THE SCIENCE AND TECHNOLOGY FOUNDATION OF JAPAN
Akasaka Twin Tower East, 13th Floor, 2-17-22
Akasaka, Minato-ku, Tokyo, 107-0052, JAPAN
Tel. +81-3-5545-0551 Fax. +81-3-5545-0554
E-mail info@japanprize.jp
URL http://www.japanprize.jp

Japan Prize News
No. 41 Jan. 2009

JAPAN PRIZE

2009 Japan Prize Honors Dr. Dennis L. Meadows, Lead Author of 'The Limits to Growth,' and Dr. David E. Kuhl, the 'Father of Emission Tomography'

Transformation towards a sustainable society in harmony with nature

Dr. Dennis L. Meadows

Technological integration of medical science and engineering

Dr. David E. Kuhl

The Science and Technology Foundation of Japan decided to award the 2009 Japan Prize, one of the world's most prestigious awards in science and technology, to Dennis L. Meadows, Ph.D., Professor Emeritus of Systems Policy, University of New Hampshire, and David E. Kuhl, M.D., Professor of Radiology, University of Michigan Medical School.

The "2009 Japan Prize – Transformation towards a sustainable society in harmony with nature" award was given to Dr. Meadows, 66, for his contribution towards a sustainable world continuing from his seminal 1972 report "The Limits to Growth" that founded a new way of scientific paradigm on the globe's limited resources. Dr. Meadows led the team of scientists to produce the report.

The "2009 Japan Prize – Technological integration of medical science and engineering" award was given to Dr. Kuhl, 79, known as the "Father of Emission Tomography," in recognition of his contribution to tomographic imaging in nuclear medicine.

The Foundation Selection Committee selected two American scientists out of the candidates nominated by prominent scientists and researchers worldwide.

OUTLINE

The Japan Prize is awarded to world-class scientists and technologists who were credited with original and outstanding achievements and contributed to the advancement of science and technology, thereby furthering the cause of peace and the prosperity of mankind. No distinction is made as to nationality, occupation, race, or gender. Only living persons may be named.

Fields of study for the prize encompass all categories of science and technology, with two fields designated for the prize each year in consideration of developments in science and technology. Each Japan Prize Laureate receives a certificate of merit and a commemorative medal. A cash award of 50 million yen is also presented for each prize field.

Field: Transformation towards a sustainable society in harmony with nature

Achievement: Contribution towards a sustainable world as founded in the 1972 Report titled “The Limits to Growth”

Dr. Dennis L. Meadows

Born : June 7, 1942 (Age 66)

Professor Emeritus of Systems Policy, University of New Hampshire

President, Laboratory for Interactive Learning

Summary

For humanity, the Earth is both irreplaceable and finite. The continued survival of humanity on Earth depends on its success in creating a "sustainable society." More than 30 years ago, Dr. Dennis Meadows was at the center of a research group that used scientific analysis to make this point. "The Limits to Growth" shocked the world when first published in 1972, and it continues even today to illuminate the way forward.

37 year-old warning increasingly relevant today

In an era of depleting oil reserves and growing concern about global warming, people today realize that, after all, the Earth is not unlimited, and that it is indeed finite. Efforts have also begun around the world to create a sustainable society.

It was a research team led by Dr. Dennis Meadows—at the time an associate professor of the Sloan School of Management at the Massachusetts Institute of Technology—that released this warning 37 years ago about the Earth’s limits, even in the midst of rapid economic growth after World War II.

On request from the Club of Rome, a non-profit organization with an international membership that asked what would happen to the future of the planet if the human beings continued its growth at the current rate, Dr. Meadows and his team conducted an analysis using the latest economic theory and simulation models. In 1972, the Club of Rome released the resulting report, "The Limits to Growth."

The report’s message was an enormous shock to a world in the midst of economic growth. It said that there are certain constraints on the Earth's physical capacity—including resources, environment, soil and so on—and if populations and economies were allowed to continue growing without restraint, humanity would face a crisis. It also said that in order to mitigate these risks, it would be necessary to aim at zero growth for population and the economy. Released during a period that was even more growth-oriented than today, the report had many detractors.

Nevertheless, reality has unfolded as Dr. Meadows and his team predicted, with oil crises in 1973 and 1978, rapid global population growth, the emergence of the problem global warming, and so on. Indeed, the message of "The Limits to Growth" is still valid today for worldwide efforts to deal with global environmental problems.

