role in cybersecurity.

Dr. Romine explained that rather than providing funding, NIST focused on forming partnerships with industry, based on trust that was built up over decades. In formulating the relevant guidance, NIST tries to ensure that it is flexible and scalable, thereby making it easier and more meaningful for industry to adopt. Such guidance fits into the regular risk management that companies are or should already be engaging in.

Dr. Koanantakool commented that in general, research and development in security and privacy was insufficient. Thailand, for example, lacks many of the research institutions and programs necessary for ensuring the required levels of cybersecurity technology among industry.

The next question touched on the recent Volkswagen scandal. How can we trust large organizations and businesses if we do not have access to the software and code they use for their products?

Mr. Saito suggested that, in a way, the Volkswagen incident showed that the system worked. While the private company tried to ensure its privacy and hide its code, an outsider evaluated this and blew the whistle when it identified that something was wrong. Afterwards, the public became engaged.

Dr. Serageldin said that because of the complexity of modern products and services, it was unrealistic for most citizens to analyze and check code and so forth by themselves. Instead, they have to trust and rely that someone is responsible for that. In many cases this is carried out by governments on behalf of their citizens. At the same time, ICT also enables whistle-blowing. For example, what Edward Snowden did would not have been possible if he had to individually photocopy every page of the documents he took.

A member of the audience then asked whether it was actually possible for governments to ensure privacy and if it was incentivized to do so.

Mr. Saito did not believe that was the case. He believed that with ICT transcending national boundaries, laws and regulations were no longer effective.

Dr. Romine pointed out that the lack of any clear ability to quantify and specify privacy meant that it would be difficult to ensure privacy. NIST is therefore working on the concept of usable privacy.

The final question was regarding how ICT would influence the power sector, and the panelists agreed that big data would open up new possibilities and have a very positive impact on the sector.

Concurrent Session 201-A3: Nuclear Technology Prospects

Session Chair

Kodama, Toshio, President, Japan Atomic Energy Agency, JAPAN [Nationality: JAPAN]

Speakers

Bamberger, Yves, Member of the French Academy for Technology, NATAF (French Academy for Technology); former Scientific advisor of the Chairman and Chief Executive Officer, Electricité de France (EDF), FRANCE [Nationality: FRANCE]

Birkhofer, Markus, Senior Executive Vice President, R&D and Innovation, Areva, FRANCE [Nationality: FRANCE]

Cashmore, Roger, Chairman, United Kingdom Atomic Energy Authority (UKAEA), U.K. [Nationality: U.K.]

Magwood, IV, William D., Director-General, Nuclear Energy Agency, FRANCE [Nationality: U.S.A.]

Yeh, Gong Ping (G.P.), Senior Physicist, Computing Division, Fermi National Accelerator Laboratory, U.S.A. [Nationality: U.S.A.]

Opening Remarks

The Chair opened the session with an explanation of the discussion points and the current situation in Japan. He noted that it is impossible to address all of the issues independently by one country, and it is therefore important to establish worldwide schemes to promote R&D. The OECD/NEA and IAEA could be good platforms for international collaboration.

In Japan, a new strategic energy plan was announced in 2014, and nuclear energy was defined as an important baseload power source, and in this context it is important to address various issues related to nuclear power, which are globally common issues for many countries. Japan Atomic Energy Agency (JAEA) is the only organization in Japan engaged in R&D on these issues, and they are engaged in development of various advanced technologies, however, this is too much to

handle by one organization, and JAEA is therefore keen to commence international collaboration on these issues.

The first panel speaker noted that low-carbon electrification is key to the future of the world, and stated that there are nine criteria for development – low impact on CO_2 emissions, low impact on the global environment, low land use, providing electricity when needed, using no fossil fuels, relatively low cost, broad use, no long-term impacts, and low risk for the population. Hydro is a solution, while nuclear satisfies seven of the criteria, and only fails on no long-term impacts and low risk to the population. He noted that if a lie is often used it does not become a truth. If the main risk for mankind is global warming, we must consider risks from nuclear accidents relative to the alternative risks. Nuclear accidents are a real risk, but compared to the risks of carbon emissions without nuclear he suggested that there is no choice. The question is whether all of the lessons from Fukushima are being used, including lessons from existing plants, and future plants. The use of UAVs or drones with sensors to collect data from the site and provide data to those in each country that can provide help and advice is something that needs consideration and preparations in advance of any accident. For new plants, it is important to prevent any significant off-site releases especially in the case of an accident. There was discussion recently at the Generation IV International Forum (GIF) on this point, noting that this has a significant impact on R&D for all new types of reactors. During the lifetime of a plant, maintaining the performance with introduction of new systems is a challenge, and collaboration with other industries could help. He concluded that former enthusiasm for nuclear is now a dream,

but to provide sufficient information for the public to consider nuclear as a valid alternative should be possible.

The second panel speaker spoke about light water reactors, where the EPR major design objective was to improve safety, but recently the major focus is on reducing costs and simplification rather than on safety. During the design phase there are many improvements that can be made to ensure that things are not over the required specification. However, innovation is also required. One area for innovation is accident-tolerant fuel that can withstand higher temperatures, and could also be designed to improve performance at the same time. As an industry we need to think systematically about what the market requires, including the return on investment for financing. Currently the payback period is 37 years, which is long for this industry. New materials can be looked at, and industry needs to work on integrating new materials.

The third panel speaker explained that the same questions often get asked in this area, and that the question on the future for nuclear power is mixed depending on the country, but overall nuclear power is growing and is not going away, although the geography of nuclear power has changed. In the past nuclear power was produced by relatively few countries, but today there is much more diversity both in the suppliers and customers for nuclear power plants. The question therefore is not whether nuclear power will exist, but what it will look like, and how it relates to our desire for a sustainable energy future. Many think that for an energy to be sustainable it has to be carbon neutral, but in isolation this is meaningless, if they are not economically-viable solutions, and they do not meet the needs of the people. In that context, light water reactor technology will be very important. Light water reactors are not very good at following load, and this could be an area to be explored. He concluded that it is certain that the future of electricity will be more complicated than it is today.

The fourth panel speaker commented that there will be an increased need for energy in the future, which will largely come from fossil fuels, and therefore to address CO_2 emissions all options must be considered including introducing renewable energies and nuclear, but enabling technologies such as storage technologies and grids must also be developed. Light water reactors are an old technology that has been with us for 60 years, and can be improved little by little, but in fact they are currently very wasteful in terms of the amount of uranium that they use. Therefore technologies such as fast breeder reactors and new fuel cycles must be considered. All of these new areas require R&D and new materials. The possibility of nuclear fusion must be considered. Nuclear fusion is seen as the ultimate

power source because it is sustainable and creates no CO_2 and no waste, and plentiful power. It is also known in principle that it works, but that is very different from making it a practical solution. It is hoped that it will be able to go into a burn phase, in which it will generate enough heat to sustain itself until the available fuel is consumed. A huge amount of related research is necessary to achieve this, as well as great vision.

The fifth panel speaker noted that fossil fuel carbon emissions are the world's biggest problem, and the world's biggest challenge is the energy consumption. He pointed out that investment in nuclear in the past year was only about 10% of that for renewable energies during the same period. Renewable energies can already annually add electricity equivalent to 50 new nuclear reactors. The 400 reactors in the world provide 2.6% of the world's energy, reducing carbon emissions by 2.6%. More than 200 nuclear reactors will be decommissioned in the next 20 years. He stated that thorium constitutes a very attractive alternative to uranium for nuclear power, as it can provide a tremendous amount of energy, and almost all of it can be used, compared to only about 0.7% for uranium. China and Russia are in a race for thorium technology, both looking to lead the world in this new source of energy. There are in October, 2015 an international thorium energy conference in Mumbai, India and a 50 year anniversary celebration at Oak Ridge National Lab in the US of the successful operation of the molten salt reactor experiment which ran for four years.

Discussion

Table 1

More positive discussion and interaction with the public is required for the immediate actions that need to be carried out, such as replacement of reactors which are being decommissioned. The shape of the industry has changed with a more active role of China and Russia, and there is a risk that past experience will be lost. There is therefore a more important role for international frameworks and the international organizations like IAEA or OECD/NEA to play in terms of safety standards and international regulation.

Table 2

It was noted that Fukushima was not primarily a technical problem but a criminal problem, because normal worldwide standards for nuclear operations had not been followed, and that the Japanese government and TEPCO had done a disastrous job of communication following the disaster, resulting in a lack of trust. It was stated that stability of regulation is key for investment in new and renewable energies. It is noted that the government in Japan

is issuing very difficult standards for cleanup of water for Fukushima compared with international standards. It was considered that nuclear energy has a large and important future, and trust is a major issue that must be addressed with consideration given to promoting the understanding of the people.

Table 3

Public acceptance is essential to address as the primary concern for nuclear power, which is a driver for many other things. It is essential to work with communities to explain the benefits and tradeoffs in contrast to the alternatives. It is also necessary to address concerns about safety at the same time as sustainability.

Table 4

Different countries take different approaches, with Germany deciding to phase out nuclear by 2022, which will be interesting to watch to see whether this can be a sustainable approach. Support in the US dropped following Fukushima, but has returned since, which shows that different societies react differently to worldwide events.

Table 5

There was discussion on waste treatment and public perception, and there is still a need to improve communication and to manage risk. There are 400 reactors operating in the world, which need appropriate technology investment to monitor them and for decontamination and end of life management. There is no alternative to building light water reactors, but there are newer technologies that can be applied, including smaller reactors, and reactors with faster return on investment. It is also important to enthuse younger scientists and engineers to work in this area. While there is a shift to thinking about gas, which is better than coal, it must not be forgotten that nuclear is better than gas.

Table 6

There was discussion on the use of molten salt reactors, and development on using thorium, and China is ahead in the development of this technology, and because of the possibility of small reactors development is easier. Advanced technologies developed recently have made this a much more viable approach. It was noted that if Fukushima had used thorium there would have been no explosion and it would not have been such a serious accident.

The Chair noted that one approach for organization of international collaboration is to use the functions of the OECD/NEA or the IAEA, and he asked one of the speakers to

comment on the prospects in this regard. The speaker explained that the NEA works with interested countries around the world on joint research projects covering many issues, but commented that the research on development of future technologies may not be sufficient, and therefore one current area of NEA activity is working with different partners to understand what research is currently underway in nuclear, and to identify the gaps in research, in order to provide greater support for national programs and to foster international research on those programs.

The Chair thanked the participants for their active discussion and brought the session to a close.

Concurrent Session 201-B3: Preemptive Medicine

Session Chair

Nagai, Ryozo, President, Jichi Medical University, JAPAN [Nationality: JAPAN]

Speakers

Anderson, Warwick, Secretary-General, International Human Frontier Science Program Organization, FRANCE; Former Chief Executive Officer, National Health and Medical Research Council (NHMRC), Australian Government, AUSTRALIA [Nationality: AUSTRALIA]

Danchin, Antoine, Chairman, CSO and founder, Amabiotics SAS, FRANCE [Nationality: FRANCE]

Goldstein, Rosie, Vice-Principal, Research and International Relations; Professor, Faculty of Medicine, McGill University, CANADA [Nationality: CANADA]

Hamsten, Anders, Vice-Chancellor, Karolinska Institutet, SWEDEN [Nationality: SWEDEN]

Hayashizaki, Yoshihide, Program Director, Preventive Medicine and Diagnosis Innovation Program, Research Cluster for Innovation, RIKEN, JAPAN [Nationality: JAPAN]

Nagayama, Osamu, Chairman & CEO, Chugai Pharmaceutical Co., Ltd., JAPAN [Nationality: JAPAN]

Opening Remarks

The Chair opened the session by outlining the complicated nature of preemptive medicine, which is a new kind of care in our information society. Many stakeholders are involved in the establishment of preemptive medicine, including researchers, patients, and the government, and the actions of international organizations are also needed.

The first speaker focused on the concept of immunometabolism. The progress in this area has revealed that the processes have an important role in almost all major diseases, including diabetes, cancer, and autoimmune diseases. It has also emerged that there are multiple components to the inflammatory response, and that a comprehensive understanding of the role of the inflammatory response requires a complete grasp of these components.

Inflammation is regulated by various mechanisms, which ordinarily maintain the individual. This can be used to identify disease inducing pathways. Inflammation can result from numerous different stimuli, and can lead to multiple different reactions. The major consequence of these insights is that inflammatory diseases need to be reclassified to reflect specific gene combinations, environmental factors, and pathogenic pathways. There are still many unresolved issues and challenges, but better understanding of the disease inducing pathways holds great promise for the development of treatment for inflammatory diseases.

In response to a question from another speaker, the first speaker spoke about differences across patients and the inadequacy of some animal models to reflect the human system, and called for clever human studies. He also discussed increased usage of assays.

The second speaker stated that he had performed calculations on the cost issue of preemptive medicine. Recently, President Obama launched the Precision Medicine Initiative and we are now facing an age when precision medicine will be the subject of national policies. The speaker said it was important to establish health systems to examine the elderly and disease risks. However, we must also consider costs and try to find solutions that are cost-effective. Some national policies are unfortunately cost ineffective, and social acceptance, the economy, and the mental climate of the society are important factors in these national policies.

The second speaker then moved to breast cancer, which recently became global news with Angelina Jolie's preventive mastectomy due to her risk of inherited breast cancer. He outlined a cost-effectiveness study of BRCA genetic testing, which showed calculations for Jewish women. The study showed that it was cost-effective to screen for Jewish women, but the speaker pointed out that this would not be the case for some population segments.

The second speaker made three final points, and first stated that his study showed that preemptive medicine is sometimes cost-effective and sometimes it is not. In addition, the idea of cost-effectiveness depends on the country. He finally said that we must prioritize national policies for preemptive medicine by considering unmet needs and cost effectiveness. The BRCA genetic testing case was a comparatively simple case, but it serves as a useful example.

The third speaker emphasized the newness of preemptive medicine, pointing out that chronic diseases, rather than infectious diseases, are now the challenge for many countries. The

frightening thing about this is the growing cost for governments to deal with these diseases. By understanding cells and their systems, we can detect diseases earlier and address them. It is vital that we convey to governments the cost-effective nature of preemptive medicine in order to place preemptive medicine prominently in the healthcare conversation.

The third speaker also stated that we need more basic knowledge of early steps. His own field is high blood pressure, but we still do not know what initiates it. Continued support of health research is crucial to find these and other causes.

The third speaker's final point was on the need for governments to enact sensible laws and regulations, which are essential for the treatment of chronic disease. For example, in Australia and other countries efforts to curtail smoking have produced positive results for the chronic diseases associated with tobacco.

The fourth speaker emphasized two points, saying first that no living organisms live in isolation – we all live with a large number of microbes. The public perception of microbes is that they are "bad," but the reality is that they are often extremely useful. The speaker gave the examples of metabolites and vitamin B12, and called for studies that take into account the microbes and the host. He also stressed the importance of viewing microbes as interconnected actors.

The fourth speaker then moved on to give examples from his native France, and advocated for increased discussions on fermented food. He emphasized understanding the quality of data, in this case for food. He stated that we must have proper knowledge of microbes, but unfortunately nobody is willing to pay for information. For this reason, incorrect information floats from person to person and because no one is willing to pay for the correct information, fallacies proliferate. The speaker called for the increased flow of correct information.

In response to a question from the floor, the fourth speaker elaborated on the blood brain barrier and vitamin B12. He said that there are many things that are not metabolized. A second participant asked about moving forward with studies of disease and metabolism given the multitude of the world's ethnic groups. The speaker responded by discussing studies on the benefits of traditional foods in different cultures. The studies isolated the microbes in the foods and found that there are common microbes. The speaker returned to fermented foods, and said it was very interesting to understand the metabolism of them.

The fifth speaker spoke from a pharmaceutical industry perspective, saying research has enabled us to begin to understand diseases, which in turn has helped the industry develop innovative solutions to treat the diseases. Pharmaceutical companies are increasing their investment in genomic testing to look at mechanisms. The major pharmaceutical companies are spending between $5-10 billion for research and development. The question of cost effectiveness and price has always been a significant issue, so companies must find ways to work with nations to ensure that people can buy their products. The speaker also mentioned the new players in the industry who are taking preemptive medicine even further.

The fifth speaker then changed the topic to the many social challenges of preemptive medicine. He said it is very important to encourage people to have healthier lifestyles and habits. By 2050, the world population will grow to over 9 billion and 22% will be 60 or older. This large elderly population will put great strain on the economies of all the nations of the world. We must encourage the elderly to actively participate in maintaining their own health, which will directly contribute to society.

The fifth speaker also emphasized that preemptive medicine is a new arena, and said that corporations must develop both domestically and at an international level. Efforts should include linkages of studies, and we should create a culture of collaboration between industry, researchers, and governments on an international basis. The use of advances such as big data will involve enormous costs, and it will be a long time until we can bring these costs down. We must discuss further these financial challenges and creating preemptive societies.

The sixth speaker stressed the importance of basic research, which is a top issue in Canada. Personalized medicine is rooted in basic research, and the best scientists at McGill University are working to encourage correct information throughout the world. She also stated that no single university or country can solve the various issues associated with preemptive medicine, and called for everyone to work together.

The sixth speaker outlined some of the initiatives at Canadian universities that are working on genomic research, and also urging the government to provide more funding. She explained studies that included examination of multiple sclerosis and connections between mental health and diabetes. McGill University is also looking at integrating the study of public health and training to implement and publicize breakthroughs.

The sixth speaker then moved to the topic of medical informatics in preemptive medicine, which is an opportunity that has not been completely taken advantage of. McGill University is working to bring together data to share medical information between hospitals and universities. Without this sharing, we will not be able to access clinical data and will thus remain behind the times. The sixth speaker closed by stressing the importance of genomics, and said we must create bridges between researchers, companies, civil society, and government. In response to a question posed by another speaker, the sixth speaker discussed networking of electronic health records and integrating data throughout Canada. She stated that Canada is not a leader in the networking of electronic health records.

In response to a question about neurodegenerative diseases, the sixth speaker said that in Canada, brain imaging, clinical information, and the work of neuropsychologists are being combined to look at early childhood to predict who is vulnerable, as well as the external environmental factors. A participant spoke up to stress that preemptive medicine should start from childhood.

A second participant asked about evidence-based precision medicine. Another participant stated that the failure of evidence-based medicine is that it "enhances the noise and decreases the signal." He said we must look at the properties of the individual and not large populations that exhibit diversity. The Chair said that we should integrate many types of data and discuss the best solutions at the level of the individual.

A participant spoke about detailed information collection in a heart disease study, and stated that big data will not help unless we have consistent data collection of good information and use it appropriately. An example of a good measure for this is asking patients to take pictures of the food they eat, which ensures that accurate information is collected.

Discussion

The first table discussed the measure of life expectancy, as well as the role of education in preemptive medicine, which ranges from diet to lifestyle choices. The group finally discussed government regulations on areas such as smoking and foods with high sugar content.

The second group conversed about diagnostic issues, including the use of biomarkers, which represent a major future for preemptive medicine. The rapporteur also stressed that we must pay attention to people who are not yet patients.

The third group had a diverse discussion, and said that in preemptive medicine we have short-term investments that will result in long-term savings. This must be conveyed to politicians. They also discussed preemptive medicine and precision medicine, including population strategies. The group agreed on the fact that preemptive medicine will result in significant changes in the taxonomy of diseases, with multiple disease phenotypes that entail different risks and treatments. Here, precision medicine will come into play.

The next table spoke about longevity, and stressed considering it from the very beginning at birth. Epigenetics is important to study quality of life. We must also consider risk factors and predict the onset of diseases such as Alzheimer's. Data collection is vital, and this entails the necessity of significant financing.

The final group also had a diverse conversation, which included the difference between preemptive medicine and preventative medicine. The rapporteur called for science education at younger ages, which will give people the information they need to make informed decisions on their health.

Following the summaries of the group discussions, a participant made the point that we should go beyond studying preemptive medicine from birth and should start at conception.

The discussion then turned to the topic of global prioritization. The Chair said that preemptive medicine does not necessarily need cutting edge technology, since even simple physical diagnoses are helpful. We must integrate knowledge and determine the priorities. To do this, scientists and policy makers must collaborate, especially on data collection.

A participant said that the government should take a large role, and should even go as far as to ban the smoking of tobacco. Another participant asked if there will be vaccinations for chronic diseases. A speaker said we are not quite at that stage, but that we can act in some ways such as preemptive measures for diabetes. Another participant stated that for the foreseeable future we will not see much progress in vaccinations against chronic diseases.

The Chair closed the session by calling for good healthcare policies that incorporate science in all countries. He advocated for the continuation of collaboration and discussion on the topic of preemptive medicine.

Concurrent Session 201-C3: New Manufacturing Technologies

Session Chair

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

Speakers

Daniels, Caroline, CEO and Chairman, Aircraft Technical Publishers, Inc., U.S.A. [Nationality: U.S.A.]
Kikuchi, Noboru, President, Toyota Central R&D Labs, JAPAN [Nationality: JAPAN]
Kuo, Way, President, City University of Hong Kong, HONG KONG [Nationality: U.S.A.]
Parkin, Robert, Pro Vice Chancellor (Research & Knowledge Transfer), University of Bradford, U.K. [Nationality: U.K.]
Reichental, Avi N., President & Chief Executive Officer, 3D Systems Corporation, U.S.A. [Nationality: U.S.A.]

Opening Remarks

The Chair opened 201-C3 New Manufacturing Technologies by introducing himself and the speakers before giving a brief statement. He stated that many manufacturing industries had been supported by consumer's great desire for consumption, benefiting both economies and individuals in their quality of life. However, he noted, mass production, consumption and disposal of industrial goods had led to a shortage of resources, and to environmental pollution and destruction. He continued on, explaining that such changes in society had greatly changed consumption trends by the rapid evolution of IT technology, and that there was a need for manufacturing industries to think about what and how they should make products to satisfy customer's needs. Then, before concluding his opening statement, he asked all participants to consider what kinds of technologies would be needed to support manufacturing industries in the future, while also realizing a sustainable society.

The first speaker opened his presentation by stating his belief that the current period of human existence was one of the most important to date, given the exponential development of technology and connectivity. As an example, he raised 3-D printing, AI, and other similar technologies, as developments that would define and reshape manufacturing industries to be more functional, customizable, and cost-efficient. Continuing on, he noted that economy of scale would also be challenged, and that the ability to tailor and customize would allow companies to create more immersive relationships between consumers and customers, such as through the disruption of supply chains in manufacturing, and the creation of patient specific procedures and medicines. In conclusion of his statement, he stated that these new developments would lead to a period of abundance and be socially challenging in many respects.

