

**Speech at the Official Dinner  
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Thank you for the opportunity to speak at this official STS Forum Dinner. It is an honor for me. Mr. Koji Omi has attracted distinguished colleagues to this forum --- leaders in science and technology, business and governments from all around the world. We are being presented with many ideas. In fact, just this evening when Mr. Tsukamoto and Minister Tokai spoke, I noticed that Minister Tokai is in charge of Education, Culture, Sports, Science and Technology. His title suggested an idea to me: that we in the United States should add Sports and Culture to our agencies which deal with science. Then the public would be more supportive of science because they would link it with Hollywood and football in their minds!

The overall theme for the STS Forum is Lights and Shadows and this year's special themes are Harmony with Nature and the role of Innovation and the need for it. These subjects are very broad and each one of us might approach them differently depending on our personal interests and experience. Some of us might think of Human Economic Development that is harmonious with nature. Others of us might think of Sustainable Development, for example, as described by former PM of Norway, Mrs. Gro Harlem Brundtland in 1987: "our ability to provide for the current generation without reducing the options of future generations" (inexact quotation). This definition is brilliant in how well it captures the challenges for science and technology and for all of us in so few words, yet it leaves several questions unasked. For example, what activities do we wish to sustain and what do we want to develop? Also, should our activities be sustainable for one human generation, two or many generations? What about the needs of other non-human living species and of natural features and landscapes? Finally, we must realize that meeting the minimal needs of humans for food, shelter and clothing has never been acceptable; humans strive for more than a bare subsistence.

Returning to the STS Forum themes, we can view them in more focused ways. In our sessions we are discussing topics like Sustainable Energy Sources and issues of Global Equity involving food, water, education, health and technology. There are indeed many ways to approach Lights and Shadows, Harmony with Nature and Innovation. One way that I envision these challenges personally is to calculate how much land is available per person on Planet Earth. With our land, we must produce food, capture fresh water, dispose of our wastes, grow our fibers and so forth. Of course, we also use the oceans but we depend mostly on land. With a population of over six billion humans, we now have approximately 26,000 square meters per person (2.6h)\*, and I mean all land. The amount of arable land is much less. Such an area as a square is 165 meters on a side.

With this small area per person, we must grow our food, capture our fresh water, derive our energy, minerals, fibers, space for wastes and also use it for our manufacturing plants, building our roads, schools, hospitals and set aside some of it for Nature. In reality, none of us can live a modern life on such a square. We depend very much on science and technology for enhanced production and highly effective processes, and we also rely on trade with our

neighbors, those who are nearby and those who are elsewhere on Earth. I should note that setting aside some land for Nature is not just a spiritual goal, it is important practically, necessary for conserving biodiversity that produces ecosystem services. The famous ecologist Aldo Leopold once said that “the first rule for successful tinkering is to save all of the parts”.

Currently, we add approximately 75 million humans annually to Earth and the global population is expected to be nine billion by mid-century at which point it might stabilize. With nine billion humans, we will have 17,000 square meters per person, or a square 130 meters on a side. Once again, science and technology will be absolutely necessary to survive and to maintain anything like a modern life style. And let me repeat --- meeting minimal human needs is very unlikely to be acceptable. People will want more than a simple diet (they prefer varied diets, not just grain and water), and they seek to travel and means of effective transportation of products and of themselves. Sustainable Development requires that people be fed, clothed, and housed beyond minimal needs and that they be nurtured, educated and employed.

Of course, questions arise as to how much consumption beyond strict requirements can be sustained.

Science and technology have carried us to where we are today. S & T have provided the means for progress, the inventions and processes that have led to enormous increases in agricultural productivity, for example, the roles of trace metals in plant nutrition, the roles of mineral fertilizers and plant genetics and machinery for irrigation and harvesting. Refrigeration has made it possible to store and transport foods. Advances in microbiology, vaccines and water purification, along with many advances in medicine have increased lifespans and improved health.

Science has also made it possible to see shadows cast by human activities and technology, shadows that were not yet dark enough in contrast to be seen by human eyes alone. For example, the reduction of the Earth's ozone layer that began to occur from synthetic chlorofluorocarbons (used for refrigeration, air conditioning and in certain aerosol-spray cans) could not be seen by human eyes. It required the use of sensitive scientific instruments that could measure tiny amounts of CFC's, less than one part per billion, in air so that scientists could employ theoretical concepts of chemical reactions, which in turn were also drawn from laboratory experiments with instruments that could measure properties of relevant chemicals, properties which were not accessible by unaided human vision. Even the damage to the ozone layer, manifested in increased amounts of biologically damaging ultraviolet light at Earth's surface, cannot be detected quantitatively without scientific instruments. The development of safer substitute chemicals (shorter lived compounds with less or no chlorine) was also based on science and on physical principles and mathematical models of atmospheric chemicals wherein the key quantity (the numbers of free OH radicals in sunlit air) was predicted even though it could not be measured directly.

Today, we are also attempting to deal with global climate change, another shadow cast by human activities and by S&T, a shadow that was first seen by scientific instruments and through conceptual and mathematical predictions rather than direct human experience. The role of greenhouse gases in adding heat to the lower part of Earth's atmosphere and oceans was identified and clarified by science which is based on laboratory experiments conducted in infrared, not visible light. Mathematical calculations (using very advanced computers) of

the size and time history of the phenomenon are similarly sophisticated rather than being through the five human senses (vision, hearing, touching, tasting and smelling). Understanding the causes and links to human fossil-fuel based energy usage is another achievement of science. The perception of the problem, its quantification and eventual solutions are all arrived at through science and technology. We have been able to discern another shadow before it became dark enough to be seen with human eyes alone.

Science and technology continue to carry us but the challenges of darkening shadows are very large. We will need a great deal of innovation. As we contemplate the growth of human population, we see the need for more intensive agriculture, demands for more affluence and consumption, more crowding and larger potential for communicable diseases to spread. For science and technology to be effective, communication, good governance and world trade are essential. Science and technology must be supported and used innovatively, and S&T must be available to everyone.

Mr. Koji Omi's vision for the STS Forum asks world leaders in governments, business and from science and technology to meet and to work together. Such meetings and collaboration are not only stimulating, they are necessary for us to achieve our overall goals.