World model predicted conditions 100 years hence

The Club of Rome is launched in 1970 by Dr. Aurelio Peccei (at the time vice president of the Italian firm Olivetti), in order to address global issues such as resources, population, military expansion and environmental destruction. Over the years it has released many reports, but its first was “The Limits to Growth,” by Dr. Meadows and his colleagues.

The Club of Rome created the “Human Risk Project” and asked Dr. Meadows to lead research on this topic, for which he assembled a research team with his late wife Donella and other young researchers. They used systems dynamics theory to create a world-scale computer model of economic activity—a simulation of the world situation 100 years hence.

The report portrayed near-future scenarios based on five variables that grew exponentially: population, food consumption, industrialization, environmental pollution and resource depletion. The analysis showed that physical constraints would make it impossible for growth to continue at the pace being experienced at the time. In particular, economic growth from industrialization and world population had a multiplier effect, resulting in negatives such as pollution, resource depletion, hunger, and so on. The pronouncement that the existing world system would eventually lead to catastrophe shocked people worldwide.

In other words, this was a “global crisis report” based on a world model that used all the scientific data available at the time. Once the report was released, in effect, the world began to test the model. In Japan, a Tokyo office of the Club of Rome and a Japan Research Team were established.

Evidence continues to grow

One could say that the real world began to move faster than the simulated world model. In October 1973, just a year after the report came out, the world was hit by an oil crisis triggered by the Fourth Arab-Islaeli War. In Japan, many people were unsettled when the consumer price index rose by 23 percent in 1974.

Then global environmental problems began to surface. Efforts to better understand the desertification of agricultural land and forest destruction caused by acid rain led to advances in the natural sciences, which accelerated progress in analysis of the global environment, then it became known the human economic activity could cause global warming. The Intergovernmental Panel on Climate Change (IPCC) was established in 1988, and it has continued to conduct scientific assessments to this day.

As the world continued to change, Dr. Meadows and his colleagues continued their work of verifying "The Limits to Growth." Twenty years after their groundbreaking report, they released their second work in 1992, titled "Beyond the Limits." Using newly-compiled data, it showed that humanity had already exceeded the Earth’s carrying capacity. With 14 scenarios, Dr. Meadows’ team called for a transformation into a “sustainable society.” Next came "Limits to Growth: The 30-Year Update," in 2004. In it, the authors added fresh data from the previous ten years. They showed that since 1990 gross domestic product had declined in 54 countries, and that humanity was exceeding the Earth’s carrying capacity by 20 percent in the year 2000.

With his conceptual foundations based on "The Limits to Growth", for the past 37 years Dr. Meadows has consistently called for the creation of a sustainable society. The reports never fail to offer prescriptions for the transformation into a “sustainable society.” The closing commentary of the original report says that “Humanity should not lose hope in the future; the only way forward is through international debate among statesmen, policymakers and scientists about the dangers and hopes of the future governmental and human systems.” This message from Dr. Meadows and the Club of Rome may well be their greatest contribution to the world.

"The Limits to Growth": Clues and Options for the Future of Humanity

- **1965**
- **1968** Meeting to establish the Club of Rome
- **1970** Club of Rome established
- **1972** "The Limits to Growth" report released
- **1972** UN's Environment Programme (UNEP) established
- **1973** First Oil Crisis
- **1975**
- **1978** Second Oil Crisis
- **1979** Convention on Long-range Transboundary Air Pollution signed
- **1980**
- **1985** Helsinki Protocol on the Reduction of Sulphur Emissions adopted
- **1988** Intergovernmental Panel on Climate Change (IPCC) established
- **1990** IPPC First Assessment Report released
- **1992** "Beyond the Limits" released
- **1992** The Earth Summit, United Nations Conference on Environment and Development, Rio de Janeiro
- **1995**
- **1997** Kyoto Protocol adopted
- **2000**
- **2002** World Summit on Sustainable Development
- **2004** "Limits to Growth: The 30-Year Update" released
- **2005**
- **2007** IPCC Fourth Assessment Report released
- **2010**

Field: Technological integration of medical science and engineering

Achievement: Contribution to tomographic imaging in nuclear medicine

Dr. David E. Kuhl

Born: October 27, 1929 (Age 79)
Professor, Radiology, University of Michigan Medical School

Summary

Today various types of diagnostic imaging systems including CT (computed tomography) are used on a daily basis in hospitals and clinics all over the world. Dr. David Kuhl, one of the world pioneers in tomography, began experimenting in the late 1950s by taking cross-sectional images of the distribution of radioisotopes in the body. He went on to develop SPECT (single photon emission computed tomography) in the late 1960s and succeeded in producing the world's first tomographic images of the human body. In addition to having a profound impact on the subsequent development of X-ray CT scanning and MRI (magnetic resonance imaging), Dr. Kuhl's research brought about the realization of PET (positron emission tomography), which is proving to be invaluable in the early detection of cancers.