The second speaker opened his presentation by explaining that he would be discussing the need for cloud based manufacturing and connectivity. To begin, he stated that change was required because consumer demand was going at a faster pace, and cheap products were no longer satisfying customers. He conceded that product customization had been possible to some extent, but that it was not possible with pharmaceuticals and other very small volumes of specialized production. Moving on, he noted that global populations were growing at an astonishing rate, resulting in endangered elements such as helium, zinc, and platinum amongst others. He then discussed Industry 4.0, a cloud based approach based on distributed cloud based manufacturing, which could allow for reduced risks and logistics costs, culminating in quicker profits and delivery for manufacturers and customers respectively. In conclusion of his statement, he stated that mankind would need to remain wary of the vulnerabilities of such complex systems, and that new business models would also be needed in order to move forward.

The third speaker opened his presentation by introducing Toyota R&D Labs and exclaiming that in order to achieve sustainability, energy saving aspects of new technologies would

need to be utilized. As an example, he explained the fact that nearly 1/3 of car factory processes were devoted to painting that requires large amount of energy use. He explained that Toyota and other manufacturers were also interested in lighter weight materials such as CFRP to use in cars, more energy saving production line for batteries and fuel cells, and other similar reinventions of material processing technologies in order to save energy. In conclusion of his statement, he stated that moving forward, manufacturers would need to consider areas in their processes that could benefit from re-invention of already existing production methods, invention of new production lines combining 3D additive manufacturing methods, as well as innovations with IoT.

The fourth speaker opened his presentation by explaining that he would be speaking on reliability manufacturing. He stated that since the industrial revolution had occurred, mass production had moved to mass customization. He raised the quick overturn of automobile and cellphone ownership despite the products' long lifetime specs, as well as the changing environments around nuclear reactors, as examples. He exclaimed that design paradigms should be changed to be consistent with user profiles and environments. He explained that it would be important to look at how liability of manufacturing products on the user and design end were defined.

The fifth speaker opened her presentation by stating that she would talk about general aviation in relation to new manufacturing technologies. She explained that the industry was expected to expand in the coming decades, with the next objective to build efficient aircraft through capitalization on technology. She explained how 3-D printing would fundamentally change manufacturing of aircraft and aircraft components, and that with many aircraft requiring high power to weight ratios, biofuels would also become an important area of focus. Building on her point, she explained that the aviation industry had promised that it would meet reductions in emissions and environmental loads created in order to contribute to a more sustainable society.

Discussion

A representative from the first group stated that they discussed energy challenges in manufacturing; the unique opportunity offered at the STS *forum* for global collaboration; the need for new design parameters and engineering mindsets to understand the tradeoffs in lifetime and quality of manufacturing; 3D printed clothing; 3D printing technology as related to solar; how 3D printing will react to massive fluctuations in the market, investment,

and production; the dumping of waste and pollution in the third world; how new manufacturing tools can be leveraged to make highly recyclable products; and ensuring global quality standards in 3D printing.

A representative from the second group stated that they discussed designing for products' lifetimes; new manufacturing technologies disrupting traditional manufacturing bases, and its effect on the economy; education in manufacturing techniques; the importance of new technologies beyond 3D printing such as advanced robotics; autonomous machines that utilize AI; emerging industrial sectors such as hydrogen; the emergence of new materials like bio materials and bio composites; and new functionality, properties, and programmable materials to more easily recycle products.

A representative from the third group stated that they discussed 3D printing; materials issues related to 3D printing; microstructure control; the importance of analytical tools developed along with devices; 3D printed food; changing education and training in the manufacturing sector; and changing business models for 3D printing.

A representative from the fourth group stated that they summarized their discussions into three points which were that; a strong transition should be made from classroom learning to learning on the job; the influence of biology on new manufacturing was increasing; and that massive disruption to traditional jobs would occur as a result of new manufacturing techniques.

A representative from the fifth group stated that they discussed the tendency of products to be overdesigned and based on what manufacturers believe customers need, as opposed to what customers actually want; as well as modular products which would allow manufacturers' to explore the need between customers' needs and wants.

To sum up, the Chair added some words by saying that we also have to pay attention to energy challenges. Education was also a keyword that came from each discussion. He also said that development in ICT has brought an end to the era of mass-production and mass-consumption. He concluded by emphasizing that it is important to keep considering what we should manufacture to cultivate a sustainable society and how industry and academia can contribute. We need to consider customers' needs as a whole, along with the needs of the society.

Concurrent Session 201-D3: Global Resources

Session Chair

Behrendt, Frank, Director, Innovation Centre Energy, Technische Universität Berlin, GERMANY [Nationality: GERMANY]

Speakers

Halpin, Peter T., Chairman of the Board and Chief Executive Officer, World Resources Company, U.S.A. [Nationality: U.S.A.]

Mason, Glenn, Assistant Deputy Minister, Canadian Forest Service (CFS), Natural Resources Canada (NRCan), CANADA [Nationality: CANADA]

McDougall, John R., President, National Research Council (NRC), CANADA [Nationality: CANADA]

Zaabi, Wafaa Al, Member of the Board; Deputy Managing Director – Planning, Kuwait Petroleum Corporation, KUWAIT [Nationality: KUWAIT]

Zimmer, Markus, Economist, Ifo Center for Energy, Climate and Exhaustible Resources, Ludwig-Maximilians-University (LMU) of Munich, GERMANY [Nationality: GERMANY]

Opening Remarks

The chair opened the session by stating that global resource use was a particularly interesting topic for discussion, because all matters raised would necessarily have some relation to energy, be it forestry, electricity, economics, or minerals. All of these matters are related, especially when looked at in terms of the adaptations in systems and processes currently taking place worldwide. Raw material sourcing in particular has resulted in interesting new scientific, technical, and social challenges.

The first speaker began by addressing energy growth and its variation between regions due to differences in GDP and energy efficiency. In spite of the current discussion surrounding the use of alternate energy, such as in electric- or hydrogen-fueled cars, fossil fuels are likely to remain the overall dominant source of energy worldwide.

At the same time, resource development processes and environmental regulations are becoming more complicated and stringent. Operating costs for resource development are also rising.

There is a need for collaboration between energy producers and consumers, as well as for further innovation and technology. In Kuwait's case, oil accounts for more than 90% of the country's revenue. At the same time, Kuwait is also investing in oil hydrocarbon resources in order to contribute to worldwide energy demand and setting new targets for future renewable energy usage, among other environmental efforts.

Challenges surrounding the managing of resources are arising worldwide. Kuwait is developing different models of collaboration with international oil companies and service oil companies in order to develop resources and also to develop a road map for innovation and technology needs, in addition to beginning collaborations with research institutions and universities. The speaker asked participants to consider how to make scientific and technological development an attractive investment for businesses in order to address resource issues, and how a successful collaboration between consumers and energy producers might be created and utilized.

The second speaker discussed the current and foreseeable challenges facing global resource sectors by reflecting on the experiences of the Canadian Forest Service. In Canada's case, 20% of its GDP comes from natural resources. For that reason, Canada is focused on sustainable and environmentally responsible approaches to the development of its natural resources. Canada has been successful in this approach due to its strategic investment in science and technology, effective collaboration with its partners, and ensuring that its development is environmentally responsible.

Canada was built on its forestry sector, and it remains a vital part of the country's identity, society and economy. Canada has 348 million hectares of forest land; this is 9% of the world's forest cover and 24% of the world's boreal forest. It is also home to 43% of the world's independently certified forests.

However, the sector has faced challenges since the 2008 global recession in the form of the collapse of the paper industry, the appreciation of the Canadian dollar, and forest pests, which destroyed vast forest areas. The key to overcoming these challenges was a sector-wide commitment to investment in science, technology and innovation. The Canadian Forest

Service employs scientists and researchers whose work supports environmental performance and mitigates risks to safety and security resulting from fires and other disturbances. For example, the Canadian Forest Service developed the first national Carbon Budget Model which monitors, projects and reports on forest carbon stock changes and GHG emissions.

However, the forest sector continues to face new challenges, and innovation alone is no longer enough to meet these challenges. Canada is adapting its forest management practices to respond to the increasingly complex social and environmental context in which it operates. In particular, Canada's forest sector uses a collaborative approach to engage industry proponents, communities, ENGO's, and Aboriginal groups to secure the social license to develop Canadian forests in a sustainable manner. This model was successful in resolving the "War in the Woods" of the 1990s though the creation of the Canadian Boreal Forest Agreement. This Agreement brought together environmentalists, industry, and other stakeholders to resolve "wicked problems" and forge a common vision of sustainable forest management.

Based on its experiences, Canada has become a model for other resource sectors in how innovation, collaboration and a strong commitment to environmental responsibility will enable us to withstand future challenges.

The third speaker addressed the matter of water resources in particular. He wanted to raise an issue he felt was being under-addressed globally. In the past, environmental

management and control approaches tended to be focused on dilution. However, since then industrial innovation has created new kinds of materials, and the earth's population has increased dramatically. The dilution approach now faces two challenges: a reconsideration of the earth's capacity to absorb CO_2 emissions, and the new issues raised by the development of synthetic materials, which are now being introduced into our environment with uncertain consequences.

Water is vital to human life, and yet problems raised by poorly-managed and untreated water affect a great number of people worldwide. Developed countries have taken steps to address this through regulation in the past, and air pollution has also been addressed. But now may be the time to turn our attention back to water, where further issues seem to be developing. Human contamination of the water supply is a growing issue, and the effects are becoming more evident. Questions need to be asked about what the materials entering our water supply, such as pharmaceuticals, polymers, and plastics, are doing to our bodies and our environments.

We also need to examine how these materials are finding their way into our water supply and to think of ways in which we can address them, either by preventing their introduction into our water supply or by figuring out how to remove them. Now is the time to address this issue, and the speaker expressed his hope that STS *forum* would provide the opportunity for scientists to speak up about and draw attention to this issue. A basic knowledge of the issues affecting the water supply is necessary in order to begin to encourage corrective measures.

The fourth speaker addressed his personal focus on innovation and its role in increasing growth rates. In particular, investment anywhere within the energy material cycle has a moral equivalency. This impacts how and where we invest in improving energy efficiencies, all the way from material production through to recycling.

Referencing his presentation from the previous STS *forum*, he spoke about the importance of a commitment to the enforcement of environmental rules and standards. In a rule-driven environment, global resources become a major asset in contributing to social justice goals. At present, the global decrease in the growth rate has predominantly negatively affected growing countries and countries dependent on their natural resources for income.

The key to restarting growth lies in innovation, and innovation is particularly present in small and medium enterprises (SMEs). Large enterprises often seek to recreate the processes

of innovation they see in SMEs. But restarting growth requires innovation, and government investment in that innovation and the availability of resources and financing is essential. Long-term financial burdens on SMEs constrain both growth and innovation. The speaker stressed the need for businesses and financial institutions to have the courage to invest in and extend credit to SMEs in order to encourage higher rates of growth and innovation.

Government leaders should also show courage and encourage investment at all stages of the supply chain, as well as higher levels of environmental protection. The current economic and environmental conditions provide a unique opportunity. With the right set of rules and incentives, SMEs could become a natural investment vehicle for the growth of stable technologies. These requirements are not surprising, but few countries have stepped up to provide the necessary opportunities.

The fifth speaker added to the previous speaker's statement, elaborating that the German economy is very strong in terms of SMEs, which may be one of the reasons Germany has absorbed economic crisis so well in the past.

He went on to suggest that the defining of exhaustible resources in opposition to renewable resources may not necessarily be a helpful distinction. Exhaustible resources are usually thought of in terms of materials such as coal, etc. But is coal really an exhaustible resource? We as a society are unlikely to ever exhaust our supply of coal, because we know that the environmental effects of doing so would be overwhelmingly destructive. Furthermore, renewable resources also incorporate their fair share of limitations.

The speaker explained that he is currently involved in a project helping small German communities to utilize renewable resources. Renewable resource use begins on a local and communal level, which brings up its own set of issues. These issues are not always technological or financial, but may in fact be largely social in nature. Germany already has a relatively high level of penetration of renewable energy use. But the further this energy use progresses, the more problems arise. He listed the examples of the social and cultural rejection of new technologies, local costs, energy security issues, and land use conflicts, among others. But the most hindering factor is that there is always a more pressing issue than climate change at hand, such as, in the European case, the current influx of refugees. Even global resources will in the end be utilized locally, raising issues that exist not on a scientific but on a social level.

Discussion

The participants divided into groups to discuss amongst themselves. Representatives from each group then reported on the content of their group's discussion.

The first representative stated that his group's discussion had touched on the combining of renewable and fossil fuel products, as well as the government's role in driving and controlling energy consumers' behavior. Is establishing environmentally-responsible consumption a government responsibility or an industry responsibility? The relationship on a global scale between the various topics presented by the speakers earlier in the session had also been addressed.

The next representative said that her group's discussion had addressed the constant nature of change, and how the manner in which we interact with the environment must be properly examined in order to provide for and protect future generations. For example, the discharge of chemicals and pharmaceuticals into the water has already begun to effect the environment and ourselves in unpredictable ways. Furthermore, we must also think about how to fully utilize and reuse the resources we already have at hand. This should be addressed on an industrial level as well. In addition, climate change should be thought about in new ways, and steps must be taken now to address the inevitable changes to our environment that will occur in the near future.

The representative for the third group explained that her group had discussed water management from an international perspective, with participants from various countries discussing their respective countries' water systems and issues. Climate change has affected the water supply in all of their countries in a variety of ways, both those who suffer from water scarcity and those who may play a role in its creation. The urgency of action was stressed, as well as the need to create specified steps for progress and governmental involvement.

Lastly, the representative from the final table stated that her group's discussion had focused largely on the matter of global versus local, touching on pollution, specifically how it effects public behavior; possible steering measures; the transfer of energy and pollution from place to place as a potential way of addressing their effects; and local power structures as they relate to mitigating and taxing pollution.

The chair asked each of the speakers to provide their final thoughts. The first speaker stated that the issues affecting the environment affect all countries, and that matters such as

carbon taxation and proper planning should be considered in advance of the upcoming Conference of the Parties to the UNFCC. The second speaker drew attention to land management in Japan, stating that all resources are connected and that we as a generation will be judged based on how we handle and treat the natural resources we have been given. The third speaker encouraged the integration of whole-system thinking. We should think of ourselves as stewards of the environment rather than users. Though we do get caught up in the struggle to create a balance between the urgent present and the important future, we must not neglect the importance of education and communication with the public so that they fully understand the issues at hand. Next, the fourth speaker emphasized the concept of equal playing fields, and stated that the winners of an eventual international environmental measurement struggle will likely be determined by the governments holding the most power. Furthermore, in the struggle between energies, we must also allow for the consideration of fossil fuel use in order to provide a full understanding of what resources are available to us. Lastly, the fifth speaker expressed his belief that all countries are in some way resource countries, and while we have traditionally wanted to make full use of our resources and thus can now exploit them very efficiently, this has created new problems in that we have become accustomed to a lifestyle of free energy consumption. The issue of climate change has fallen from environmental scientists into the hands of social scientists, proving, he proposed, the desperation of the situation, and suggesting that no real solution is at this point actually expected.

Concurrent Session 201-E3: Collaboration among Academia, Industries and Government

Session Chair

Wallberg, Harriet, University Chancellor, Swedish Higher Education Authority, SWEDEN [Nationality: SWEDEN]

Speakers

Dolphin, David, Emeritus Professor, University of British Columbia, CANADA [Nationality: CANADA]

Kawabata, Shigeki, Vice President, Evolving Medical Solutions, Astellas Pharma Inc., JAPAN [Nationality: JAPAN]

Nunes, Pedro de Sampaio, Head of the EUREKA Secretariat, EUREKA, BELGIUM [Nationality: PORTUGAL]

Satomi, Susumu, President, Tohoku University, JAPAN [Nationality: JAPAN]

Sibisi, Sibusiso, Chief Executive Officer, The Council for Scientific and Industrial Research (CSIR), SOUTH AFRICA [Nationality: SOUTH AFRICA]

Opening Remarks

The Chair opened the session by introducing herself and her work as the Chancellor of the Swedish Higher Education Authority. Cooperation between industries, academia and governments has developed rapidly in recent years, she stated, but the way in which these linkages occur varies significantly by region. One reason is that universities are in the process of significant change as students are becoming more mobile with the advent of e-learning and other digital educational and networking tools.

What are the incentives for collaboration? What sparks innovation – and do we need to teach it beginning from the undergraduate level? What are the roles for each stakeholder? Going forward, these are some of the questions that must be considered in identifying the important assets and approaches in implementing collaboration, as well as the obstacles and challenges that may be faced.

The first speaker talked about the university-academia-government framework in the Japanese context. The government has been promoting industrial development and cooperation, but cooperation with private companies has not advanced in recent years. This is something that must change. He proposed that collaboration should be approached as a new kind of investment, which might incentivize industrial collaboration with the government and academia.

In Japan, there are a number of efforts to enhance multi-dimensional partnerships. These efforts have led to various projects receiving funds from diverse stakeholders. Each stakeholder can bring their own expertise, ensuring strategic cooperation and the development and protection of cutting-edge intellectual property. In turn, this leads to the commercialization of intellectual property originating in university research institutes or laboratories. The establishment of start-up clusters has also played a major role in driving innovative collaboration.

The next speaker touched on a success story of collaboration – the interface between academia and industry in the creation of the drug Visudyne. The drug began in University of British Columbia laboratories, to be used to eliminate the abnormal blood vessels in the eye associated with macular degeneration, for which there had previously been no treatment. After a decades-long process, the drug was approved in over 70 countries, and created a multi-million dollar market. The University of British Columbia took a 2% share in the invention, and he was able to spend half his time at the University, and half his time

at the company which was founded to produce and market the drug, where he was the Vice-President of Technology Development.

He said that this story demonstrates the potential benefits that come from industry-academia collaboration. Each stakeholder informs the other, and information sharing is possible. Productivity increases, and the challenge of raising capital, is alleviated to a certain extent by funds and programs established by the university or by the government. He has used this expertise to establish The Centre for Drug Research and Development, which is jointly funded by the University of British Columbia and the Provincial and Federal Governments.

The next speaker talked about the role of public research institutions. They must compliment the roles played by academia, industries and government. The ecosystem requires public institutions that are actively engaged in research, and transmit the research from academia to industry. He encouraged the participants to see the relationship as a triangular one, with each point occupied by academia, industry and public research institutions respectively.

He also noted that it is important to consider how to create a new industry, especially if it can support or expand an existing industry. South Africa, for example is very mineral rich, with over 60% of the world's supply of titanium. It is important to develop indigenous industries that add value to titanium. In South Africa, the Council for Scientific and Industrial Research's (CSIR) addresses these issues.

The next speaker said his current mission is to create new business fields in the pharmaceuticals industry. As the world changes rapidly, it is important to approach healthcare with the intention of addressing these problems and meeting the needs of world citizens while also stressing efficiency and convenience. Disruptive innovation is key. A different set of players must come into the picture, such as research institutes, IT industries, insurance companies and others.

The focus must shift from only trying to develop a breakthrough drug, to adding more strategic challenges such as involving various players and creating a flexible environment which emphasizes diversity. The role of government is to lead such a strategic direction, making legal provisions and implementing deregulation, thereby creating investment value and encouraging the participation of new stakeholders. In this way, research with a much wider scope than previously possible may be conducted. A system for partnerships should be established to facilitate such collaboration.

The next speaker described the EUREKA Initiative, an intergovernmental organization for the promotion and coordination of collaborative innovation. It was created 30 years ago in response to fears stemming from the advent of Star Wars and related strong support to projects from the US Government – risking the creation an innovation and technology divide between the US and the EU. Initially strongly Eurocentric, with 16 founding members, it evolved and currently has over 40 member states, partnering with quickly emerging economies. It is an organization that attempts to develop approaches for rapidly bringing research results to the marketplace in an efficient way, supporting collaborative projects between industry and academia, including start-ups.

At EUREKA, good ideas are assessed from a business perspective, in a process that is divorced from political considerations. It is bottom-up, flexible, and with short time to contracts. It has been very effective in delivering commercial successes that impact our way of living today, he concluded.

Discussion

The Chair touched on the usage of the term "ecosystem," and how it is important because it indicates that work is not necessary regarding just one stakeholder, but rather on the entire process. She broke the session up into discussion groups, by sharing the focusing conversation around questions, such as: "What should the role of each player be?" "How should change be driven in the ecosystem?" and "What incentivizes cooperation?"

A participant from Sweden said that successful collaboration is based on cooperation between industry and academia, where the government acts as a bridge. Making personal partnerships between entrepreneurs and researchers is also a source of potential collaboration.

A participant from Lebanon added that there are different standards and needs in different countries and regions throughout the world. What is needed in Kenya, for example, might not be needed in another country. It is important to provide an environment for innovation.

A South African speaker emphasized the point that confidentiality and the protection of intellectual property is a prerequisite in making collaboration happen. It is necessary to develop frameworks that allow for this throughout the world. The notion of academic mindsets must be addressed as well, especially when it comes to incentivizing innovation.

A participant from the United States, with experience working in both academia and industry, stated that one reason projects fail is that there is a lack of trust between the various stakeholders, leading to conflicting goals. For example, the government is often not educated about the importance and benefits of translating research into marketable products. It is the responsibility of academia to educate the government. On the other hand, academics are often not incentivized to conduct applied research. Therefore, it may be a good idea to facilitate a matrix between industry, academia and the government. In this way, stakeholders can discover commonalities, and share knowledge and lessons learned in a more effective and focused way. Many different projects could be efficiently jump-started, taking advantage of proven approaches and the appropriate experts.

It is also important to address the challenge of hedge fund representatives, especially for large-scale research projects which require significant funding, such as quantum computing. Hedge funds, which contribute significant financing, often want a share of profits and influence in the direction of projects.

A participant from Tunisia added that collaboration should be enhanced to better connect stakeholders in developing and developed countries. If this were to happen, researchers can be oriented to produce research with practical applications reaching across borders.

The group noted an initiative from Thailand, where 10% of university professors work in industry for three years. Their salaries are paid by the government over this time, and it leads to diversified experience and more collaboration.

A participant from Germany asked how to facilitate closer collaboration between university and academia and build trust. Industry often wants to purchase the rights to research or intellectual property, rather than collaborate strategically.

A participant responded that the aim of industry is to make money, while the aim of research is to develop new dimensions to fields and further careers. In this way, there is a conflict in aims.

A participant from the United States added that university timelines for project tend to be 3-5 years, while industry funding lasts six months to one year. In this way, there are different attitudes towards deliverables – with longer timelines, she said, significant research projects can be conducted, while shorter timelines make it difficult to produce true innovation.

A participant said that prioritization should be pursued as a future policy. Profitability depends on the problem that a new product can solve, and how it can be justified while balancing the healthcare and economic viewpoints. It is necessary to reconcile these perspectives.

In response, another participant said that higher education has a responsibility for stewardship of talent and innovation, which should dovetail with the industrial interests of driving growth and developing new markets and cash flows. In this way, the goals of academia and industry might not be irreconcilable.

A participant said that one possible benefit for industry funding academia is that representatives from pharmaceutical corporations have the opportunity to sit on the boards of the research centers or institutions they contribute funding to. They may not have veto rights or first rights to license products, but they can be involved in the decision-making process and therefore know the details of what research is being undertaken.

A university president from Sweden added that students are a key component in transferring knowledge between academia and industry – not just professors or researchers. As the labor force becomes more mobile, many students can be involved in many different aspects of the ecosystem, and this potential should be harnessed.

The Chair brought the session to a close, and thanked the participants for their input.

Concurrent Session 201-F3: Social Innovation for Sustainability

Session Chair

Kleiber, Michał, Vice President, European Academy of Sciences and Arts (Salzburg, Austria); former President, Polish Academy of Sciences; former Minister of Science and Technology, Polish government, POLAND [Nationality: POLAND]

Speakers

Al-Essa, Bader Hamad, Minister, Ministry of Education and Higher Education, KUWAIT [Nationality: KUWAIT]

Lamberts, Koen, Vice-Chancellor, University of York, U.K. [Nationality: BELGIUM]

Maex, Karen, Dean of the Faculty of Science, University of Amsterdam; Dean of the Faculty of Sciences + Faculty of Earth and Life Sciences, VU University Amsterdam, NETHERLANDS [Nationality: NETHERLANDS]

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

Wünning Tschol, Ingrid, Senior Vice President, Health and Science, Robert Bosch Foundation, GERMANY [Nationality: GERMANY]

Opening Remarks

The chair began by stating that the ideas in this session were important to human development around the world, and called for a free and open exchange of thoughts. Some important issues in social innovation for sustainability are defining sectors of sustainability that should be given priority, subsidizing communities in areas such as water supplies and energy, harmonizing various sectors such as NGOs and companies, promoting open-source innovations, and emphasizing best practices. In addition, a more multidisciplinary approach needs to be adopted in science. He then invited the speakers to make their opening remarks.

The first speaker stated that humans have always been social innovators throughout history. This is an important concept to bear in mind because we tend to think of innovation in terms of scarcity, when we should be thinking of it in terms of abundance, opportunity, and potential for the future. Thus, the current global challenges surrounding sustainability should be viewed as golden opportunities to foster innovation. The speaker then brought up energy, and how we need to think of energy as a place for opportunity, because the possibilities are potentially limitless. Indeed, while many people see the potential for a green economy as static, this way of thinking needs to be reformed, and a more opportunistic approach must be adopted. Food also offers opportunities for innovation; as some experts say we will have to more than triple the current food production rate to keep up with rapid population growth. Inventing food with higher nutritional value is one example of tackling this issue in an innovative and opportunistic fashion. The speaker also raised Hello Tractor, a system similar to Uber that supplies farmers in Nigeria and Niger with tractors, as an example of an initiative that is promoting innovation and prosperity.

The second speaker expressed his pleasure at being able to attend STS *forum* and said that the topic of this session was very relevant to his home country of Kuwait. He then raised the point that the culture of a society often dictates the technological developments, and in particular, a society that doesn't value education will have difficulties. Kuwait is a country that has actively pursued improvements in education by emphasizing multi-disciplinary approaches. He also emphasized that education and training are important factors towards innovation, as is the proliferation of the internet. Another factor in promoting sustainable

development is ensuring that the public and private sectors are simultaneously engaged, and that they provide transparent information to each other.

The third speaker discussed how the discovery of the transistor effect mid-last century has led to the present interconnected network society, which has changed the heart of our society. For example, in science, materials are designed at an atomic level. The capabilities of computers and A.I. have evolved enormously and the possibilities of Big Data have resulted in a paradigm shift in other disciplines like economics, social sciences, and the humanities. As a consequence of ICT, a network society has emerged, changing interpersonal communication as well as the democratic and political environment. It is to be questioned whether a focus on jobs and market is sufficient for social innovation towards a sustainable society. For that, a sound public debate and increased literacy in science and technology are mandatory. The speaker then called for increasing investment in all levels of education in order to ensure sufficient literacy in science and technology as well as in social sciences for all future university graduates.

The fourth speaker stated that innovation occurs because when technology develops, changes in behavior inevitably happen as well. Therefore, it is evident that these changes in behavioral issues need to be addressed. Commercial and collective interests are also important to address because while they can be aligned at times, there can be gaps between them. For example, in the US, there is a vigorous debate between these two interests over energy and climate issues. This shows that it is necessary to change societies in a fundamental way to bring about change. Income inequality and business views are two other major factors in a society's willingness to tackle environmental issues. The speaker then stated that further studies in these areas are essential to driving further sustainable innovation.

The fifth speaker spoke on the role of social sciences and the humanities in driving social innovation for sustainability. While we have abundant technological knowledge and ability to improve science, there are often barriers to applying these innovations in real life. In order to effectively apply these innovations, further collaboration with the social sciences to influence policy makers is needed. Research has shown that hard sciences have solved many problems in terms of using greener systems. Yet, consumers continue to employ less green methods because there is currently an inability to implement and communicate the developments in science and technology. Social scientists can help facilitate this. This is important to note because people often opt for what is convenient and familiar rather than what is logical. The power of "nudging" citizens by the governments is effective in filling this

logical gap. The speaker then raised the town of Schonau, Germany as an example of a town that was successfully nudged by its local government to adopt greener policies. Along with nudging, education can be important, but is often not sufficient, and a comprehensive and balanced approach is therefore the most effective approach. Using innovative nudges such as a stairway in Nanjing that plays a piano song when you walk up and down it, thereby encouraging people to do something for their own health, can provide solutions for sustainable development.

Discussion

A participant asked for further clarification of the term, "social innovation" and its effect on the development of societies. To one participant, this term meant trying to involve all aspects of society in finding solutions. It was brought up that mobilization of society is indeed important and that there are three pillars of innovation that must be addressed along with mobilization: science and technology, social, and business innovation. These three pillars must be integrated to bring about the mobilization of society. The Integrated Innovation Institute, a joint initiative at Carnegie Mellon University's College of Engineering, was raised as an example of an institute that is currently bringing these three pillars together in a comprehensive way.

One participant brought up his experience as a journalist and his work in Cincinnati, which is a city that has successfully improved its education system using integrated data and approaches. The speaker then addressed the UN development goals in Africa and stated that its success has been due to an integrated approach to development and social innovation. As recently as 1998, sustainable responsibility was ignored by many business and policy makers, but that has changed rapidly. It was then brought up that the US has created a new model of sustainable innovation that brings together actors from all aspects of society, and has made significant strides in sustainable development. This came about because it was recognized that no single sector could solve all issues. Chattanooga, Tennessee and San Diego, California were brought up as examples of US cities that saw an economic turnabout due to an approach that brought all levels in society together.

Another point that was raised during the discussion is that there are still many people throughout the world who have a negative view towards science and technology because they believe it will harm their culture and way of life. This is unfortunately true in many developing countries and exacerbates economic woes there. While this certainly needs to be

addressed, another speaker emphasized that traditional knowledge needs to be respected at the same time. There are communities that, while they may not have a traditional view of scientific methods, still have much to contribute to innovation. The local context must always be taken into consideration as there are many different cultural perspectives in the world. A participant raised the example of the Middle East, where people often expect the government to take care of society and to provide innovation. This is important to recognize because it highlights the diverse situation of the world.

A question was raised regarding nudging and how it can be calibrated. A participant asked how the correct balance in terms of nudges can be found and how we can ensure that nudging doesn't infringe too much on personal rights and freedoms. Another participant answered that the solution relies on a balance with improving education at one level and making intelligent policy decisions on another.

A participant stated that that in his native country of Sudan, a diverse country with many types of people, there are many views on social innovation. In particular, there are groups in Sudan that accept technology, while others are more reluctant as it may infringe on their culture.

Another participant called for further responsibility in social innovation. In particular, someone needs to take charge because responsibility is too often passed down. Furthermore, changing the facades, even in small ways, in many areas of society is necessary. For example, in Dubai, they have changed the aura of the immigration office by offering sweets and providing a friendlier vibe.

Another participant asked if education, innovation, and creativity really work hand-in-hand, as there have been many failures in this regard, especially in more rural areas. It was brought up that innovating together from the beginning and identifying what needs to be integrated is what needs to be addressed to solve this dilemma. It was then brought up that this approach is indeed what is necessary, and that addressing these problems from the beginning is the only way to promote social innovation.

With that final comment, the chair closed the session, reflecting on the variety of issues that were discussed, and praised the open exchange of ideas that had taken place.

Concurrent Session 201-G3: Internet of Things (IoT)

Session Chair

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

Speakers

Brandenburg, Karlheinz, Director, Fraunhofer Institute for Digital Media Technology IDMT, GERMANY [Nationality: GERMANY]

Francis, David, Cyber Security Officer, Huawei Technologies (UK) Co., Ltd., U.K. [Nationality: U.K.]

Kant, Peter, Executive Director, Center for Science, Technology and Economic Development, SRI International, U.S.A. [Nationality: U.S.A.]

Kranz, Maciej, Vice-President, Corporate Strategic Innovation Group, Cisco Systems, U.S.A. [Nationality: U.S.A.]

Kuwana, Eiji, Head of Science & Core Technology Laboratory Group, Nippon Telegraph and Telephone Corporation (NTT), JAPAN [Nationality: JAPAN]

Sakamoto, Yasuo, Vice-Minister for Policy Coordination, Ministry of Internal Affairs and Communications (MIC), JAPAN [Nationality: JAPAN]

Sasse, Angela, Head of Information Security Research, Director of the UK Research Institute in Science of Cyber Security (RISCS), University College London, U.K. [Nationality: U.K.]

Opening Remarks

The chair greeted everyone a good morning, provided the agenda for the Concurrent Session on Internet of Things (IoT), and gave brief introductions for each of the speakers. He stated that IoT is interconnecting the cyber world with the physical world, that there are more devices speaking to each other than people, and there will be more than 50 billion devices by 2050 which will both improve quality of life as well as expose us to vulnerabilities and increase our attack surface.

The first speaker commented that if we want security that works, we have to make it easy for people to do the right thing. When looking at security management, company policies, and compliance of employees, she found that in most cases there was a lack of compliance with those security policies. The first ground rule that has to be set for functioning security in IoT is that it has to be transparent and easy for one to see how devices are behaving when it comes to data and to be able to make decisions about it. Oftentimes the government will advise the use of virus protection software, but many do not know the level of security that is being implemented in the use of that software, which raises many questions. Trustworthy professional services are needed to deal with complicated issues, leaving users free to make choices about what business they want to accept in order to receive the benefits of these services. She also touched upon the issue of lengthy privacy policy agreements and emphasized that we need to look at the contracts in this space and how trustworthy agents collaborate in order to keep our workplace and homes secure. Attackers are already collaborating and sharing information on individuals, and paying each other for that information. We need to get to a situation where corporations and consumers work together.

The second speaker spoke about network sensors creating big data which will be stored in the cloud and be led by 5G to provide concurrency and capacity in the networks. Cheap devices that have small processors and components, a small memory footprint, and long battery life will also influence spaces in healthcare, education, and green energy. However, these developments will also lead to a massively bigger attack surface that can be targeted. As a result, trust is vital since society will increasingly be reliant on these networks and they will be absolutely critical in our day to day lives. He then questioned how to achieve fact based trust that was based on analysis – What is in the device? How is the device secured?

What assurance mechanisms have been put around it? It is about active management in the global supply chain, about getting people involved in the thought process, thinking about what buyers demand when looking at technology, and taking a holistic approach to security. You can build a very insecure network with secure products if put together incorrectly; you can also build very secure networks from insecure products if put together correctly. Do we have the will to work together to define what “good” looks like? Do we have the will to produce international standards so we can genuinely assess between good and bad? We need to think of the challenges and evaluation of IoT and how we can secure our future.

The third speaker stated that IoT has led to the revolution of consumer experiences and enterprise processes, and that much has been debated on its game-changing impact, eventually interconnecting cars, devices embedded in buildings, and infrastructure. When utilized with big data analytics and networking and communication, things can be controlled and optimized. IoT will bring about more value, efficiency, and autonomous services. The idea of a system of systems generates a distinct coordination of value chains. Although we have an array of enabling technologies for IoT, such as small devices with low power consumption and wireless connectivity, IPv6 Protocol, and learning functionalities, there are many issues to solve for the world of system of systems. One of the technical challenges is that real time data from multiple sources requires tight feedback of sensing and control around 10ms or less. Scaling the huge amounts of data, up to several exabytes, the velocity of data production and consumption will be enormous for some applications, such as with high precision image data analysis and sensor data analysis for receiving real time traffic information, around 43 gigabits per second. This locality and distribution of data computing may be key to handle this volume of data. One of the characteristics of IoT and the system of systems is that it is a self-propagating evolution. How will we balance public benefit and individual rights? Who is responsible for system malfunctions or failures? We must study social, ethical, and legal implications as IoT will change the way people work and the way society will make decisions.

The fourth speaker believed that IoT will have a greater impact on the world economy than the Internet had over the last 25 years. But why now? What he observed was that it was the business outcomes that were driving connectivity. Over the last couple of years, the line of business, people that run assembly lines, oil fields, and logistics systems, have become the primary buying center, looking for business outcomes and solutions, which is driving a huge migration in how the IT industry is operating. As a result, there is also a convergence of IT and OT. The business outcomes are driving the connectivity as well as the need for the data

to travel from the plant to the enterprise to the cloud. Lastly, the migration from proprietary systems to open systems was also driving connectivity. The three key use cases of IoT that he noticed were a focus on real time data, the question of scale, and the amount of data we process. A connected vehicle uses about 2 petabytes of data per year, and oil rigs generate about 5 terabytes of data per day. In a couple years, this data for oil rigs will increase to 20 terabytes per day. Connecting and assessing these oilrigs in real-time can increase productivity. This means that there will be a huge migration in the industry, and the winners will be companies that embrace open systems and architectures. Ecosystems of partnerships must be built to deliver solutions, and the open architectures are needed to connect all the enterprises, plans, and the cloud together. Losers will be companies that stick to the old models. When you look at the S&P500 companies over the last 51 years, only 19% of these companies still exist. He believed that in 10 years only 40% of those companies will exist, as the rest will miss the transition from closed and proprietary systems to open and eco systems due to the impact of IoT.

The fifth speaker commented on researching the nexus between government and technology, and what he found was that no one really knew what IoT truly meant and where to focus. Trying to categorize threats has been difficult and where industry should focus is important. There is not really a good framework for dealing with these challenges. As responders use interoperable communications, GPS environments, and other interconnected devices, what happens when the link between those devices is disrupted? The focus is primarily on law enforcement and the security community being the first places to secure. Can the weaknesses of IoT be its security strength? The huge amounts of data, devices, and significant amount of data analytics and algorithms could be the technological barrier to entry. They also have to go through petabytes of data.

The sixth speaker stated that IoT was already here, that it was just missing some of its potential because it was missing interoperability, and that the estimate of 50 billion devices by 2050 was too low. Connected devices are here – window shades, lights, heating, sensors, TVs, smart grids, microwaves, coffee makers, or refrigerators. On the application side, the standards are different. He provided an example in the music industry where they failed to tie content purchases to devices as there wasn't enough interoperability or a defined set of standards. He also questioned the design of backdoors for governments in these devices.

The seventh speaker stated that a new global space where everyone was connected will be achieved, and how to utilize this space will be a challenge. The economic value of IoT

will be achieved by maximizing the creation of high added value and streamlining through networking, in other words, increasing the value of information dramatically by bringing transformation of information in both quality and quantity. In Japan, IoT is utilized through water and mud slide level sensors in the area of disaster management; maintenance data is used in infrastructure to prevent the collapsing of bridges; and actively utilizing sensors and wearable device technology in the field of medicine. It is expected that the utilization of IoT will be promoted in many fields, changing the economic system and the way we work in the future. Japan has also been working on the utilization of 5G before the Tokyo Olympic Games in 2020. The most important role for government is creating an environment where society can enjoy the benefits of innovation as soon as possible, and to enhance public private partnerships and international cooperation.

Discussion

The second speaker commented on if it was possible in the modern era to have a rigid definition of critical national infrastructure, in the US being defined as the network. He questioned if society felt comfortable with a camera on it instead of a police officer; what the cultural impacts of privacy were, what is considered privacy in different regions, and what governments should be doing about privacy; and should citizens do nothing or move toward a society where the individual has more power? In cases such as with Instagram, individuals were able to wield that power. He noted that security must be built-in, instead of being a bolt-on approach.

The third speaker stated that ownership of data was a main theme since IoT was commonly thought of as a huge collection of data. He also questioned how to define the authenticity of the data. How do you know from the vast amounts of data that it is coming from a legitimate source? The next step forward was the social network of things where machines and things would be able to communicate with each other.

The fourth speaker discussed the parallels in dealing with cybersecurity with bio. A culture of responsibility that is being embedded in the bio field should be adapted or exported to the world of IoT and security. He also stated the challenges of governments in the design of the regulatory environment to keep up with the acceleration of technology deployment.

The fifth speaker pointed out that it was the Internet of Everything as opposed to just IoT. When thinking about security and privacy, many solutions are already present when looking

at the frameworks for secure devices, secure networks, and secure people. However, there was skepticism in the ability of governments to effectively deal with this particularly due to the machine-to-machine issue, as well as the rate of change of scale. The challenge is that we do not know exactly what the impacts of IoT will be over the next century.

The sixth speaker summarized a discussion on biological and chemical entities, or nanostructures, in our bodies; implants; and security issues. He agreed that security should be implemented from the very beginning instead of being tacked on at the end of development. Interoperability had also been raised and there was clear consensus that it was a central issue for all discussions to come. He also discussed national solutions versus international solutions, who the authority was to deal with the standards for operability, as well as the effect of IoT on education.

The seventh speaker noted healthcare opportunities using data from sensors and wearable devices and his group discussed issues such as the opportunity to correlate data, context in terms of application and culture, IoT in emerging technologies, using leapfrog technologies in developing countries; the application of IoT in environmental applications; solving problems of interoperability and standardization; solutions for measuring security; security by design; and the issue of poor user interfaces.

The chair then thanked all participants and speakers for the intriguing discussion and concluded the Concurrent Session on IoT.

Plenary Session 202: Global Health

Session Chair

McKinnell, Henry A., Chairman, Moody's Corporation, U.S.A. [Nationality: U.S.A.]

Speakers

Yamanaka, Shinya, Director and Professor, Center for iPS Cell Research and Application (CiRA), Kyoto University, JAPAN [Nobel Laureate 2012] [Nationality: JAPAN]
Zerhouni, Elias Adam, U.S. Science Envoy; President, Global R&D, Sanofi, FRANCE [Nationality: U.S.A.]
Reinhardt, Jörg, Chairman, Novartis A.G., SWITZERLAND [Nationality: SWITZERLAND]
Weber, Christophe, President & Chief Executive Officer (CEO), Takeda Pharmaceutical Company Limited, JAPAN [Nationality: FRANCE]
Hood, Leroy, President, Institute for Systems Biology (ISB), U.S.A. [Nationality: U.S.A.]

Opening Remarks

Dr. Henry A. McKinnell began the session by sharing a statistic that he felt demonstrated the most remarkable development in global health in modern times, which is that during his lifetime, the average life expectancy had risen from over 60 years to over 80 years. It is clear that there has been remarkable progress in life sciences. Even in developing countries, though there are still concerns with regard to life expectancy, there are also promising trends and developments.

Every 100 years there are on average two global pandemics, so the world is overdue for another. Ebola emerged and could have been such an epidemic, but it was somewhat contained, although it did highlight many areas in need of urgent improvement.

There have also been great advances in gene and cell therapy, which holds promise for the future, but we must also consider who bears the cost of such research. The importance of regulation and communication with regulators must also not be overlooked.

Prof. Shinya Yamanaka began by sharing the story of how his father convinced him to pursue a career in medicine. His father passed away from Hepatitis C 27 years ago and when he was diagnosed there was no cure. Now however, there is a simple solution, in the form of a small daily tablet. This demonstrates the great progress medicine has made in recent years. There have also been developments in stem cell research and stem cell-based research, which give great reason for optimism.

However, though breakthroughs have been achieved, many of the new medical treatments to emerge are very expensive. Furthermore, for the more novel and experimental treatments, it is not yet possible to predict whether patients will respond to the medicine or not. Despite this, patients must still bear the huge expenses. We must therefore both lower the cost of medical treatment, and identify ways to predict which patients will respond well to particular treatments.

Dr. McKinnell commented that one of the problems of stem cell therapy was that stem cells were not only expensive to develop but also to manufacture, as that was effectively done at the bedside. On the other hand, small molecules, though expensive to develop, are not that expensive to manufacture. They can be manufactured in factories and then transported around the world. Dr. McKinnell asked if, based on his research, Prof. Yamanaka thought it would be possible to replicate the effects of cell therapy using small molecules.

Prof. Yamanaka thought it was certainly a possibility. He explained that development of the cells was carried out outside the patient and then transplanted, which was very expensive. In addition, there is a need to evaluate the results afterwards as these are totally novel emerging therapies, which is again very expensive. Prof. Yamanaka said it was his hope that one day the science in question would make significant enough progress such that such high costs did not need to be borne, and that cells themselves could be rejuvenated from inside patients' bodies.

Dr. Elias Adam Zerhouni agreed that progress was being made in medical treatment, pointing out that infant mortality was falling while the life expectancy of those new-born children was rising. That being said, a number of challenges exist. First there is a need to enhance

the health systems that are responsible for applying such medical treatments and also for preventing disease. There has also been a rise in international pandemics exacerbated by the global nature of our society. Chronic diseases are also growing.

Elaborating on the first challenge he mentioned, Dr. Zerhouni believed that health systems needed to be enhanced, not only in developing countries, but also developed countries, where vaccination rates are falling and chronic diseases are rising. Moreover, national systems alone are not enough. There needs to be a global system in place, and the lack thereof was made painfully obvious by the recent Ebola outbreak. Furthermore, in terms of global post-regulation, Dr. Zerhouni referred to his own experience overseeing R&D at Sanofi, saying that of all the regulatory decisions made relating to his company's products, in not a single instance did the regulatory bodies in different countries or regions make the same decision on a particular matter.

Dr. Jörg Reinhardt commented that the pharmaceutical industry had a responsibility to continuously generate innovative medical treatments and technologies, and secondly to ensure that they are accessible to as many people as possible. The pharmaceutical industry is struggling more with the latter. Novartis is now making efforts to provide essential medicines at affordable prices to populations in developing countries in collaboration with their governments.

Mr. Christophe Weber stated that although progress had been made in global health, such progress was not linear with certain areas lagging behind others. Furthermore, as the other speakers noted, greater effort needs to be made to make medical treatment more accessible. The key question that needs to be addressed in this regard is who will fund the necessary R&D.

Dr. McKinnell explained that pharmaceutical R&D was not only expensive, but 80% of projects fail. If a successful drug is developed, a patent can be secured, lasting for 21 years, giving the company a monopoly to recoup costs. However, in the biomedical sphere, even if a patent lasts for 21 years, it could take 15 years to develop the patented drug, incentivizing the company to sell it at a higher price to recover its expenses. Therefore the reason drugs are expensive is because they are expensive to develop, and not because they are expensive to manufacture.

Dr. Leroy Hood spoke about how the concept of wellness was transforming medicine. This is primarily being driven by four factors, which are systems medicine, big data, digital devices

that provide personalized measurements, and social networks. This has resulted in P4 medicine, which is predictive, preventive, personalized and participatory.

Dr. Hood then focused on the concept of placing the individual at the center of medical treatment. This is characterized by treatment that is proactive not reactive, a focus on the individual not a population of individuals, a focus on wellness, the creation of dense dynamic data clouds for each individual that will be aggregated for medical testing and research in the future, and social networks and engagement of the public to transform the currently conservative healthcare system.

Moving onto the work of the Institute for Systems Biology, Dr. Hood explained that in 2004 the institute decided to create a longitudinal study with dense dynamic data clouds for over 100 people, based on which the lab would propose actionable items to optimize wellness and prevent disease. A key element was the coaches for these people who provided simple explanations about the science and gave advice regarding the actionable items. They were effective and in 70% of cases they convinced the individuals to act on the aforementioned actionable items.

Dr. Hood then highlighted a few important points to note from the study. First, there was strong emphasis on making personal medical data available to research institutions

for study. Secondly it is possible to use GWAS data to identify genetic risks for about 50 different diseases. Finally, there is the striking possibility that, for the first time, it may be possible to address problems of aging and reduce the huge expenses that are incurred at the termination of a disease.

Summing up, Dr. Hood said that the 10,000 dense data clouds his study would produce would transform how pharma, biotech, and nutrition companies deal with the signal to noise problems that continue to plague them. In addition, the digitalization of medicine is fast approaching, which will significantly reduce the cost of assays and make studies such as those carried out by the Institute for Systems Biology available in both developing and developed countries, thereby democratizing healthcare. Finally, scientific progress offers the potential to optimize one's human capital to function physically and mentally until the end of our lives, and allow us to understand diseases as we always should have and visualize the wellness to disease transition.

Dr. McKinnell pointed out that the medical system was paid to treat disease, not prevent them. Therefore it is more like a disease system than a health system. Secondly, people do not always lead their lives in ways that would maximize their wellness.

Dr. Hood explained that the coaches in his program, who had medical and psychological expertise, played a critical role in helping people act on the actionable items for their own wellness. Regarding covering the costs of disease prevention, he explained that wellness lay at the heart of prevention and suggested that first, individuals should pay for wellness and later insurance companies should do so as it will save them from paying for future medical expenses.

Dr. Zerhouni agreed that the healthcare system drove the fact that healthcare was paid for, whereas prevention was not. He believed the question of healthcare and wellness could not be separated from macroeconomic incentives and the system. For example, the high level of fructose and sugar found in food in recent years has been transforming the diets of Americans for the worse. The root of this is the agricultural subsidies given out that incentivize farmers to produce cheap corn, which is eventually used to produce high fructose corn syrup.

Next Dr. McKinnell asked Mr. Weber to comment on the healthcare culture in Japan.

Mr. Weber explained that, compared to other countries, there was much more of a culture of prevention and wellness in Japan. He thought that as more and more data emerged that

could be applied to maintaining wellness, this culture would be further reinforced. Japan has also made a conscious decision to prioritize healthcare and science for funding, which is to be commended. However, one weakness is the inadequate links between academia and pharmaceutical companies and other actors.

Prof. Yamanaka commented that a new conditional approval system had been introduced in Japan. It is currently limited to stem cell technology, but would hopefully be expanded in future. As a result, Japan is now perhaps the fastest country in the world in terms of giving approval to companies working in stem cell technology. Until this new regulation was introduced, however, Japan was one of the slowest in the world.

Dr. Reinhardt agreed that there had been a shift in Japan in terms of the speed with which it was recognizing and approving innovation. He also highlighted the increasing importance of personalized medicine and individual data, especially in the treatment of cancer. Overall, one can say that even in diseases of the central nervous systems there are more genetic tools for treatment, which provides hope for the future. As such, Dr. Reinhardt believed that progress was being made in many different disease areas, with new and varied tools emerging. He was therefore very optimistic for the future.

Dr. McKinnell then asked the panelists to discuss how countries could overcome issues of covering medical expenses.

With regard to funding, Dr. Reinhardt cited the example of Japan, pointing out that it was one of the countries with the lowest penetration of generic drugs. There are still old drugs on the market that are being sold at very high prices. If generic drugs, which are far less expensive, are brought in to compete with that, this would free up money to be spent on more innovative products. This approach has been successful in the United States and in some European countries.

Dr. Zerhouni believed that in many countries there was much resistance to change, and many stakeholders with vested interests. Therefore the system as a whole must be fixed, and any effort to foster change and make medical spending smarter and more appropriate must be integrated, rather than fragmentary.

Dr. Hood felt that there were many efforts emerging that were similar to his own, with which he was seeking to establish strategic partnerships. To capitalize on such efforts, he

called for consilience between humanities, the social sciences, and sciences, stressing the psychological dimension in particular.

As the final question, Dr. McKinnell asked Prof. Yamanaka what his hopes were for his stem cell research and therapy.

Prof. Yamanaka said he hoped his research would be applied to the provision of stem cell therapy, and also for drug discovery. In fact he thought the latter was of greater importance. Prof. Yamanaka thought that stem cell therapy was transient, and hoped that in the longer-term small molecules and other medicines would be identified that would rejuvenate any kinds of cells. He also hoped to use stem cell research to realize personalized medicine. Finally, Prof. Yamanaka stated that while the future was very bright, there are many challenges that must be overcome, including cost, predicting efficacy, and ethical issues. That is why discussions like this are so important.

Concurrent Session 203-A4: Energy for Transportation

Session Chair

Toyoda, Masakazu, Chairman and Chief Executive Officer, The Institute of Energy Economics, Japan (IEEJ), JAPAN [Nationality: JAPAN]

Speakers

Al-Khowaiter, Ahmad O., Chief Technology Officer, Technology, Oversight & Coordination, Saudi Arabian Oil Company, SAUDI ARABIA [Nationality: SAUDI ARABIA]

Gona, Yusfandri, Chairman, Indonesia Aviation Biofuels and Renewable Energy, INDONESIA [Nationality: INDONESIA]

Kubota, Takashi, Executive Corporate Advisor, Chiyoda Corporation, JAPAN [Nationality: JAPAN]

Sulaiman, Mohd Yusoff, President & Chief Executive Officer, Malaysian Industry-Government Group for High Technology (MIGHT), MALAYSIA [Nationality: MALAYSIA]

Opening Remarks

The Chair opened the session, explaining the ground rules and introducing the speakers.

The Chair noted that 28% of final energy consumption is used for transportation, and that over the next 20 years this energy consumption could increase by 50%. He pointed out that around 90-95% of energy for transportation comes from oil, and even in the future the expectation is that around 90% of energy for transportation will come from oil. However, in order to address climate change, many are trying to promote energy conservation and to use alternative energies, even for transportation, including natural gas, biofuels, and hydrogen. If significant efforts are made to reduce the percentage of energy from oil, energy for transportation would increase by around 25% instead of 50%, with 80-85% oil based. The Chair then invited the other speakers to give opening remarks.

The first panel speaker explained that during the last COP conferences world leaders took steps ahead to limit global warming in the 21st century to below 2 degrees Celsius. Thus

the realization of low carbon strategy is an urgent issue. The transport sector is responsible for about 23% of CO_2 emissions, of which about 70% is from automobiles. To support the reduction of CO_2 in the transport sector in a short timeframe, utilizing more natural gas, solar energy and biofuels was suggested. Utilizing more natural gas for power generation is believed to be the fastest way to reduce emissions. In Japan a process has been developed to utilize CO_2 in field gas to convert to synthesis gas for further processing. Utilization of solar energy and biofuels is effective in reducing CO_2 emissions, but reduction of production costs is required as costs are still higher than fossil fuels. There have been successful demonstration of concentrated solar with molten salt as a heating medium, which is now ready for commercialization. For biofuels, many research projects have been underway to study production from different sources. By the time the Olympics take place in Tokyo in 2020 there will be large amounts of hydrogen using an organic chemical hydride method ("SPERA® hydrogen" system) which enables storage and transport of hydrogen in ambient conditions. Ammonia is also viewed as an attractive hydrogen carrier, as it has high carrying potential. During the coming 10 - 20 year period, the majority of fuel for transportation will be cleaner gasoline/diesel including GTL with highly efficient consumption rates. Engineering companies are continuing to collaborate with oil/gas companies to manufacture those cleaner fuels with highly efficient processing plants.

The second panel speaker stated that management of transportation to make it more efficient is an important approach to address the energy issues in the transport sector, but focused his remarks on biofuels. He noted that second generation biofuels are still a new technology and that developing countries have a great opportunity in this area, with availability of raw materials from forests and agriculture. He noted that waste from agriculture is either returned to the soil or burnt, which can create environmental issues, but it was hoped that better uses of the waste could be developed. He also suggested that the biofuel industry would touch upon all stakeholders in local areas, with involvement of other areas of industry. He cautioned however that transportation would be a major issue, because generation would be in rural areas. He also noted that there is the issue that the feedstock is in the developing world, while the technologies are in the developed world, requiring collaboration between them to achieve climate goals. He explained that Malaysia was aiming to have the second biomass refinery plant in the world completed by 2017, and looked forward to biomass being a leading energy in the future.

The third panel speaker noted that since hosting COP in 2007 with success outcomes of Bali Roadmap, Indonesia has committed to reducing GHG emissions of 28% by 2020, and it was mandated mitigation program especially to five sectors such as Peat land and Forestry, Industry, Agriculture, Waste and including the Energy and Transportation sectors. He noted that Indonesia has successfully on land transportation biofuels policies scenario, which has been mandated 15% biodiesel blended (B15) by 2015 and continuing with 20% blended (B20) by 2016 and B30 by 2020, and Indonesia also committed to achieve 3% drop-in blend of biofuels in aviation fuel by 2020, and a 5% drop-in blend by 2025. He hoped for collaboration between Indonesia and regional countries and international partners for addressing challenges. Indonesia considers that strong leadership of governance is required to initiate policies and program development on biofuel and renewable energies in the transport sector, including developing collaboration on technology and sustainability.

The fourth panel speaker reflected on the fact that the automotive sector consists of 1.1 billion cars and over 250 million commercial vehicles, and that it is expected to continue to grow to about 2.5 billion cars by 2040, with most of the growth in non-OECD countries as their economies improve. There is a very low base of existing battery electric vehicles, and it is expected to grow to only around 10-15% by 2040, meaning that 85% will still be hydrocarbon-based. The majority of the decision on the fuel is cost, but the second factor will be emissions and sustainability. The third factor, although not appreciated, is energy density. In one gallon or about 4 liters of fuel there is 33kWh of energy. An entire vehicle

battery, by contrast, has around 25kWh of energy and weighs around 300kg. Therefore the energy density is around 100 times lower, and the cost of the batteries are very expensive. He differentiated between fossil fuels and the use of the fossil fuels. He also noted that CO_2 is not bad in itself, it is only the balance that can pose a problem. He also raised the issue of primary energy source for electric vehicles, as if the electricity is generated from coal the CO_2 emissions can be worse than for diesel or hybrid vehicles. Better battery technologies with better energy densities will need to be found, but the quickest route to improvements in CO_2 will come from improvements in conventional engines. Local carbon capture on the vehicle is also being investigated.

Discussion

Table 1

Discussed biofuel, but felt that this is not very efficient, and spent most time discussing hydrogen. One idea is to use hydrogen storage, which can achieve 70% efficiency. However, creating a fleet of hydrogen cars is expensive. Toyota has a plan to make 300 hydrogen powered cars per year at a price of US$70,000, but this will be a very small impact on the total number of vehicles on the road.

Table 2

The options of CNG for local transportation and LNG for long-distance commercial transportation were discussed, but it was noted that these were very price sensitive. There was consensus on the possibility of bacteria and micro-algae but it is blue sky and twenty years away. It was noted that with chemical processes there are chemical engineering tools to scale up processes, while with biochemicals high temperatures kill the bacteria. Currently to produce hydrogen overall the efficiency is around the level of a good diesel, and there is also the question of infrastructure and the cost of the vehicles themselves. Therefore if there is a future for hydrogen, it is not going to be in the near future.

Table 3

The most desirable energy for transportation was considered to be biofuel, with EV second, and natural gas third. For FCV it was considered that even in twenty years it will still be far away. For biofuel costs and viability it was considered that it will slowly be introduced into the fossil fuel mix. Many national oil companies (NOCs) are already diversifying into biofuel. It was also suggested that scooters could help to relieve congestion in cities for short distance transportation.

Table 4

Despite efforts to introduce alternative fuels, there will still be a majority of conventional fuel vehicles on the road, and therefore the issue for the short term is how to capture and use CO_2 either directly from vehicles or off vehicle. There are also issues concerning storage of CO_2 as some countries do not have appropriate geology for that. There are also concerns that some alternative fuels are not really carbon free, and concerns over whether people are prepared to pay high taxes to develop technologies to deal with CO_2. For biofuels, in countries like Japan there are issues such as a lack of land area to support biomass production.

Table 5

The general consensus was that 10-20 years was too short for changes to the energy system, but that regulation could be used to change behavior, and also societal behavioral changes are seen where young people in some cities no longer aspire to own a car. It was also noted that the existing infrastructure and high energy density of traditional automotive fuels make it difficult to see it being replaced in the short term. It was noted that CCU could help, but the overall contribution would be too small to make a major impact on the emissions problem.

Open discussion

CCS and CCU were raised as the most important short term solution, and the question was asked of why more rapid development of solutions cannot be achieved. The Chair noted that cost was a major issue for CCS, but there is a lot of enthusiasm for CCU and he stated that at the ICEF conference in the coming days in Tokyo, CCU would be one of the technologies to be discussed to come up with solutions such as artificial photosynthesis.

The Chair concluded the session noting that there is no perfect energy and many challenges to be solved even in the transportation sector to address Climate Change.

Concurrent Session 203-B4: Infectious Diseases

Session Chair

Nagai, Yoshiyuki, Former Director of Center of Research Network for Infectious Diseases (CRNID), RIKEN, JAPAN [Nationality: JAPAN]

Speakers

Bonneville, Marc, Vice-President in charge of Medical and Scientific Affairs, DMS, Institut Mérieux, FRANCE [Nationality: FRANCE]

Miyamura, Tatsuo, Former Director-General, National Institute of Infectious Diseases (NIID), JAPAN [Nationality: JAPAN]

Ruxrungtham, Kiat, Professor of Medicine, Faculty of Medicine, and Chula Vaccine Research Centre, Chulalongkorn University; Deputy Director, HIVNAT, Thai Red Cross AIDS Research Centre, THAILAND [Nationality: THAILAND]

Slingsby, BT, CEO & Executive Director, Global Health Innovative Technology Fund, JAPAN [Nationality: U.S.A.]

Sung, Joseph Jao-Yiu, Vice-Chancellor and President, Office of the Vice-Chancellor and President, The Chinese University of Hong Kong (CUHK), HONG KONG [Nationality: HONG KONG]

Opening Remarks

The Chair opened the session by stating that we have learned from the recent Ebola virus disease outbreaks that capacity building for rapid diagnosis and isolation of patients and high quality case management are essential for mitigating the spread of the disease. In addition, burial practices were one of the key factors facilitating the spread of the disease. Thus, literacy building in society on what Ebola virus disease is and how it is transmitted is also very important. The Chair then discussed the spread of MERS in Korea, which is very far from the Middle East. He also noted the importance of learning about more conventional diseases that still remain a major threat to mankind.

The first speaker noted that more priority should be given to infectious diseases, not only in the developing world but also in the developed world. He said infectious diseases remain a major health problem for three main reasons: the lack of efficient treatments for several neglected infections, the limited access to treatment and diagnostics in low resource countries, and the rise of drug-resistant infections due to the misuse of antibiotics.

The first speaker then introduced two new trends for microbiology diagnostics. The first was the development of molecular techniques that have improved turnaround time and diagnostic accuracy. One problem is that most techniques still require skilled professionals, and reagents with short shelf-life and cold chain constraints. This restricts the work to centralized laboratories in high income countries. Automated multiplex molecular tests targeting more prevalent pathogens in particular syndromic contexts can be performed by non-specialists, but result interpretation remains tricky. Next generation sequencing presents an interesting approach, as it allows comprehensive analysis of infectious agents. However, despite rapidly decreasing costs and time, this approach is still restricted to skilled laboratories, and still needs better standardization, more bio-informaticians, and comprehensive and well curated databases.

The second point made by the first speaker was on raising the development of point of care testing. Point of care testing should be affordable, rapid, and equipment-free. However the performance of many tests seemingly fulfilling these criteria is not rigorously validated, and therefore the tests frequently do more harm than good because of misdiagnosis.

The point of care testing market involves many small actors in infectious diseases that cannot afford the cost of development of fully validated tests. A key question is how much we are ready to pay for point of care tests fulfilling stringent quality criteria. We should also keep in mind that the main goal of a point of care test is for it to result in an actionable decision (e.g., start treatment) within the same clinical encounter. Therefore, development of such tests should be driven by the turnaround time and not necessarily by cost. Efficient implementation of a point of care testing program requires good communication between the patient, the doctor, and the laboratory. If this communication is not in place, point of care testing is unlikely to have a major impact on public health outcomes.

The Chair then spoke on challenges to develop broad spectrum anti RNA virus drugs. He described the classification of categories of diseases as defined by the Infectious Diseases Law of Japan, which includes many RNA viruses. We must of course continue to make efforts

to find medicines efficacious to individual diseases. At the same time, RNA viruses apparently differ from one another in structure and function, but share common pathways of replication. The Chair thus proposed the importance of challenges to develop broad spectrum anti RNA virus drugs. This challenge does not always appear to be preposterous in view of the recent discovery of BCX4430 that was capable of inhibiting not only filoviruses (Ebola and Marburg viruses) but also many other RNA virus families (Warren TK et al. Nature. 2014 Apr 17; 508 (7496), 402-5).

The second speaker shared experiences in Hong Kong and other parts of Asia with SARS and MERS. He said infectious diseases are still a major threat to the whole world due to international travel and the lack of awareness of emerging infectious diseases. He described a major outbreak of SARS in Hong Kong, when a single person infected 10 other people who traveled and brought SARS to many other countries. This was a shocking experience.

The second speaker stressed that hospitals are not designed to deal with infectious diseases and that international travel increases the risk of the spread of infection in a very short period of time. He said border controls must change and that government input should play an important role.

The speaker's third point was that many infectious diseases emerge from contact with wild animals. For example, SARS involved cats and MERS involved camels. We must think about

how to limit interaction with wild animals. His last point was on housing design in Asia, which can pose problems. In Hong Kong, the sewage systems of apartments facilitated the spread of SARS. This is also something that governments must tackle.

The second speaker concluded by saying that infectious diseases have an enormous economic impact. Therefore, governments and healthcare providers should be alert to prevent large economic losses. For example, the number of tourists to Korea has dropped due to MERS. In addition, international collaboration is necessary to share knowledge and fight infectious diseases.

The third speaker shifted the discussion to chronic infectious diseases, focusing on HIV/AIDS in Asia, where approximately 5 million people are living with HIV. Fighting against the disease requires collaboration between the public and private sectors, academia, and the patients. It is best to treat the disease early to reduce serious illnesses and decrease the likelihood of the disease being passed on to others. In addition, the treated patients can live with normal life expectancies.

The third speaker then discussed the search for a vaccine HIV cure. He explained the RV 144 trial and called for additional work in the field to bring about more developments. He said the lesson learned was that science and technology have to work together to bring benefits to the community. He cited efforts by the United Nations to eradicate AIDS by 2030. Fighting against the disease requires collaboration between basic science and clinical science, the public and private sectors, academia, the community, and patients.

The fourth speaker discussed the lessons learned from international collaboration for the control of infectious diseases. He started the session by introducing the control of hepatitis C. It has been 25 years since the hepatitis C virus was discovered, and international collaboration was the key to its isolation and identification. By using the most recent molecular biology techniques, diagnosis and therapy for hepatitis C has been developed tremendously. The number of new hepatitis C cases has drastically decreased. Now the hepatitis C virus can be eradicated from individual patients, but global eradication is impossible.

One problem is the cost associated with handling hepatitis C. In particular, recently developed DAA (Directly Acting Antivirals) can eliminate the hepatitis C virus completely, but the treatment is extremely expensive for patients to receive it. Another problem is that safe blood transfusions are not performed in areas such as Sub-Saharan Africa due to screening

issues. As for developed countries, the main transmission route is illicit intravenous drug usage. Control of hepatitis C is not only about hygiene; for the global control of hepatitis C virus infection, it is important to have a clear recognition of the disease and examine how to protect against it. The fourth speaker closed by saying that he hoped to discuss the route of transmission of hepatitis C in the session.

The fifth speaker noted that many different aspects of infectious diseases had been discussed. In his experience, infectious diseases can be divided into three categories: antimicrobial resistance, pandemics, and chronic infectious diseases. For antimicrobial resistance, the problem occurs mainly in developed countries due to the overuse of antibiotics and too much hospitalization. Pandemics are a different problem. Ebola, SARS, and MERS are correlated to the increasing rise in urbanization and human mobility or international travel and will only increase in risk over the next decade.

The fifth speaker next discussed chronic infectious diseases. The access issues related to these diseases, such as HIV/AIDS, malaria, tuberculosis, and other neglected diseases, do not only encompass healthcare systems, but also the affordability, availability, and adoption of the innovation. The problems pertaining to these three categories of infectious disease are wide-ranging, but the one commonality is that the market itself does not produce new innovations, new interventions, and new products. The fifth speaker then said that the only solution will be public-private collaboration to drive product development for infectious diseases.

Discussion

The first group discussed the need to monitor for emerging diseases and to educate the public, and the general consensus was that infectious diseases are being ignored. The group also discussed the Ebola crisis and suggested the need for a non-governmental consortium.

The second group discussed rapid tests and pathogen identification. The group pointed out that it is still a challenge to identify if fever is caused by bacteria or a virus and that this is a very important issue. There was also discussion on needs for rapid testing in the developed world and the developing world. A speaker called for increased discussions on the subject of costs of rapid tests.

The third group spoke on under-addressed infectious diseases and whether they should be tackled through better access to existing treatments or whether new medications are needed. The table also discussed pandemics and trackers. Finally, the group discussed public-private partnerships, which come down to the size of the market. If the infected population is poor, companies are less likely to develop treatments for it.

The fourth group discussed hepatitis C, as well as treatments that are currently available. They also discussed lifecycles, funding, and the spread of disease. There are difficulties to get people to go to centers to check their status. The most prevalent excuse for not getting testing is "I have no time." It is surprising that people do not devote time to their health. The group also discussed the spread of disease in Egypt. The group concluded by emphasizing the need for global education on hepatitis C.

The final group spoke on a variety of issues, including funding. There is a bottleneck that results in all researchers needing to be part of an institution to receive funding. The group also discussed the role of the host in infectious diseases and targeting therapeutics to understand this role. There was also discussion on access issues and conversation on the role of controlling and eliminating diseases, including the need for a vaccine for HIV. Discussion then took place on the burden of different diseases.

A participant closed the session by stressing the fact that infectious diseases are still an extremely important issue, but that they are often overlooked due to the perception that they only apply to developing countries. He stated that infectious diseases must be on the agenda to create a better world.

Concurrent Session 203-C4: Robotics

Session Chair

Cross, Stephen E., Executive Vice President for Research, Georgia Institute of Technology, U.S.A. [Nationality: U.S.A.]

Speakers

Gil, Dario, Vice President, Science and Technology, IBM Corporation; Director, Energy & Natural Resources, IBM Research; Founding Director, Smarter Energy Research Institute (SERI), U.S.A. [Nationality: U.S.A.]

Kheddar, Abderrahmane, Director, CNRS-AIST JRL (Joint Robotics Laboratory), UMI3218/RL; Titular full member, National Academy of Technologies of France (NATF), JAPAN [Nationality: FRANCE]

King, Dan, Director BD, Robotics and Automation, MacDonald, Dettwiler & Associates Inc. (MDA), CANADA [Nationality: CANADA]

Sankai, Yoshiyuki, Founder/CEO, CYBERDYNE; Professor, Center for Cybernics Research, University of Tsukuba; Program Manager, ImPACT Program by JST/Cabinet Office of Japan, JAPAN [Nationality: JAPAN]

Opening Remarks

The Chair opened 203-C4 Robotics by introducing himself and the speakers, before introducing the discussion points for the sessions, which were:

1. Based on what we now know, what will be the positive impacts to society? Will there be negative impacts too?
2. How can concerns about safety and ethical use be addressed and overcome?
3. Will robotics eliminate human work, as some articles in the popular press have claimed, or will it lead to new kinds of human endeavor and meaningful work?
4. What do you see as the major technological issue that needs

The first speaker opened his presentation by explaining that robotics had spread into various industries in recent years, with robots that clean, conduct medical surgeries, construct cars and other machinery, and other kinds or robots providing many services with specific applications. He added that developments in micro and nanotechnology had allowed for technology to be imbedded in robots, and that currently, robots that could access the internet and make judgements for themselves, similar to humans, were being researched. Continuing on, he explained that the democratization of robots toward personal robots was the breakthrough that everybody was expecting. He explained that because robots were making the leap from service to personal usage, robots were now being developed with humans in mind, rather than processes or projects. He then concluded his presentation by noting that all new robotics technologies had brought new requirements and conceptions of what robots would be in the future.

The second speaker opened his presentation by stating that he would focus on the trustworthiness of robots in terms of critical application where human lives were involved or at stake. One such example raised by him was a system ("Canadarm") that had been installed in the space shuttle for many years, which was critical for on-orbit servicing missions such as Hubble Space Telescope repairs, among other responsibilities. He explained that while the technology had been developed and ready for a long period of time, it took many years for said technology to be trusted by NASA and operated freely. In another example raised by him, he discussed robots used in invasive surgeries, such as those conducted on the brain. He explained that while, for example, surgeons can lose dexterity in their hands over long surgeries, people still tend to trust human hands over robots. In conclusion of his presentation, he commented that there were many other issues to deal with besides technology, particularly in the case of technologies that go hand in hand with humans around it, and that trustworthiness would need to be worked on by society.

The third speaker opened his presentation by stating that he would be discussing the broader meaning of technologies, such as robots and information systems, and their relations to humans and society. First, he spoke about the need for advanced technologies, stating that "Cybernics: fusion of human, robot and information systems." He added that it would help develop solutions for very severe social problems such as aging societies. He explained how Japan and many developed countries were or were on course to face very severe aging societies. He explained that society would need to be prepared with several solutions, and that advanced robotics in the form of those that work in cooperation with humans, as well as robots that work as separate entities from humans, could be one such solution.

The fourth speaker opened his presentation by stating that he would speak about the intersection between robotics and cognitive computing. He explained how the intersection was at the confluence of the byproduct of the digitizing world, and utilizing said data to train machine learning algorithms that are capable of learning by example. He added that computing systems were powerful enough that such programs could be run at scale and at latencies previously unimagined. Continuing on, he stated that mankind was in a cultural revolution in human interaction, and that coherent computing experiences across space and time would eventually become possible. Regarding the role and relationship between systems and humans, he noted that humans bring context, problems, expertise, values, and common sense, and that systems bring a unique ability to connect the dots. As an example, he spoke about IBM's WATSON, which was able to ingest 23 million scientific paper abstracts and make connections between them, while adding that the average researcher could only read several hundred scientific articles in a given year. In conclusion of his presentation, he stated that while the creation of technology to extend our bodies freed mankind from the industrial revolution and changed the world, imbedded cognitive systems and its capabilities in expanding our minds could be even more transformative.

Discussion

A representative from the first group stated that they discussed how humans and robots could share the same space; how to clarify the difference between automatic vs autonomous; how or what kind of human jobs robots could replace; why planes and trains were still flown or driven by pilots and drivers; areas where humans trump robots or computers; and standardization.

A representative from the second group stated that they discussed the positive impact robots had on society; potential timescales for the introduction of robotic technology; safety considerations and the degree to which products will be failsafe; the confluence between big data and robotics; IT security; battery performance in robots; and international partnerships and how it could help guide integration of robots into society.

A representative from the third group stated that they discussed the impact of robotics on jobs; public concern regarding robotics in the long-term; how economic value is captured by robotics; safety and ethics related to robotics; human nature and skepticism regarding new technologies; what societies and sectors are most accepting of robotics; and partnerships and collaborations for expansion.

A representative from the fourth group stated that they discussed in what spaces robots could be found in the near future; legal systems to prevent robotics from being utilized for military purposes; robotics in hospitals; robotics in factories and manufacturing; material and battery issues in manufacturing robots; artificial intelligence; and collaborations and mixture between humans, machinery, and robots.

A representative from the fifth group stated that they discussed inexpensive and expensive robots; robotics in agriculture to increase crop yield; robotic assisted surgery; the spread of robots limited by the human comfort factor; ethical issues related to robotics; autonomous vehicles; greater international coordination to determine new regulations and laws related to robotics; and a changing labor force due to robotics.

Concurrent Session 203-D4: Adaptation to / Mitigation of Climate Change

Session Chair

Hamanaka, Hironori, Chair of the Board of Directors, Institute for Global Environmental Strategies (IGES), JAPAN [Nationality: JAPAN]

Speakers

Kovacs, Paul, Executive Director, Institute for Catastrophic Loss Reduction, CANADA [Nationality: CANADA]

Loyzaga, Antonia Yulo, Executive Director, Manila Observatory, PHILIPPINES [Nationality: PHILIPPINES]

Yasunari, Tetsuzo, Director-General, Research Institute for Humanity and Nature (RIHN), JAPAN [Nationality: JAPAN]

Opening Remarks

The chair commenced the session by stating that climate change and mitigation are vast and complex issues. He provided examples of several of the pressing social and environmental problems currently arising worldwide, such as coastal erosion, rapid urbanization, extreme weather events, etc. All of these factors have severe local effects. The question posed to the session, to be considered in preparation for the upcoming Conference of the Parties to the UNFCCC, was whether these local consequences might be more easily overcome than the global consequences.

He suggested how potential synergies between adaptation and mitigation policies might be addressed through a holistic approach on a local level. Synergies clearly exist in the realms of adaptation and mitigation over a wide range of sectors, but careful planning is required to overcome challenges to realizing these. For example, while mitigation in

compact cities is easier than in sprawling urban developments, for adaptation, geographical location and climate determine the appropriate urban form, for example in matters of flood prevention.

The greatest opportunities for successful adaptation and mitigation are in rapidly urbanizing areas, specifically in small and medium urbanizing areas in developing countries. The chair introduced an Institute for Global Environmental Strategies project carried out in a sub-watershed in the Philippines that is undergoing rapid urbanization and land use change. The project aims to integrate mitigation and adaptation into local government land use planning, especially with a view to flood prevention. The project devised a systematic process with practical tools for local governments to plan for the increased occurrence of flooding projected for the area because of climate change. It is supporting the development of a coordination mechanism to harmonize land use and policies such as zoning controls to address increased flood risk and other consequences of climate change, along with fundraising, education, public relations, local governance coordination, etc.

The first speaker spoke about the seventh meeting of the Regional Action on Climate Change (RACC), which took place on October 3rd. Disaster management was one of the main topics of discussion. The RACC recognizes that disaster risk is multiplying rapidly, while the timescale in which to prepare for it is shrinking. The RACC discusses the fact that local adaptation response to disaster risk occurs on varying timescales and is dependent on various factors such as available infrastructure systems. The development of adaptation systems must address this reality.

The speaker emphasized that natural disaster risk reduction and climate change adaptation and mitigation should both be viewed as a long-term environmental issues. The two communities are often viewed as separate and independent, possibly because risk reduction management is thought to be short-term, while climate change adaptation and management is thought to be long term.

He explained however, that ecosystems and human society are non-linear and complex. Experience shows that extreme disaster events can cause long-term environmental change. Recent climate change is now amplifying weather events. At the same time, rapid changes in human systems, such as urbanization, are increasing the fragility of human settlements. Disaster risk and climate change are likely to become more and more interconnected as time goes on.

Interdisciplinary and transdisciplinary studies for global sustainability are beginning to form. The committees of the Future Earth program are now considering action-oriented long-term solutions to sustainability issues as one of the Knowledge Action Networks (KANs), asserting that disaster risk management issues should be considered as part of a long-term sustainability initiative.

The second speaker addressed the adaptation challenges arising in the rapidly urbanizing Philippines. How will an urbanizing Asia adapt? The “new normal” has become one of drastic changes in temperature and extreme weather events in addition to rapid urbanization and its corresponding economic issues, creating an environment of layered risk.

Urbanization occurs across different sectors, relying on all of them to make vital decisions on matters such as water, food, etc. As a result of inadequate integrated planning, improperly managed urban growth has created unregulated land use with drastic ecological consequences. In the case of the Philippines, urbanization has revealed dynamics of social instability and inequality in the country, particularly in terms of resource access. Struggles are taking place over the availability of water and electricity for domestic use. Failures in infrastructure have actually resulted in flooding and a corresponding rise in disease. A state of alarm has been declared in order to release necessary emergency funds.

There is a pressing need to enhance conversation between the social and scientific sectors on regional, local, and global levels, and to address the lack of data analysis on the effects of climate change in Southeast Asia. Endeavors are being made to develop a consensus on climate change in the region and to create models based on those results. Knowledge is translated and consumed at different rates within and without the scientific community, and efforts must be made to involve both business and civil society in understanding and addressing the effects of climate change.

The third speaker explained his field of study, which is adaptation to extreme weather events. He shared some views on the performance of society in addressing weather changes over the past 25 years, as well as some predictions for the future.

He explained that reviews of international climate change research show that loss from extreme storms will only increase. While strategies, frameworks, and efforts have continuously been established and defined over the past 25 years, data on their results remains poor, and they cannot be easily measured. The speaker proposed measuring disaster

adaptation using loss of life and property damage as indicators. While loss of life as a result of extreme weather events has largely decreased in recent years, and remains very low relative to death due to disease or traffic accidents, the prevention of property damage to buildings and infrastructure has seen little to no progress. These two indicators show a vastly different story on where we stand in terms of our preparation to deal with extreme weather events.

The scientific community has been very active in the field of climate change, looking at it in a variety of different ways and seeking to improve its overall understanding of the phenomenon. A variety of initiatives have taken place to collect evidence on how governments are utilizing the information on climate change provided to them, with largely positive findings. However, we continue to see growing rates of property damage as a result of extreme weather events.

Using this information to look ahead, certain research groups have tried to determine how much of this damage was actually caused by climate change. Their findings have shown that very little property damage has occurred exclusively as a result of climate change, though such events are soon to come. The large increase in property damage we have observed is due to human choices to locate in risky areas.

There is strong consensus that over the coming years we will see a large increase in extreme weather events. The Sendai Agreement marked the first time world leaders have come together to discuss measures for the reduction of property damage. The speaker stressed that we have been losing ground, and there is much work to be done in terms of adaptation and the effective use of information in the face of the challenges to come.

Discussion

Participants then divided into groups for further discussion. Representatives from each group relayed the content of their discussion to the rest of the participants.

The first representative reported that his group had discussed how a lack of knowledge regarding scale made it very difficult to address climate change and to convince the public of its urgency. There is a need for the integration of governance and policy change. The distribution of information must be directed toward different interest groups and different levels of knowledge. In addition, there must also be continuity planning for businesses.

The next group's representative briefly highlighted several topics addressed during its discussion. Action plans were discussed, specifically in terms of the Knowledge Action Networks and lessons learned from previous natural disasters. Oman and Mongolia were provided as examples of countries that had successfully implemented ideas regarding efficient resource use. The necessities of progress on climate change quantification, as well as of introducing insurance to improve living standards and prevent disasters on a local basis were also discussed. The group concluded that action must be taken now in order to address what we are currently able to change.

Moving on, the third representative summarized three specific issues, beginning with the acquisition of information and the creation of models on a variety of levels, as well as the proper use of that information. Next, in terms of decision-making, she expressed the need for development policies to address a wide level of uncertainties. Lastly, she stressed, we must examine ways to bring different specialties to play in addressing climate change. In spite of all the remaining uncertainties, addressing climate change is ultimately about behavioral change on an individual level.

The final representative stated that his group had focused largely on the idea of "think globally, act locally." They discussed local issues in particular, with one important conclusion

being that the scientific community must ensure that assessment ultimately leads to action. Furthermore, as there are currently not enough scientists available to comprehensively act locally, capacity-building is necessary, as well as the ability to communicate scientific information on a local level. Face-to-face communication between scientists and local decision makers and advisory groups and the establishment of trust will be keys.

The chair then invited questions. One participant stressed the importance of bringing the message of conservationism to the people. While STS *forum* meets every year to discuss possible global actions, substantial change will not occur until we take action personally and individually. He demonstrated how action could be taken at a personal level by showing that he had cut his business cards down to half the regular size.

Concurrent Session 203-E4: Science and Technology in Developing Countries

Session Chair

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

Speakers

Dong, Dang Huy, Vice Minister, Ministry of Planning and Investment (MPI), VIETNAM [Nationality: VIETNAM]

Kurokawa, Kiyoshi, Chairman, Health and Global Policy Institute; Adjunct Professor, National Graduate Institute for Policy Studies (GRIPS), JAPAN [Nationality: JAPAN]

Natera, Angélica, Executive Director, LASPAU (Academic and Professional Programs for the Americas), Harvard University, U.S.A. [Nationality: VENEZUELA]

Ndlovu, Lindela R., Vice Chancellor, National University of Science and Technology (NUST), ZIMBABWE [Nationality: ZIMBABWE]

Zulkarnain, Iskandar, Chairman, Indonesian Institute of Sciences (LIPI), INDONESIA [Nationality: INDONESIA]

Opening Remarks

The Chair remarked that many of the problems affecting the world have their greatest impact in developing countries. He praised the recently announced post-2015 United Nations (UN) goals for sustainable development as an important milestone for addressing these issues. When we reflect on science and technology in developing countries, he continued, it is important to remember that many of the issues these countries face, whether related to water, air, healthcare or biodiversity loss, are caused by the unsustainable manner in which society operates.

It is also important to understand that the situation in developing countries is often caused by their dependence on developed countries. In the past, the lack of investment of developed countries in developing countries was a serious issue. However, many countries are currently

following a trend of increased investment in development and capacity building programs, sometimes as much as 5% of their GDP. There is also significant diversity in the issues and challenges that developing nations face, as these countries themselves are diverse.

The first speaker stressed that policy makers must not wait to establish a knowledge-based economy until a certain level of development has been reached. Effective use of existing resources is key to building an advanced economy founded on scientific and technological innovation. Many countries have limited natural resources, but the one resource which is limitless is humans. It is important to develop and educate human minds, who can turn their attentions to addressing the problems faced regionally and worldwide. After all, spending money wisely to create the right ecosystem is more effective than spending large amounts of money non-strategically. Therefore, focusing spending and research on practical initiatives is essential, as they will have the most direct and drastic effect on people's daily lives and work.

The next speaker shared details of science and technology initiatives in Latin America. She said that for the first time, the region is becoming harmonious in terms of investment, purpose and practice regarding the development of science and technology capacity through education and knowledge mobility. There are also great improvements in the available funding from governments to train individuals with doctoral and master degrees in STEM fields. Through these efforts, research is strengthened and capacity building is developed in private, academic and governmental sectors by educating leaders in science and technology. In recent years, governments have been strongly committed to developing the region as a knowledge-based economy. Countries have made and continue making great efforts in science and technology education, and some great examples are Brazil, Colombia, Chile, Peru and Mexico.

The development of research centers and institutions to foster research has also been undertaken. There is strong commitment to creating positive science and technology ecosystems in the region, but more is needed. On the other hand, however, there are challenges with limited English competency among research institutions and universities, which can limit communication and knowledge exchange, but governments are also working on addressing that through national programs to strengthen English proficiency. Universities must become focused and engaged, on educating students in science and technology, and creating educational ecosystems that foster innovation. She concluded by outlining three pillars for the continued development of science and technology in the region: Education, Collaboration, and Smart Ecosystems.

The next speaker talked about the challenges of developing appropriate science and technology programs in the African region. Often, universities do not communicate effectively when it comes to sharing knowledge. Therefore, it is necessary to pursue national strategies to facilitate these kinds of exchanges, and harmonize communication. There is lots of good work being done, he said, but it is often done in isolation.

The Science and Technology and Innovation Strategy for Africa 2024 is an initiative that will contribute to facilitating closer exchanges within the region. It has four pillars, including those related to infrastructure development, technical competency, entrepreneurship and the environment. In Africa, many countries' GDPs are quite low, which means that the monies that can be spent on research and development is also quite low. Therefore, effective collaboration is very important.

The next speaker stated that in both developing and developed countries, science and technology is very important to fulfill the basic needs of citizens, as well as assure their safe and peaceful lives. However, government commitments are key to ensuring smoothly executed research and development, even as global and regional priorities change.

To compliment government commitments, it is necessary to effectively educate and train experts. However, government priorities can change as situations change. In Indonesia, for example, after the Asian economic crisis, the priority has shifted away from science and technology as politicians and bureaucrats turn their attentions to other issues. Investment has begun to focus on research projects that have more short term benefits and output, rather than those which facilitate and trigger true, deep innovation.

The final speaker stressed that friendship is very important to implementing change. As the world changes rapidly and becomes more fragmented, the ability to network and establish friendships is key. One key enabler of this is smartphones – by 2020, he said, 80% of the world's population will have one such device, which they can use for communication and collaboration with peers throughout the world. Creating "Multilayered Brain Circulation," or opportunities for international knowledge exchange, at universities and research institutions all over the world, will be key to growth and the establishment of partnerships and collaborations with those from backgrounds. This can be accomplished at all levels of education – from high school students to post-doctoral students.

A network for future generations will be an important resource for innovation in the future. Investment in the next generation, across political and geographical boarders, should not be overlooked.

Discussion

The Chair broke the session into discussion groups and focused them on the following questions: What needs to be in place in developing countries to achieve scientific and technological growth, and how can the wealth, stability and good health of the citizens of these countries be achieved and maintained? Also, what roles should the public and private sectors play? He said that the politics of will – the politics of commitment – are important in implementing steady, penetrating change.

The rapporteur from the first group shared that the issues faced in many developing countries are similar to those faced by the developing world. Therefore, innovation must be embedded in the culture from the grassroots level, through such initiatives as improving education. There is tremendous potential for local innovation, he continued, as well as for the development of political will and aspiration. Unless the government is willing to invest in and recognize science and technology as a national priority, progress will not occur. Success stories should be shared, so peers can learn lessons from them.

The rapporteur from the second group said that more dialogue with the government is of vital importance. How do the perceptions and goals of the research institutions fit with

those of the government? Partnerships between developed and developing countries are also important, as are partnerships with private companies, especially in companies where funding is scarce. The commitment of governments is key to achieving the growth of developing countries.

In addition, the issue of how science and technology should be implemented in developing countries was discussed. The benefits of partnerships and internships were emphasized, because they led to employment and government-supported research and development. Coaching entrepreneurs to meet the needs of developing countries feeds into capacity building, and it incentivizes industry to invest in capacity building. There was a sense that it is better to dispatch and develop researchers on the grass-roots level because it creates expertise about the problems faced by communities. There was debate about whether it was better to strengthen undergraduate or graduate education to better address the needs of developing countries.

Viewing development as a three-way collaboration between industry, academia and government is not accurate, one participant posited, because the population must be accounted for in the equation.

The discussion then moved to the concerns of logistical overhead as relating to network-building. There is also the issue of "brain drain," where qualified experts from developing countries go to developed countries and stay there. It is necessary to incentivize these experts to return to developing countries to apply their knowledge. They reached consensus that it would be worthwhile to explore the feasibility of a process to facilitate the involvement, not only of large corporations, but also SMEs.

A participant from South Africa emphasized that the opportunity to share knowledge about the research initiatives undertaken by developing countries is of vital importance. Perhaps there is a problem in metrics regarding distinguishing between developing and developed nations, which could affect a change in perspective to show the whole world the practical research that is being undertaken in developing countries. Another participant from South Africa spoke further about her country's grant-making fund initiatives. More interest should be taken in the Southern hemisphere, she said, because it could reveal some unexpected and useful information.

Concurrent Session 203-F4: Responsible Public Dialogue in Science and Technology

Session Chair

McNutt, Marcia, Editor-in-Chief, Science family of journals, American Association for the Advancement of Science (AAAS), U.S.A. [Nationality: U.S.A.]

Speakers

Castro Díaz-Balart, Fidel, Scientific Advisor, State Council of Cuba, CUBA [Nationality: CUBA]
Chi, Youngsuk, Chairman, Elsevier, U.S.A. [Nationality: U.S.A.]
Galli, Fiorenzo Marco, Director-General, National Museum of Science and Technology Leonardo da Vinci, ITALY [Nationality: ITALY]
Matlosz, Michael, President and Chief Executive Officer, French National Research Agency (ANR), FRANCE [Nationality: FRANCE]
Roberts, Richard J., Chief Scientific Officer, New England Biolabs, U.S.A. [Nobel Laureate 1993] [Nationality: U.K.]
Widding, Astrid Söderbergh, Vice-Chancellor, Stockholm University, SWEDEN [Nationality: SWEDEN]

Opening Remarks

The chair remarked that this session is a significant topic for STS *forum* because public perception of science has recently become more negative. For example, the publication on the link between vaccines and autism has recently led many US families to avoid vaccination and has increased mistrust of the scientific community in the public eye. While it has been made clear that these studies were plagued by biased research, many families still show reluctance towards vaccination. The chair then relayed her experience with a paper focusing on acceptance of same sex marriage, and how, despite its merits, it was later withdrawn due to fraudulent data. These cases illustrate why the public can become confused about scientific data. The chair then concluded by stating that viewed through the lens of time, almost all papers will eventually be labeled as

wrong. However, science is built on this foundation, brick by brick, and even though studies can be imperfect, science still has merit. The chair then invited the other speakers to make their opening remarks.

The first speaker stated that in his opinion two somewhat related topics impact rather strongly our collective capacity to achieve responsible public dialogue in the area of science and technology. First, science is now a specialized professional activity. One of the consequences is that the "closed" professional "guild-like" structure of contemporary professional science (peer review, jargon, specialized journals, career evaluation according to "community" standards, etc.) is a potential barrier to mutual comprehension in public dialogue. Second, there is not always clear understanding and distinction in society between, on the one hand, scientific controversy resulting necessarily from the critical scientific method employed in research, and on the other hand, scientific expertise for providing "scientific truth" as a contribution to public policy. Progress in responsible public dialogue requires better understanding by society of what scientific research is (and what it is not).

He spoke on the issues associated with the concept of "scientific truth" and related it to Dalton's Law and the theory of atoms, which even though was based initially on erroneous

data, many of us still believe and value. Mistrust among the general public is a serious and growing issue because as it grows, taxpayers become more reluctant to fund vital scientific research. Benevolent monologue and scientists telling the public what is true in a one-sided way, is not an effective method of communication for fighting this mistrust. Furthermore, the public has easier access to information now than in the past, and this creates a more challenging context for dialogue between experts and the public.

The second speaker first spoke about a major success in fostering public dialogue about science. Several weeks ago, with the help of scientific advisors, the UN published a series of goals to promote sustainable development. During this process, UN Secretary-General Ban Ki-moon called for solutions that crossed national boundaries, and there was a strong sense of international support when these goals were passed. Scientists will continue to play a powerful role in making sure initiatives such as these continue. He then stated that Sustainability Science in a Global Landscape, a groundbreaking report conducted by Elsevier in collaboration with SciDev.Net, illustrated that the scientific community is aligned with policy makers and the general public on developing research in sustainability science. Thus, there is a strong sense of hope that the scientific community will continue to work with the general public and policymakers in the future.

The third speaker spoke about the difficulties of explaining GMOs to the public from the scientists' point of view. Despite these difficulties, this is a really important issue to communicate to the general public. This is especially true for the developing world that needs GMOs to grow enough food, and every year in the developing world, countless children die due to a lack of access to GMOs. A strong barrier to spreading GMOs to the developing world has been Greenpeace, who has been involved with a very strong publicity campaign against GMOs. This demonstrates that there is a need for the scientific community to better reach out to the public via a similar method; if the scientific community fails to provide stronger publicity for GMOs, the developing world will suffer. The speaker then asked that other participants consider this issue very seriously and provide advice.

The fourth speaker spoke on the importance of reporting facts for political decisions. Due to the magnitude of current problems, providing sound scientific advice to policy makers will be more important than ever. He then called for a more multi-disciplinary approach to science as there are also needs to better communication between multiple disciplines in science. For spreading scientific knowledge to other specialists and the public, further cooperation through various seminars and conferences are necessary. Improved use of

mass-media by scientists can also further these goals. Science education is an important aspect as well, and we must develop the critical thinking ability of scientists during their educational period as early as the kindergarten level.

The fifth speaker spoke about public dialogue and its relation to the historical experiences of universities. Universities in the 19th century, used to use a one-way, hierarchal model that communicated their findings to the public, but this needed to change, and so does the rest of the scientific community. The European Commission is presently attempting to meet these conditions and create a two-way dialogue between science and civil society. Now, not only has the trust in science decreased, but the public is now demanding more information and a bigger voice in scientific decisions. There is an ongoing media-revolution that is playing an ever increasing role in perceptions of science as well. It must be noted, however, that the public is diverse and there can be no single dialogue. The speaker concluded her remarks by stating that she believes that universities need to engage in broad discussions about the visions and goals of science to communicate the complex reality of science.

The sixth speaker stated that scientists need to encompass in their work a fruitful interaction with the general public, and then argued that museums can be a good channel to achieve this goal. The museum he directs - the National Museum of Science and Technology Leonardo da Vinci of Milan - disseminates science and culture relying on exhibitions, the web, and many other interactive methodologies. Thousands of adults, schools, and families visit the Museum every week coming into contact with science and experiencing hands-on approaches in the Museum's interactive labs. He emphasized that we need to involve the public actively through this methodology in order to foster a free and open dialogue in science. Scientists can use both verbal language and practical experiments to share the messages of science and gain the public's trust, ultimately contributing to the creation of a scientific citizenship and a new society based on knowledge and comprehension.

Discussion

It was first brought up that GMOs are very important to Africa, and bananas in Uganda was raised as an example of this. Bananas are vital to Uganda's nutrition and economy, but there has recently been a disease that is damaging the crop. The scientific community has been trying to persuade the Ugandan parliament to use more GMO bananas that resist the disease. The speaker then suggested that museums use simpler language to explain GMOs.

Another participant stated that at his museum in Italy, they do employ such methods to reach the general public. In addition, the museum is propagating the importance of spreading access to electricity. Another speaker brought up fishing and how her museum in Monterey Bay addressed overfishing. It was initially worried that this would be very controversial in the fishing community, but it was a message that needed to be conveyed and eventually ended up as a success.

One participant asked the session what they thought the public could offer to the dialogue of science. Another participant responded by using GMOs as an example. Scientists can provide data and say GMOs are safe, but scientists need to hear the values of the general public. Furthermore, while the public has a right to debate the business models of GMOs, the scientific community has an obligation to tell the public that GMOs are safe from a scientific point of view. It was brought up that perhaps the misunderstandings in GMOs and the vaccine autism debate was not brought out by scientific illiteracy. The problem is taking the values of the public into account and addressing their concerns.

Another participant stated that misinformation remains prevalent in the mass media in movies and TV which often portray scientists as unconcerned with the fate of the world and determined to bring about its destruction. The next participant stated that he did a presentation on a similar topic to young people and emphasized that reaching out to young people not only educates the future generation, but can also be a very effective method for reaching out to the older generation when children talk to their parents about scientific issues.

Discussion also covered the lack of communication in the scientific community. While scientists certainly need to have technical skills, they also need to learn how to communicate with the world. There was consensus that science education needs to play a more active role in this regard. If science education had been better employed 40 years ago, perhaps a lot of the current misinformation in science would not exist. For example, it used to be common (although incorrect) knowledge that all chemicals in food were unhealthy. However, since education on this matter has improved, this misinformation has gradually begun to disappear.

The next speaker spoke on qualifications for scientists and how while a Ph.D. authorizes one to do science, there is currently no credential for ethical behavior. Perhaps there should be an accreditation system that can take away credentials if a scientist behaves unethically.

The next speaker then questioned why the public tends to question the trust of scientists. The chair addressed this question by stating that it is difficult for the public to navigate through the many forms of information that exist today. She then related this to legal cases where opposing parties use science to come to opposite conclusions. Another participant was involved in the Castro Case where he worked with experts on a legal case where no lawyers were involved, and came to a scientific and unbiased solution.

It was mentioned that while human beings are not good at understanding numbers, having pictures and access to images can convey powerful messages. Images of the Minamata disease, the image of Syrian refugee, and the image of seagull covered in oil after the BP spill were powerful ways to reach people. Looking at science fiction is another way to convey the messages of science as it gives a narrative and creates empathy. By these methods, science should be less reactive and more proactive and achieve more credibility by becoming more visible.

The last participant to speak wished to quickly address the status of public dialogue in Japan. After the 2011 Fukushima disaster, scientists couldn't take proper information to the public due to the influence of the government. This led to a loss of trust that Japanese scientists haven't been able to recover from yet.

Concurrent Session 203-G4: Big Data

Session Chair

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

Speakers

Emura, Katsumi, Senior Vice President, Central Research Laboratories, NEC Corporation, JAPAN [Nationality: JAPAN]

Ergin, Ahmet Arif, President, The Scientific and Technological Research Council of Turkey (TÜBITAK), TURKEY [Nationality: TURKEY]

Feigin, Paul D., Vice President for Strategic Projects and Professor, William Davidson Faculty of Industrial Engineering and Management, Technion - Israel Institute of Technology, ISRAEL [Nationality: ISRAEL]

Peitsch, Manuel, Chief Scientific Officer, Philip Morris International R&D, SWITZERLAND [Nationality: SWITZERLAND]

Schulthess, Thomas C., Director, and Professor of Computational Physics, Swiss National Supercomputing Center, SWITZERLAND [Nationality: SWITZERLAND]

Opening Remarks

The chair greeted everyone a good afternoon, and opened the Concurrent Session on Big Data. He mentioned the application of data analytics in national security, particularly in the area of preventing the spread and potential use of weapons of mass destruction; and IBM's development of the Blue Gene/Q machine, which currently dominates general-purpose data intensive computing, and developments in neural computing and deep learning. He observed the exponentiating ability to collect and aggregate datasets having profound implications, as well as the challenges of verification and validation of data; and privacy. He noted that it could be argued that data analytics was fundamental to mapping the human genome, but questioned whether it could have discovered the double helix, though allowed that developments of deep learning made such possibilities conceivable. He believed that

big data has arrived as a result of Moore's Law, but that debate was growing about the limits as well as about the demise of Moore's law.

The first speaker commented on petascales, the usability of systems, and what is possible in systems biology and genomics. Big data and high-end computing has really made science very powerful today and as we move on into the next decade it will only grow further. Usability will make things more interesting as it will open things up into new domains. We can study complex data and find correlations to generate models that are much more complex than humans can comprehend. So if we do not understand the models generated by the data, how can we test or verify the data correct?

The second speaker commented that the scaling of things will be challenging us in the future. But it is also how to distribute and aggregate the data into analytics programs. The three major concerns in the big data world were the scalability, distribution, and management of what you aggregate. On the security versus privacy issues, he emphasized that most data is collected without permission. On the challenge of how you overcome scale and distribution issues, he detailed the 3V concept; the variety of data, volume of data, and velocity of data. He noted that we need to come up with smarter class structures in which privacy and security are also addressed. And he touched upon disease management, crowd behavior modeling, as well as managing green and fuel sources of energy.

The third speaker stated that in biosciences, understanding the biological mechanism and the causing chain of events that link disease to biology is absolutely fundamental to developing diagnostics, treatments, and to assess the health risks that are associated with consumer products. To gain knowledge about disease mechanisms, one has to conduct experiments which are becoming increasingly complex as they are designed to collect large amounts of data and become a key driver of Big Data in biosciences. If we apply the knowledge of systems sciences to medicine, we will be able to better diagnose disease and conduct much more personalized treatments for such diseases. He also highlighted that, in biology, big data does not only mean data complexity and diversity but also refers to the dimension of time. While most experiments only provide a snapshot of an organism's state at one point in time, biological processes are dynamic and the time dimension is crucial to get answers to important health-related questions, especially in preventive medicine. This will further drive the need of robust solutions to deal with big data. Within this context, he saw six challenges: data management, annotation and quality control; computational analysis tools for large data sets; reuse of existing large data sets and extraction of

prior knowledge from the scientific literature; mobility of large data sets versus mobility of analytics; independent verification of scientific conclusions; and data privacy.

The fourth speaker commented on 3V, added that *veracity* (degree of certainty) was a potential fourth component, and stated that big data has allowed us to expand the ways we discover knowledge. Because big data usually involves proprietary information, it is not usually available to the public or researchers and there is little opportunity for learning or creating new methodologies. By creating data centers, we can collect, clean, and curate data and make it available only to academic researchers. And there is public interest in making this operation more efficient for applications such as in call centers and hospitals. He then expressed his concerns on the issues of privacy and cost.

The fifth speaker discussed advanced data technology, and stated that by properly utilizing or analyzing information, prediction and planning can be implemented. He then described a project with NEC that involved the use of sensor pairs at nuclear power plants. The proper usage of knowledge is changing the world, and the next step for the use of big data could be to address issues in areas such as energy and healthcare. The next step on the usage of analytics and how we can contribute to social issues by utilizing big data, include assisting decision making, creating better cities, and recommending improved education systems. The issues of the quality of data, security, and privacy would also need to be addressed.

The sixth speaker questioned what everyone's thoughts were on privacy in the 21st century and the generational change in how people look at privacy. The first speaker replied that there was more awareness among the young than the elderly realize. The fourth speaker added that the consumer does not commonly see the impact of making private data public and stressed that it was more of an economic issue. The chair questioned if there was an opportunity for the individual to take back control of their data under certain circumstances and if one could cut out the middle men between the consumer and the purveyor of products or services.

Discussion

The second speaker focused on the issue of privacy, the various types of big data, as well as the idea of anonymous data for public use.

The fourth speaker spoke about big data leading to paradigm shifts in science and social science, one example being learning how to predict airplane engine failure based on data

continuously collected from numerous sensors; and another being the integration of data from a variety of sources.

The third speaker discussed the move from science based on correlations to science based on causation. While correlations provide a good foundation to build hypothesis, causation will be needed to substantiate them and provide the basis for the discovery of, e.g., novel diagnostics and treatment modalities. There is both good and bad big data. Good big data often provides a solid starting point to identify causation, however the misuse and unethical use of big data, as well as big data of poor quality, are the inherent risks of data driven endeavors.

The first speaker pointed out that big data was not necessarily a science and questioned if big data presented anything new or if it was just reusing existing techniques in a slightly newer arena. However, he added that big data has given us the ability to explore things that were previously quite challenging, and that machine learning and big data together could potentially drive science in the future in a system where machines could learn and interpret rules to generate new rules which would become the science of the future.

The fifth speaker commented on the nature of big data being domain specific, verification problems involving big data, the new toolkits and technologies such as AI and machine learning, the lagging public policies in the advances in big data; as well as the cultural and national disconnects and attitudes towards big data.

A participant discussed big data being used for science compared to other purposes, the use of good statistical methods, the issue of lagging policy, aggregated anonymous data and data attributed to individuals, copyrightable data, what principles will be implemented when sharing information with scientists, and how to sell data without attributing your source.

The chair then thanked everyone for participating and concluded the Concurrent Session on Big Data.

Plenary Session 204A: Population & Resources

Session Chair

Nurse, Paul, President, The Royal Society, U.K. [Nobel Laureate 2001] [Nationality: U.K.]

Speakers

El-Beltagy, Adel El Sayed Tawfik, Chair, International Dryland Development Commission (IDDC), EGYPT [Nationality: EGYPT]

Siew, Vincent C., Former Vice President, Chinese Taipei 2008-2012, Office of Former Vice President Vincent C. Siew, CHINESE TAIPEI [Nationality: CHINESE TAIPEI]

Amano, Yukiya, Director General, Director General's Office for Coordination, International Atomic Energy Agency (IAEA), AUSTRIA [Nationality: JAPAN]

Kumar, Ashwani, Member of Parliament of India, Rajya Sabha (India), INDIA [Nationality: INDIA]

Farhadi, Mohammad, Minister of Science, Research and Technology, IRAN [Nationality: IRAN]

Madius Tangau, Y.B., Minister, Ministry of Science, Technology and Innovation (MOSTI), MALAYSIA [Nationality: MALAYSIA]

Opening Remarks

Sir Paul Nurse began by offering a few remarks. The world's population has grown rapidly in recent decades, surpassing 7 billion and likely to reach 9 billion by the middle of the century. This population growth, combined with growing consumption and climate change, threatens the sustainability of the world. At the same time, population and levels of consumption vary by country and region. Rapid population growth has also accelerated urbanization. At the same time, it has also exacerbated poverty. In addition, demographic changes are expected to increase the number of people exposed to various extremes, such as adverse weather conditions.

The world must take urgent action to lift the poorest out of poverty, reduce overall material consumption, and flatten population growth. To do so, we must devise socioeconomic systems that do not rely on continued material growth, and this can only be achieved when governments, businesses and citizens respond to these challenges. How successful we are will determine the future of humankind.

Dr. Adel El Sayed Tawfik El-Beltagy reiterated the fact that the population of the Earth was rapidly growing, far beyond its capacity. Another challenge is climate change, which will lead to population migration, affect flora and fauna, and impact the world's environment.

Speaking of Egypt and the Nile delta area in particular, Dr. Beltagy explained how Egypt was addressing the dual challenge of population growth and climate change, which threaten the nation's social security. Poverty is a major concern in the region as well, which exacerbates population growth, as do religious and cultural traditions. This presents both a challenge and opportunity. The Egyptian government has demonstrated the political will to tackle these issues. It is engaged in programs to modernize and reform institutions to minimize poverty, raise social and food security, and create new job opportunities.

Dr. Beltagy then expressed his belief that developed countries had an ethical responsibility to partner with developing countries, such as by facilitating technology transfer, not merely for the benefit of the populations of developing countries, but for peace and stability for all people in the world. Finally, he urged all countries to form a global alliance and support the UN Sustainable Development Goals.

Dr. Vincent C. Siew discussed the nature of the relationship between population and the economy. A society's population has positive and negative impacts on the economy. Population can be a key asset in the form of human capital, which can also counterbalance a lack of natural resources. Of course, the population needs education and training to be productive. A good example is Japan, which has high population density and ample supply of highly educated human resources. It achieved a remarkable transformation into an industrial revolution in a few decades. Taiwan followed suit in a similar manner.

On the other hand, a population that is not educated can also be a significant burden on the economy. There are times where a large population is a deterrent to economic development. The hyper-aging of society also results in large sections of the population requiring support from society and the economy, and, at the same time, fewer younger members of the population to provide such support.

To address these issues, Dr. Siew proposed that STS *forum* should function as a platform for scientists and policymakers to work together and consider how to educate the population to fulfil the needs of global society.

Mr. Yukiya Amano believed that science and technology was at the heart of development. This is recognized in the UN Sustainable Development Goals. He then spoke of the contributions of the International Atomic Energy Agency (IAEA) and nuclear technology to developing countries. The IAEA makes nuclear technology available to its member states in areas such as human health, food production, environmental protection and, of course, energy. Nuclear technology is extremely important and has an extraordinary impact on millions of people around the world.

Widespread use of nuclear technology can be found in many developing countries, such as the use of gamma radiation to sterilize medical equipment. In addition, as an energy source, nuclear power offers a stable solution that produces no greenhouse gases. This is enjoyed not only by developed countries, but also developing countries.

In closing, Mr. Amano stated that the IAEA would continue to work to meet the needs of the growing world population, declaring that the IAEA worked for peace and development.

His Excellency Dr. Ashwani Kumar believed that population and resources were essential topics for discussion. Moreover, these are pressing issues that must urgently be addressed. As the population grows more rapidly, the ability to provide the necessary food, as well as water, is becoming increasingly scarce. Despite the decline in fertility rates, 58 high fertility countries are projected to triple the global population by the end of the century. At that time, 60% of the world's GDP is forecast to be the consumption of food, goods, and services. This is not conducive to the sustainability of the Earth. That is why global nations and the UN has set shared targets for the sustainable development of the world.

In that vein, His Excellency Dr. Kumar reminded that these were not merely national issues, but part a common global challenge. He then quoted Mahatma Gandhi, "The Earth has enough to satisfy everyone's need but not enough to satisfy everyone's greed." At the heart of this issue, is the question of a just world order, not a systemic order. If 10% of the world's richest consumes 60% of its resources, surely that is a sign that change is needed.

His Excellency Dr. Kumar then called for international cooperation, citing the African proverb, "to travel fast, travel alone; to travel far, travel together." Moreover, the actions taken by the international community now, will be judged by future generations. If we act now, there is still time to preserve our planet.

Dr. Mohammad Farhadi spoke on the huge demographic changes that Iran had undergone. The high population growth has resulted in a vastly increased supply of young human resources. Furthermore, a significant portion of the population is in higher education or research, and is poised to contribute to addressing the problems that Iran faces. On the other hand the growing number of workers also means a growing number of consumers of resources and greater impact on the Earth.

Iran recognizes the immediate need to conserve natural resources and mitigate the effects of climate change, and therefore employs three strategies. These are to raise awareness for the optimum use of resources, reduce pollution through renewable energy technologies, and develop recycling technologies and products.

To conclude his remarks, Dr. Farhadi declared that while each country must harness its science and technology capabilities to address environmental problems, these were not the issues of individual nations, but a global challenge that all countries must face together.

The Honorable Datuk Madius Tangau began by stating that global food security problems were already having an impact on the world and tragic consequences in countries around the world. This requires an urgent response from the international community, and is being exacerbated by rapid population growth. However, raising food production alone will not solve food security problems. Rather, countries need to come up with development projects that simultaneously address both population and food production factors. This requires a complex, multi-disciplinary and multi-stakeholder approach. Science and technology are not the only solutions.

Malaysia applauds and supports the Sustainable Development Goals and is making efforts to preserve its precious natural resources for future generations, centered on restoration and reforestation programs, integrated water resource management, natural resources governance and stewardship, biodiversity enforcement, and sustainable financing mechanisms.

However, many challenges remain, such as a lack of financial mechanisms, scattered information, ineffective implementation, non-compliance to development deadlines, among others. To address these shortcomings, Malaysia will introduce a number of strategies for natural resources, including appropriate indicators for their sustainable use, establishing an inventory thereof, strengthening financial mechanisms for their management, and educating the public on their use. Finally Malaysia understands that alongside science and technology, it must develop complementary socioeconomic systems.

Discussion

Sir Paul noted that all of the panelists had touched upon both political and economic ways to deal with the issues raised, as well as solutions through science and technology. He invited them to weigh in on which was more important.

Dr. Beltagy believed that both approaches had to be complementary. As an example, he cited the need to double food production in the world. This will be impossible without the application of cutting edge technologies in agriculture. Natural resource management also needs to be based on science. At the same time, there needs to be governmental acceptance, as well as collaboration across national boundaries.

His Excellency Dr. Kumar believed that all approaches were equal but it would not be possible to make a significant advance without the necessary political will and leadership.

It is only political leadership that can convince and motivate people to take the necessary action.

Mr. Amano pointed out that while his organization, the IAEA, was built on technical knowledge, there must nevertheless be political leadership, as well as social acceptance to implement any technologies and ensure that they would have the necessary effects. Therefore respect must be given to technological, political and societal considerations.

Dr. Beltagy mentioned an example whereby the populations in some countries were facing starvation. Other nations offered shipments of genetically modified seeds to rectify the situation. However, because of ignorance and without any scientific reasoning, these seeds were rejected through irrational fear. In light of this, there must be more communication and information-sharing among developing countries regarding developments in science and technology to help each other move forward.

Sir Paul asked His Excellency Dr. Kumar how it would be possible to most effectively achieve international collaboration.

His Excellency Dr. Kumar acknowledged that this was a difficult question but emphasized that there was no alternative other than to come together, transcending national, geographic, informational, and cultural divides.

Dr. Farhadi agreed on the importance of working together, and fully supported this call for collaboration.

Sir Paul then asked the panelists to comment on the challenge of water shortages faced around the world.

His Excellency Dr. Kumar said that 3.6 billion of the world's population was without access to adequate water and opined that the next wars would be fights over water. Despite all the research being conducted, the fact is that no one really has an answer, and water shortage remains the single most important challenge facing mankind.

Mr. Amano explained how nuclear technology had strong advantages in terms of locating or analyzing water, helping prevent waste and ensuring its sustainable use.

Dr. Beltagy noted that there was conflict of water not only between nations, but within nations and between communities. One area of promise is desalination, but more progress is still needed to make this technology more efficient.

As a final question, Sir Paul pointed out that ultimately, the question of controlling population growth boiled down to controlling reproduction. There is both the voluntary approach, as can be seen in developed countries, where greater affluence leads to lower fertility rates, or there is the approach of applying strict controls. Sir Paul asked the panelists to offer their take on which was more appropriate.

His Excellency Dr. Kumar said that in most cases, strict controls failed; moreover, they violated human rights. Instead, he believed in the power of education to encourage free people to take the right course of action.

Dr. Beltagy also stressed the importance of education, particularly for those from whom it is sometimes withheld, such as girls.

Plenary Session 204B: Science and Technology in Business Management and Strategy

Session Chair

Colombani, Pascal, Chairman of the Board, Valeo S.A., FRANCE; Vice-Chairman, French National Research Strategy Council, FRANCE [Nationality: FRANCE]

Speakers

Jackson, Keoki, Chief Technology Officer, Corporate Engineering, Technology and Operations, Lockheed Martin Corporation, U.S.A. [Nationality: U.S.A.]

Chubays, Anatoly B., Chairman and Chief Executive Officer, RUSNANO, RUSSIA [Nationality: RUSSIA]

Piou, Olivier, Chief Executive Officer, Gemalto, FRANCE [Nationality: FRANCE]

Hays, Ed, Senior Vice President and Chief Technical Officer, The Coca-Cola Company, U.S.A. [Nationality: U.S.A.]

Quintana-Plaza, Susana, Senior Vice President, Technology & Innovation, E.ON SE, GERMANY [Nationality: SPAIN]

Varasi, Mauro, CTO, Finmeccanica SpA, ITALY [Nationality: ITALY]

Opening Remarks

Dr. Pascal Colombani opened the session by stating that we live in a world full of new challenges. We need new avenues for growth, new technologies, and innovation for business strategies. We also need to develop knowledge that can develop into economic benefits. It is important to manage risk, and not to overly focus on avoiding it at the expense of innovation and creativity.

Dr. Colombani stated that two revolutions are taking place in our present time. The first one has to do with digital and big data, characterized by the availability of, and synergies between, a large amount of data, artificial intelligence, computing power, and rapid prototyping. Dr. Colombani's second

point was on climate change, and he stated that we need more efficient forms of energy in a context marked by increased decentralized production of electricity, and the need to limit energy consumption. His last point on business strategies was on the importance of the emergence of new materials.

Dr. Colombani then gave examples of the strategies of Valeo S.A. for research and development. Valeo focuses on corporate open innovation, including its 50 academic partnerships, and develops crowd sourcing of ideas and talent. They have set up a global student challenge, with Chinese, Indian, and American teams emerging this year as the winners. Valeo also collaborates with startups, technology companies, and venture capital firms, and places utmost value on innovation.

Dr. Keoki Jackson outlined the goals of Lockheed Martin Corporation, which relies on innovation for business success. The landscape has changed in recent years, and Lockheed Martin has led several initiatives that have enabled them to understand that the skills and models of the past are not sufficient for the future.

Dr. Jackson outlined three driving forces: complexity, velocity, and nonlinearity. Solutions are found at the seams of multiple technologies for complexity. For companies like Lockheed Martin, velocity is vital and new platforms are essential to connect to problem solvers around the world. Nonlinearity is where technology converges, entailing continuous change and disruption. Tools such as big data can help Lockheed Martin reinvent its core business models.

There are three key roles for the technology function of business: creation, integration, and anticipation. Creation means the development of business and technology strategies for customer needs. For integration, technology drives operational excellence across Lockheed Martin's businesses. The third theme of anticipation was on the courage to be open to disruption, and to take advantage of emerging opportunities. Anticipation is also about having the talent, infrastructure, and skills to succeed. Challenges, such as lack of personnel and friction in systems for taxes and regulation, must be addressed by leaders such as the participants at the STS *forum*.

Mr. Anatoly B. Chubays spoke on changes in disruptive technologies. He began by giving an example related to climate change and greenhouse gas emissions. The traditional paradigm is to focus on energy. However, Mr. Chubays questioned if energy is the only approach to examining climate change, and emphasized the analysis of manufacturing, transportation,

and storage of basic materials, which account for 28% of greenhouse gases. He called for green materials that involve less greenhouse gas emissions during the manufacturing and production chain. Nanotechnology will bring promising opportunities in this area. The global effect of green materials can lead to the decrease of greenhouse gas emissions without subsidies, and can even have better effects than clean energy.

Mr. Olivier Piou stated that it is indeed challenging to define strategies in a rapidly changing world. Technology and innovation can make a huge difference in education, health, and development at large. The question is how to make a great idea accessible to the largest number of people. For a corporation, Mr. Piou argued that a vital question to ask is, "What do the people who want me to become obsolete do?"

Mr. Piou then discussed various trends, including low cost, which does not necessarily mean cheap but also entails involving the customer in the process, such as online booking of airline tickets. Mr. Piou also said that businesses should question if their "traditional competitors" are in fact the most relevant in rapidly changing times, when digitalization, crowd funding, and collaborative platforms such as Uber deconstruct well-established integrated processes which benefitted from centralization and scale, exactly the opposite attributes of the rapidly expanding mobile and digital world.

Mr. Piou then stated that exploring sources of innovation is essential. One approach is biomimicry. IoT systems' resilience to disasters is similar to the natural resilience to viruses found in nature. He also emphasized creating practical solutions to local issues, raising the example of Nokia, which became very popular in India by adding a flashlight to cellphones since many small roads are not lit in the country. Collaboration with third parties is often necessary for strategy. Mr. Piou gave the example of modern cars, which generate a large amount of data. The data can be used for very different purposes, such as advertising for a restaurant based on location data, offering low cost insurance using driving data, or preventive maintenance from diagnostic data. Mr. Piou concluded by saying that innovation has never been so pertinent, close, or exciting. We should find inspiration in nature, create collaboration, and take advantage of the rapidly changing world to define innovative strategies based on the best benefits created for society.

Dr. Ed Hays began by answering a question about the Coca-Cola Company, saying that innovation is extremely important at the company. Their holistic approach to innovation is embedded in everything they do, including bottle shape, marketing innovation such as the

"Share a Coke" campaign, and water initiatives. The Coca-Cola Company must ensure the quality of 1.9 billion servings per day.

Dr. Hays then explained the history of the Coca-Cola Company, saying that research and development have been important at the company since its founding. For example, the company has worked in the area of low and no calorie sweeteners in response to customers. The company also develops beverages in order to meet the needs of different kinds of consumers, including coffees, teas, and waters. In addition, collaboration in science and technology is important for the Coca-Cola Company. Dr. Hays concluded by focusing on women in technology and the company's conscientious efforts to promote women in this area.

Ms. Susana Quintana-Plaza focused on how to define a strategy in a new innovation environment, changing the question slightly from the one first posed by Dr. Colombani. She said that innovation does not only come from experts or people with PhD's. Innovation can come from anywhere and many successful entrepreneurs never finished their formal education.

Ms. Quintana-Plaza also raised the topic of Millennials, who are no longer interested in owning material things such as cars and homes. They are interested instead in services, and also value having many different choices in the products they do buy. Collaboration is needed to provide seamless products and services to consumers. Ms. Quintana-Plaza also questioned the traditional system of patents, and called for more open innovation.

Ms. Quintana-Plaza then spoke on the speed of disruption that innovation is bringing, and first raised the example of the newspaper industry. She then moved to energy, saying that new players in the market have disrupted the traditional industry. Solar producers are now called the Uber of energy. In this changing world, setting up long-term strategies is useless. Instead, human capital is essential. Ms. Quintana-Plaza concluded by calling for a change in the way we work and the way information flows.

Dr. Mauro Varasi spoke on the marketplace of Finmeccanica, emphasizing innovation and new approaches to technology. Finmeccanica is an industrial leader in the aerospace and security sector, a field in which customer needs are rapidly changing, demanding constant innovation and speed to market.

To capture innovation opportunities, Finmeccanica has adopted an organizational model based on a federation of internal specialized laboratories, linked to an external eco-system

of innovation stakeholders, such as universities and customers. The nature of the organization ensures the timely recognition of the needs of the market and rapid inception of the innovation, minimizing the barriers between the technology scout and the product engineer. Too often, in fact, the physical and cultural distance of the R&D centers from the real customer needs, and their separation by the product engineering departments, has held back the correct addressing of the innovation process toward real customer needs and hampered the insertion of results into products.

Collaboration between industry and public administrations is a crucial element in Finmeccanica's markets. Collaboration with customers, in terms of product requirements and technology intelligence and in particular with the domestic nation governmental entities, is a key driver for Finmeccanica's product and technology innovation strategies, making the customer a partner in the innovation process. This collaboration is even more important at the present time in Europe, where the continuous reductions of defense budgets are pushing the governments to agree to a roadmap to the specialization of the industrial base at the national level.

Finally, Dr. Varasi concluded that networking was vital for innovation. As Finmeccanica has shown, the creation of external networks, in which the customers play a key role, can be very successful.

Discussion

A participant from the floor asked Ms. Quintana-Plaza about her point on energy, and mentioned subsidies for energy. Ms. Quintana-Plaza pointed out that governments give subsidies in many areas, including fossil fuels. Until now, the reason for the growth of renewable technologies has been subsidies but that is no longer the case. Renewable energy and wind power have now achieved low costs.

A second participant asked about nanotechnology, saying that there have been ups and downs in terms of investor interest. His first question was on how to enhance the understanding of high technologies so their perception of risk is mitigated, and the participant gave the example of Google. The area of angel capital is also important, but big firms cannot work at the angel stage. The participant asked what such large firms can do for this.

Mr. Chubays answered by comparing large and small breakthroughs and the different levels of enthusiasm they inspire. He stated that there is no secret recipe for the problem outlined by the participant, but said there are seed stages that are supported by the state in Russia. Incubators for startups are given subsidies and help is given to young people for innovation in the form of non-commercial money.

The next question was on human resources and untapped capital, and how to get researchers to work with industry. Mr. Piou stated that it was a question of education, and that communication between researchers and industry is affected due to their different mindsets. Dr. Jackson replied that he sees the opposite of what was described by the participant. He stated that he sees incredible excitement for applying science and technology to change the world. He also cited the progress of women and highly skilled immigrants in science and technology, but called for more advancement for minorities. Mr. Chubays responded by providing definitions of science and innovation, namely that science transforms money into knowledge and innovation transforms knowledge into money. He said some researchers do not want to think about money beyond funding for their next study. He said that one of Russia's initiatives centers on picking up research and technology that can be commercialized.

The next question was on using data to keep up with the demands of customers. The participant pointed out that companies are also customers to their contractors and suppliers. Dr. Jackson stated that in his line of business, there is interest in the performance of everything in the supply chain. He said that Lockheed Martin often has to help small and medium enterprises. Ms. Quintana-Plaza said that the problem for energy companies is that their customers are their competitors, and that the companies must work to keep up.

The final question was on the large gap between Africa and the rest of the world. Ms. Quintana-Plaza said that Africa has received certain innovations, such as the jump from landlines to cellphones. She said the people of African countries themselves should determine consumer needs and meet them.

Day 3

Plenary Sessions 300
Closing Plenary Session 301

Plenary Session 300: Key Messages from Concurrent Sessions

Session Chair

Yoshikawa, Hiroyuki, Special Counselor to the President, Japan Science and Technology Agency (JST), JAPAN [Nationality: JAPAN]

Speakers

Kitano, Hiroaki, President & CEO, Sony Computer Science Laboratories, Inc., JAPAN [Nationality: JAPAN]

Meunier, Bernard, President, Academy of Sciences of France, FRANCE [Nationality: FRANCE]

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

Colwell, Rita R., Professor, Center for Bioinformatics, University of Maryland; Professor, Computational Biology, Johns Hopkins University, U.S.A. [Nationality: U.S.A.]

Saovapruk, Yongvut, President, National Food Institute, Ministry of Industry, THAILAND [Nationality: THAILAND]

Hassan, Mohamed Hag Ali, Co-Chair, iap (global network of science academies), ITALY [Nationality: SUDAN]

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

Adly, Noha, First Deputy to Minister, Ministry of Communications and Information Technology, EGYPT [Nationality: EGYPT]

Future Leaders

Kuznetsov, Arseniy, Division Manager / Senior Scientist, Advanced Concepts and Nanotechnology (ACN), Data Storage Institute (DSI), (A*STAR), SINGAPORE [Nationality: RUSSIA]

Oni, Tolu, Senior Lecturer, Division of Public Health Medicine, School of Public Health and Family Medicine, University of Cape Town, SOUTH AFRICA [Nationality: NIGERIA]

Key Messages

Prof. Hiroyuki Yoshikawa opened the session by stating that STS *forum* was a wonderful gathering of diverse participants spanning government, industry, and academia. Science and technology knowledge must be applied to society. However, at times, due to lack of understanding, this is applied in a random, haphazard manner, resulting in negative impacts as well. Therefore, the type of discussion held at STS *forum* is essential.

Prof. Yoshikawa then informed that 28 concurrent sessions were held at STS *forum* this year, over 7 thematic lines. In addition, a very fruitful dialogue was held among future leaders and Nobel Laureates.

Prof. Yoshikawa also noted the different approaches adopted by scientists and policymakers. Scientists are interested in elucidating scientific laws and knowledge. Policymakers are interested in the effects of the application of scientific knowledge and not scientific knowledge itself. Nevertheless, even though both sides may have different approaches, resulting in difficulties in communicating effectively with one other, they ultimately share common goals, such as sustainability, safety, and efficiency. The question of how to overcome such differences, was one of the many key points of discussion during the concurrent sessions.

Prof. Yoshikawa then invited the rapporteurs from each line, as well as the representatives from the future leaders group, to report on the main themes of discussion.

Prof. Hiroaki Kitano presented the discussions from the first line of concurrent sessions, on the theme of energy. Overall, energy is fundamental and critical to supporting society. Over the different sessions, sustainability was a key topic of discussion, including the need to reduce CO_2 emissions.

The first session covered shale gas and oil. The shale gas and revolution is not temporary, and will permanently change the energy landscape. One negative trend that may however be emerging is that in some cases, shale gas is being preferred to renewable energy, due to its lower price. This trend must be reversed. The participants in the discussion also spoke about the success of the shale revolution in the United States, which has been the result of the readiness of physical and financial infrastructure. The question is whether this can be replicated in other regions of the world. Furthermore, it was agreed that the role of shale gas was to act as an intermediate bridge to renewable energy.

With regard to the session on nuclear energy, safety was identified as one of the key concerns. Related to this is the question of public acceptance. Japan is a good example of extreme public rejection, not arising from technical issues, but governance of operators. Investment in newer and safer reactors in India and China, and potentially other parts of the world, may shift the landscape in the nuclear industry.

As for the session on renewable energy, the main topics of discussion were necessary infrastructure and material issues. Furthermore, increasing renewable energy alone will not reduce CO_2 emissions. The whole lifecycle for CO_2 emissions must be managed to ensure emissions are not merely shifted to other areas.

The same applies to transportation and electric vehicles, which was discussed in the session on energy in transportation. Even if a car produces no emissions, its production or the charging process may rely on fossil fuels. As such, a holistic approach is need.

Finally, it is not clear that change is progressing rapidly enough for humankind to attain the necessary climate change targets. Nevertheless it is not too late to act, but efforts will require significant investment in the necessary technologies and infrastructure.

Prof. Bernard Meunier presented next on the life sciences track. First, with regard to regenerative medicine, there has been huge development in genetics and better understanding of science at the molecular level, which has promoted advances in treatments of genetic diseases, such as the emergence of the therapeutic use of antibodies. In addition, knowledge about the genome has given rise to gene therapy. There are also positive

prospects for personalized medicine. iPS technology and the reprogramming of cells is another promising development. Stem cell therapy would also allow for the rejuvenation and modification of organs. However, one major barrier is the cost of the research in regenerative medicine and treatment. The question is whether there is leeway for greater investment, or if we must achieve more for less. The development of biomarkers have also been very useful for adjusting treatment for individual patients for maximum effect, taking us one step closer to realizing personalized medicine.

In relation to nutrition and food, there is a need to raise the quality of food and provide better nutrition. However, the growing global population has made this a more difficult challenge. High quality food needs to be made available worldwide, not only in certain parts of the world. Food security is an international matter that must be addressed globally, including by the UN. GMO offers one answer. It is not popular in Europe, where there is abundant food, but certainly, it offers a promising solution. Associated with food security is also the shortage of water around the world.

Preemptive medicine is linked to personalized medicine and also prevention in medicine. Prevention is far cheaper than treating disease. In this regard, awareness of the importance of vaccination falling in developed countries, but this trend must be reversed. Reduced consumption of alcohol, tobacco, and sugars is also essential.

Due to the global nature in which we lead our lives, infectious diseases, such as Ebola, which used to be limited to certain regions of the world, have now spread across national boundaries. There is a need for new antibodies

and other technologies, as well as better-coordinated efforts worldwide.

Prof. Eric Mazur presented the key messages from the engineering and innovation track. The first session addressed industrial innovation and interaction between government, academia, and industry. Government seeds innovation, academia carries out fundamental research and lays foundation for disruptive research, and industry produces the fruits of innovation. An excellent example of successful collaboration between these three groups include blue LED technology and synthesis of graphene. Such success stories firstly require stability of government funding and policy. Successful partnership between academia and industry is also necessary to ensure greater impact and a broader range of benefits. To mitigate the risks for startups, it was proposed that existing facilities of universities can be leveraged.

Moving onto nanomaterials, these can be created from either a top-down or bottom-up approach. While we think of nanomaterials as being engineered, nanostructures have long existed in nature, such as in viruses or DNA. Nonetheless, more progress must be made from basic research to application. At the same time, bottom-up research has resulted in the ability to design and engineer novel materials. The field is also fundamentally cross-disciplinary. However, research is, by nature, often defined by disciplinary boundaries. It is therefore necessary to carry out education, research and innovation across multiple disciplines. Another challenge is the fact that it is difficult to adapt the bottom-up approach to manufacturing. For nanomaterials to be useful, new forms of assembly will be required, such as potentially self-assembly.

The third session concerned new manufacturing technologies. Even though the physical lifetime of products has increased, their useful lifetime has decreased as users are constantly seeking something more desirable. An extreme example is the mobile phone industry, where phones are generally replaced every two years. This kind of mass consumption has

resulted in a shortage of resources, mass waste, and environmental challenges. There is already an emerging list of endangered elements. We are also producing huge amounts of production waste which are being exported to developing countries that are not capable of adequately recycling them. 3D is a new technology that has emerged that holds the potential to revolution manufacturing. However we must reconsider education and training of workers, and business models.

As for the session on robotics and robotic systems, reliability and trustworthiness are of the utmost importance. Without these, the public acceptance of autonomous cars or robotic surgeons will remain low. Robotic computers hold vast potential. Much like robots that could perform physical labor helped exceed human strength, thereby revolutionizing manufacturing, robotic computation and the extension of human cognitive systems holds limitless potential.

Prof. Rita R. Colwell first presented the discussion from the workshop on the Regional Action for Climate Change. Two key issues are climate change and resource depletion. She presented key messages from the sessions on nature conservation.

Oceans hold great biodiversity and huge populations of bacterial and other species that we are only just becoming aware of that maintain their stability. We are increasingly depending on the ocean for harvesting resources, as well as for a source of food. Therefore, we need both technological advancements and consideration of environmental conservation. We must also understand that the ocean is not just a resource to be exploited, but a fundamental source of support for the existence of life. A promising development is the emergence of technology that allows real-time monitoring of chemical, physical, and biological information regarding the ocean, giving oceanography and society new “eyes” that, if applied wisely, can be used for the benefit of human society. Understanding life in the ocean may also yield answers regarding the question of life on other planets. Big data

has also expanded possibilities. Nevertheless, the complex functions of the ocean are not yet fully understood. In addition, governance of oceans is underdeveloped. Both must be tackled in an international collaborative effort.

With regard to water, water distribution is a complicated issue. We need to understand that this is a necessary resource in times of disaster and will be one of the most difficult problems facing humankind in the immediate future. However, technology has not addressed this crucial inefficiency. Water requires more attention from both a development perspective, as well as a science and technology perspective. The issues seen in California were also a major topic of discussion, highlighting the need for better predictive models of water transportation and its efficient use. Chemical pollutants being discharged into water are also inadequately understood, not only their effects on humans, but also other organisms. People must work locally and globally to gather the necessary data. There needs also to be better understanding of the water footprint in manufacturing of products.

Regarding climate change and environmental adaptation, we must understand that these are complex systems, with very long time-scales. As such we must begin acting now. Furthermore, everything is interrelated in nature. Therefore, we must take a holistic and multidisciplinary approach towards addressing the environmental issues we face, and learning and education for people of all ages is crucial.

Mr. Yongvut Saovapruk reported the key messages from the track on cooperation in science and technology. First, science diplomacy and international collaboration are important for tackling international issues and large-scale projects. Many initiatives have been launched worldwide to improve science communication and diplomacy to ensure better understanding of science and technology issues among policymakers and the public. These also help countries with underdeveloped diplomatic relations to identify and work on areas of common interest. Overall, this yields benefits for the international community.

Next Mr. Saovapruk spoke about "coop-petition" or the need for both cooperation and competition among global industries. We must also develop standards for the Internet of Things (IoT), which requires cooperation across the international community.

The third session was on social innovation for sustainability. One point of discussion was the fact that cooperation between companies and startups could be a successful model for developing novel products. It must be customer-driven and based on understanding of customer needs in each region.

With regard to collaboration among academia, industries, and government, scientific collaboration is also advancing at unprecedented rates. Collaboration can be viewed as a new form of investment, fostering cooperation between industry and academia. Funding programs should be established, as well as new rules that would allow academic researchers to work with industry part-time. Public policy must complement efforts of industry and academia. A healthy and balanced triangular relationship is needed. Government should act as bridge between entrepreneurs and industry. At the same time, however, there is unfortunately a lack of trust between stakeholders, creating tension in large-scale multi-stakeholder endeavors.

As for science and technology in developing countries, capacity building in many is underway, but governments must provide for the necessary levels of education among the population, before embarking on the creation of knowledge-based society. Development in different regions may vary, but we must rely on education, infrastructure, eco-systems and collaboration. Science, technology and innovation must be embedded in society and this can only be achieved if governments treat this as a priority.

Prof. Mohamed Hag Ali Hassan reported on the science, technology, and society track, noting that the overriding question common to the four sessions was how to significantly increase the contribution of science and technology to global sustainability issues, as

encapsulated in the new Sustainable Development Goals. The four sessions also identified education and communication as the most critical issues to be addressed.

Prof. Hassan then highlighted seven key messages. First, regarding education methodology, there is a strong feeling that we must introduce new and innovative ways to provide science and technology education, moving away from fact memorization to problem solving, and hands-on and inquiry-based education, especially in STEM. This will create skills and creativity for fostering new ideas and innovation that will benefit society. The proper training of teachers and the use of ICT in this regard are considered very important.

Second, to improve the ability of science students to solve social problems, they must develop broad knowledge of social sciences. Likewise, social scientists need better understanding of natural sciences.

Third, research in sustainability science is rising very rapidly, helping science make a significant contribution to addressing issues of sustainability. Many universities have introduced research and education programs in sustainability science. This trend should continue.

Fourth, social innovation is critical to sustainability. However, it has to be combined with science and technology innovation and business innovation to form integrated innovation, which is becoming a powerful tool for fostering the development and acceptance of innovation, and bringing its benefits to society.

Fifth, the public perception of science has recently become more negative. This is partly due to the improper conduct of a few scientists. The false link between vaccination and autism is one recent example that has been highlighted. Mistrust often arises from inadequate understanding of science and scientific process, and perhaps science should do more to communicate with and engage the public.

Sixth, institutions such as interactive science centers and museums have shown great success in demystify science and making it accessible to the general public. They have an important role to play to explain science to society at large. Many are now beginning to introduce exhibits related to sustainability issues. Unfortunately they are very rare in developing countries, especially those on the African continent. This is a matter that deserves the careful consideration of African governments to ensure that every country has at least one well equipped science center.

Finally, national, regional and global political leaders are paying more attention to the value of receiving evidence-based science advice, including from individual advisors, advisory panels, academies of science, among others. This is a highly positive trend and it is hoped that this will continue.

Prof. Tomoko Y. Steen presented the key messages from the sessions on smart cities. The participants in the sessions agreed that smart cities were living and evolving things. The design of smart cities can differ greatly, and should be adapted to their inhabitants, taking into account, for example, whether the city includes young children or the elderly. The sessions also highlighted the importance of a multidisciplinary approach and partnership across government, industry and academia. The EU already has a definition of "smart cities" and the ISO is seeking to establish definitions and standards for smart. The advantages of smart cities include reducing cost and resource consumption, thereby increasing quality of life, engagement of citizens, and smoother and more rational infrastructure. ICT was also discussed as a core facet of making smart cities possible. One participant also pointed out that cities are like people. Cities fail because they have failed their people. If they satisfy their people, they will succeed. Sustainability is also an important issue that is closely linked to smart cities.

With regard to the quality of life aspect, smart cities offer higher quality of life through better jobs, efficient transport, clean and reliable water, and a safe environment. Many societies are aging rapidly, and smart cities offer a potential solution. At the same time, as they rely so heavily on ICT, cybersecurity issues must also be carefully addressed. Good healthcare is also a crucial consideration for smart cities. Smart cities offer promise for addressing challenges such as population explosion and resource conservation. It may also be possible for the smart city system to rejuvenate areas that have been abandoned or neglected, such as Fukushima. The building of a smart city there could create good case studies for demonstrating advancements in science and technology.

Dr. Noha Adly presented on the IoT and big data sessions. First, the IoT may sound futuristic, but it is already here. Its impact is already evident for consumers. IoT also offers benefits to industry. With an expected 50 billion connected devices by 2020.

Big data is an important resource that can drive value creation, helping organizations gain insights in natural phenomena, and automating or improving decision-making. The creation of big data provides significant added value for industries. Furthermore, the use of data and

analytics is expected to boost productivity as well. Overall, by facilitating better-informed decision-making, creating added value, and boosting productivity, big data can save time for people and businesses and improve our quality of life.

However there are still challenges to overcome, chief among them concerns about cyber-security and privacy. Consumers need to trust the organizations collecting their data and such organizations need to protect this data from illegal access. These organizations must also manage other risks, such as when physical assets are controlled by machines, for example self-driving cars. The question of how intellectual property rights are attributed must also be addressed. Furthermore, we must ensure interoperability across systems for maximum benefit. Adopting open standards is one way of achieving interoperability, but a fully functioning ecosystem is essential. In terms of technological challenges, scalability and distribution of data, as well as the evaluation of the quality of data analysis results is required. There is also a shortage of adequate experts with the necessary data management and analysis skills. Regulations and policy are also needed but are not progressing as rapidly as the science and technology. All these issues must be addressed through government-industry academia investment in long-term projects and the success of IoT and big data will only be possible if the necessary eco-system is in place.

Dr. Arseniy Kuznetsov and Dr. Tolu Oni reported on the dialogue between future leaders and Nobel Laureates. First Dr. Kuznetsov stated that STS *forum* was a unique forum bringing together diverse participants with a shared interest in science and technology. As an engineer he said it was very valuable to hear the views of other stakeholders.

Dr. Kuznetsov also pointed out that while most of the participants understood that renewable energy, climate change, and sustainability posed major challenges, there was still inadequate awareness of how to solve these issues. In many cases decision-makers do not fully understand these issues scientific perspective. Decisions are often driven by markets and immediate considerations. To address this there must be better education of the public and policymakers. Furthermore, education for children must be enhanced, to include not only science and technology education but also education on the social issues we face.

Dr. Oni made the point that in many cases a lack of sufficient scientific understanding was a barrier to the adoption of new science and technology for achieving a better and more sustainable society. Global society needs global scientists on a global stage.

Dr. Oni then expressed her gratitude to engage in discussions and hear the views of such diverse stakeholders. Nevertheless, she noted that only 12% of the participants came from low and middle income countries, and greater representation would yield more fruitful discussions. She also spoke about women in science and society. For meaningful discussion with society, scientists must be representative of all parts of society. Only 10% of the speakers at STS *forum* were women. On the other hand, it is highly positive that 50% of the future leaders at STS *forum* were women. This hopefully represents significant progress and may be a sign of positive results that encourage greater participation by women in science. Nevertheless more must be done.

Next, Dr. Oni said that alongside the systemic challenges, efforts must be made to address the barriers to scientific literacy in society. Finally, she expressed her hope that the interaction among the participants would foster greater international collaboration.

Discussion

Members of the audience were invited to comment. It was pointed out that wonderful discussions were held again this year. However, it may be worthwhile for STS *forum* to consider building an action plan to implement the brilliant ideas raised each year in a coordinated manner.

Prof. Yoshikawa wrapped up the session, noting that no single scientific discipline can resolve the diverse challenges we face. In light of this we may need to consider modifying the scientific disciplines to better address the challenges faced by global society.

Closing Plenary Session 301: How Do We Move Forward to Maintain Sustainability for the Future of Humankind?

Session Chair

Lee, Yuan Tseh, President Emeritus, Institute of Atomic and Molecular Sciences, Academia Sinica, CHINESE TAIPEI [Nobel Laureate 1986] [Nationality: CHINESE TAIPEI]

Speakers

Pandor, Naledi Grace Mandisa, Minister, Department of Science and Technology, SOUTH AFRICA [Nationality: SOUTH AFRICA]

Nakao, Takehiko, President, Asian Development Bank (ADB), PHILIPPINES [Nationality: JAPAN]

Al-Attiyah, Abdullah Bin Hamad, Chairman, Foundation for Energy & Sustainable Development, QATAR [Nationality: QATAR]

Friedman, Jerome Isaac, Institute Professor and Professor of Physics Emeritus, Physics Department, Massachusetts Institute of Technology (MIT), U.S.A. [Nobel Laureate 1990] [Nationality: U.S.A.]

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

Dr. Yuan Tseh Lee opened the session by discussing the recommendation by the Intergovernmental Panel on Climate Change (IPCC) that we must not allow a rise in the Earth's temperature by two degrees Celsius compared to pre-industrial levels. However, after so many years, we are still talking about two degrees Celsius, but talk alone is irresponsible. We must address this issue with more urgency. We cannot blindly believe that everyone on earth can lead the life of western material comforts, with increasing global population, while still achieving sustainability.

Such problems are global. They cannot be solved by scientists or any one country alone. The participants gathered here hope

to promote international collaboration, while also enhancing the competence of their own countries. At the same time, we must all be more aware of the fact that we are fellow citizens of Mother Nature. It is hoped that 50 years from now we will identify ourselves as such, and pay heed to our reasonability to Mother Nature, as opposed to our own individual countries. Such a transition in mindset is essential.

Her Excellency Ms. Naledi Grace Mandisa Pandor presented on the theme of sustainability and the diverse subthemes related to this challenge. While sustainability has occupied our attention for many years, the concrete issues have been constantly evolving, mirroring the rapid pace at which the world is changing. We are approaching the deadline for achieving the Millennium Develop Goals and have newly adopted the UN Sustainable Development Goals. It is essential that we do a better job of achieving the latter, than we did the former.

Her Excellency Ms. Pandor then stated three areas of action that apply particularly her own region, Africa, as well as other developing parts of the world. Specifically, Africa must close the research gap with the world, African governments must take the lead in promoting science and technology-based development, and finally, Africa must develop a robust human capital development program and put its talent to use.

In terms of closing the research gap, increased attention needs to be paid to research and innovation. However, it still lags behind the world in most areas of science and

technology. Africa is home to 13.4% of the world's population, but only 1.1% of world's scientific research. This points to a deep set of troubling problems. There must better intra-regional collaboration and international partnerships in science and technology for sustainable development. South Africa has made good progress, but many other countries in the region lack the same capacity.

Her Excellency Ms. Pandor also commented that the STS *forum* could lead a new approach to scientific partnership that would build the science and technology capacity of Africa to address the issues of sustainability the continent faces. In addition, rather than introducing the latest science, there should be a focus on how the latest science and technology was impacting the world and making it better. She also called for more attention to be paid to best practices. The question for the next forum is, are we making a difference?

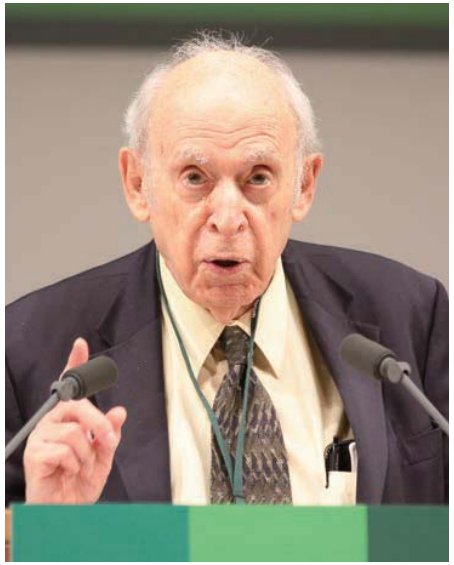
Her Excellency Ms. Pandor then proposed three ways to transform capacity in poorer countries. The first is to locate some of the world's leading research infrastructure in the poorer parts of the world to attract and retain talent. We must also expand regional collaboration in science and technology for shared challenges. International partnerships should also be co-owned by countries involved. Furthermore, to move forward for sustainability we need to focus on advancing countries that remain at the margins, helping to fully link science to the reality across the world.

Mr. Takehiko Nakao first discussed the importance of 2015 for the world, as a new year for kick-starting efforts to address climate change. It is hoped that at 2015 Paris Climate Conference, world leaders will agree on the actions required for combatting climate change, and how to finance climate actions. In September, the UN leaders agreed to the ideas of the new Sustainable Development Goals. The Millennium Development Goals spanned from 2000 to 2015 and many of the goals have been addressed, such as poverty reduction,

raising primary school enrollment, and improving maternity and child health. The new goals adopted by the UN have stronger focus on sustainability.

Mr. Nakao then made the point that Asia was key to achieving these new goals. Asia's population is over 50% and the continent accounts for over one third of the world's GDP, with forecasts suggesting that this will exceed 50% by 2050. However, while in 1990 Asia accounted for 17% of the world's CO_2 emissions, this amount was 30% in 2011 and will grow further in the future. A key challenge will be how to ensure Asia's growth is environmentally friendly and sustainable.

With regard to the role of the Asian Development Bank (ADB), ADB finances and builds capacity in the countries of Asia. In September it doubled financing for combatting climate change to 6 billion US dollars by 2020. Of the 6 billion, 4 billion will be devoted to mitigation efforts, such as renewable energy, sustainable transport, and smart cities, among others. Efforts will also be made to promote drip harvest and more efficient use of water, as well as building better disaster resilience against water disasters. Asia is actually one of the most vulnerable to natural disasters in general, as well as climate change disasters more specifically.



Finally, Mr. Nakao discussed the role of innovation. Without innovation global society cannot grow and make progress. When ADB was founded, its original goal was to feed the growing population of Asia. Technology has helped address this issue and allow ADB to expand its mission to more broad fields. In addition to technological innovation, financing is also important. Greater innovation is needed in finance. There has to be reform to procurement systems to encourage procurement of the most sustainable option, rather than the least expensive option.

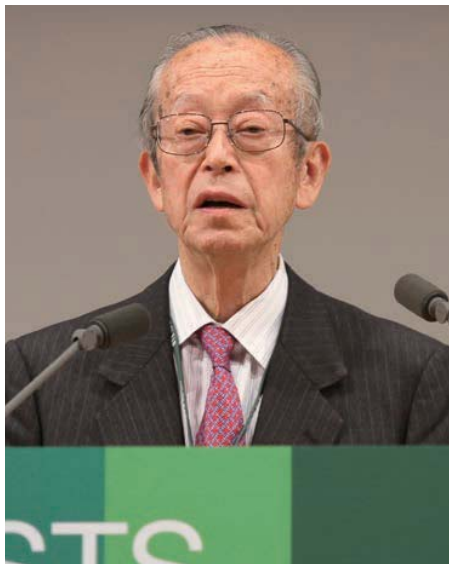
In closing, Mr. Nakao expressed his hope that such continued efforts as those discussed at STS *forum* would help human society to evolve for the better.

His Excellency Mr. Abdullah Bin Hamad Al-Attiyah spoke about the role of science and technology in achieving sustainability, focusing on Qatar's experience. While we all wish for a better society, free of war, disease, and poverty, we live in world of inequality. It is science and technology that holds the key to resolving this.

Science and technology has a significant role to play in ensuring the sustainable development of the world. There is a pressing need to enhance education, research and innovation in fields. In Qatar, the energy sector is of particular importance, and it is necessary to produce energies that are cleaner and more efficient. While the implementation of new technologies can often result in new challenges, these challenges must be overcome.

Another issue affecting the entire world, and Qatar and the Middle East in particular, is inadequate access to water. Water is essential to life, and its scarcity, if left unmanaged, could lead to armed conflict.

Prof. Jerome Isaac Friedman pointed out that one of the important themes of this year's Annual Meeting is the urgency with which human society has to address the serious issues it faces. Humankind is at a perilous point. The developments that improve our lives have



also raised new challenges. These include the need to provide sufficient food and water for the rapidly growing world population, as well as better ways of combatting infectious diseases. We are also doing major damage to our environment, including the oceans and forests, leading to loss of biodiversity. However, the most serious crisis humankind is facing is climate change, which will intensify all other problems.

Global warming is already having a destructive impact on the world, including death and illness. There have also been major societal disruptions from natural disasters resulting from climate change. CO_2 is accumulating very rapidly in the environment and much more stringent measures are urgently required. Climatologists say that policymakers must curb CO_2 emissions in the next 50 years or risk permanent change to our environment. Negative effects have been underestimated by climatologists, and negative developments are occurring more rapidly than was anticipated.

All the various stakeholders and disciplines seeking to address these issues must work together in an integrated manner. Science and technology in particular must be utilized to solve these problems. The development of new innovative technology to address climate change and CO_2 accumulation will require massive investment. Wealthy nations have a strong responsibility to make this happen, and also to help build such capacity in developing nations. There is no single magic bullet, and efforts must be coordinated across a broad range of science and technology research programs. Because science and technology have indispensable roles in addressing humankind's most serious problems, they should have high priority in national budgets. Nations must find the will to make investments in education, research, and innovation. Political leaders and the public have to be persuaded that this is an absolutely urgent and necessary issue. If we do not take action now, we will have betrayed future generations.

Mr. Koji Omi, Founder and Chairman, STS *forum*, began by expressing his deepest appreciation to the participants for their great contribution to the success of the 12th Annual Meeting of STS *forum*. STS *forum* has grown from a mere conference to a global conference, with leaders in different fields working for the betterment of the future of mankind and sustainability. Nevertheless, we must continue to strengthen the "lights" and control the "shadows" of science and technology.

Chairman Omi then shared some of the major messages from the official Statement of the 12th Annual Meeting of STS *forum*. Regarding energy and environment, over the long-run, depending only on fossil fuels will use up the finite resources of the Earth and have an unacceptable environmental cost. We should have diverse energy sources for ensuring sustainable supply. Nuclear power should remain an important option. There is also a need to establish an international framework for effectively mitigating greenhouse gas emissions. In the field of life sciences, recent developments such as genomics and iPS cells have produced breakthrough results. Furthermore, there have been promising results in regenerative, preemptive and personalized medicine. However, a new system is needed for global health for addressing global infectious diseases. In addition, a global-level consensus on universal ICT rules is needed as advanced utilization of ICT with improved security and privacy protections becomes essential for future human development. It is also hoped that science and technology, especially ICT, will be used for more livable urban environments and the creation of smart cities. Collaboration between government, industry, and academia is essential for stimulating economic and social vitality.

Additionally, Chairman Omi informed that this year a CTO meeting was organized to bridge industry and academia and stimulate innovation. In addition, this year a dialogue was held between future leaders and Nobel Laureates and it is hoped that this will continue into the future.

Until the 20th century the world's resources seemed infinite, but in the 21st century we realize that is not the case. Achieving economic growth and preserving the environment at the same time has become historically and critically important. We must protect the environment and ensure sufficient resources for future generations. We must also not forget that humankind is part of nature and we must live in harmony with nature.

Next Chairman Omi stated that thanks to the contributions of its participants, STS *forum* was making a visible achievement in the world. He hoped participants would spread the

message of STS *forum* through their own networks to reach ever broader audiences, In addition, STS *forum* also intends to expand activities and hold workshops in Brussels, Bangkok, and other countries to enlarge the circle who believe in the fundamental concept of STS *forum*.

Finally Chairman Omi announced that next year's Annual Meeting would be held from Sunday, October 2 to Tuesday, October 4, 2016, and said he looked forward to seeing the participants gathered here again to pave the way for future generations.

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STS *forum* 2015 Summary – 12th Annual Meeting
Issued by Koji Omi
Edited by Science and Technology in Society *forum* (STS *forum*)
Sanno Grand Building 419, 2-14-2 Nagatacho, Chiyoda-ku, Tokyo 100-0014, Japan
Tel: +81-3-3519-3351

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