Success in the world's first tomographic imaging

It was Roentgen's discovery of the X-ray that first fulfilled the dreams of medical practitioners who wanted to study in detail the inside of the human body without hurting the patient with the use of a surgical knife. Today X-ray imaging is still widely used in the diagnosis of bone and lung diseases but it was the development of computed tomography (CT) from the late 1960s to 1970s that brought about groundbreaking advances in diagnostic imaging technology. It was this technology that made cross-sectional images of the body possible and enabled more detailed investigation of internal organs.

Today in the field of medicine various medical diagnostic devices are widely used in clinical applications such as X-ray CT scanning, magnetic resonance imaging (MRI), positron emission tomography (PET), and single photon emission computed tomography (SPECT). However, it was the development of SPECT by Dr. Kuhl that was at the forefront of groundbreaking imaging technologies. Unlike X-ray CT scanning, which produces tomographic images from the absorbed amount of X-rays the body is exposed to externally, SPECT is a diagnostic system that produces images by picking up gamma radiation emitted by a minute amount of a radioactive agent injected into the body. By capturing the dynamic state of the agent inside the body, SPECT reveals physical functions such as vascular flow and the metabolism of the internal organs.

In terms of achieving tomographic imaging of the human body, SPECT developed by Dr. Kuhl predated X-ray CT scanning and his research had a significant impact on the development of various diagnostic imaging devices. Because of his achievements in this area, Dr. Kuhl is known as the "Father of Emission Tomography."

Accelerating the development of diagnostic imaging including CT

Born in 1929 in St. Louis in the eastern part of Missouri in the United States, Dr. Kuhl was interested in chemical experiments from the time he was a child and during high school earned recognition for his experiments using radioisotopes. He went on to study at Temple University's Department of Physics but ended up choosing the application of radioactive substances in medicine as his final research topic.

Dr. Kuhl received his Doctor of Medicine degree from the University of Pennsylvania in 1955, at the very time when nuclear medicine was in its infancy. Three years later, in 1958, the scintillation camera was developed. This camera produced images of the distribution of a radioactive agent injected into the body. However, Dr. Kuhl was not satisfied with this technology. As a camera designed to observe two-dimensional projections of a radioactive agent distributed inside the body three-dimensionally, it was not able to provide quantitative data as to how much agent existed inside the body and where.

To resolve this problem, a research group at the University of Pennsylvania embarked on a world first study of tomographic imaging of the distribution of radioisotopes within the body. Later proposed by Dr. Kuhl in 1962, the imaging technique the group developed was based on the principle of emission CT, which is to produce tomographic images of the body through computer analyses of radiation data obtained from all directions of the body over a 360-degree range (see diagram). Essentially, the computer at this time performs an enormous series of matrix operations where one cross-section is divided into a reticular pattern where the amount of radiation in each segment is set as an unknown quantity. A simultaneous equation where the total is made to equal the actual amount of radiation is then used.

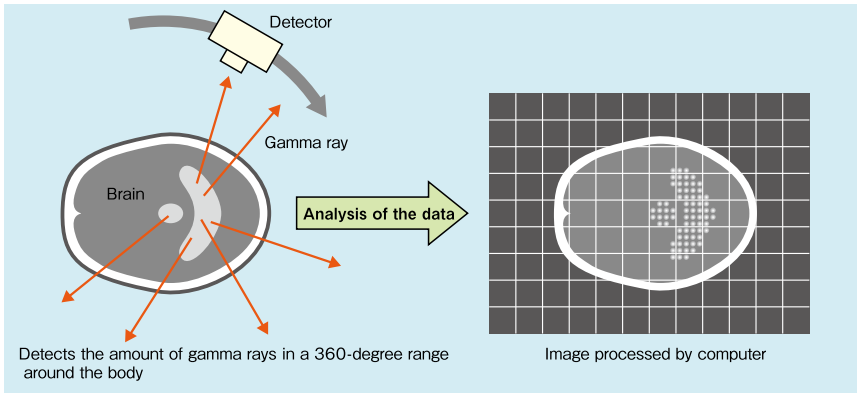
In 1964 the research group developed the Mark II SPECT series, which is a single photon emission computed tomography camera. With this unit, the group succeeded in producing the world's first tomographic images of the human body. This achievement was considerably earlier than Godfrey Hounsfield's development of the X-ray CT device in 1972.

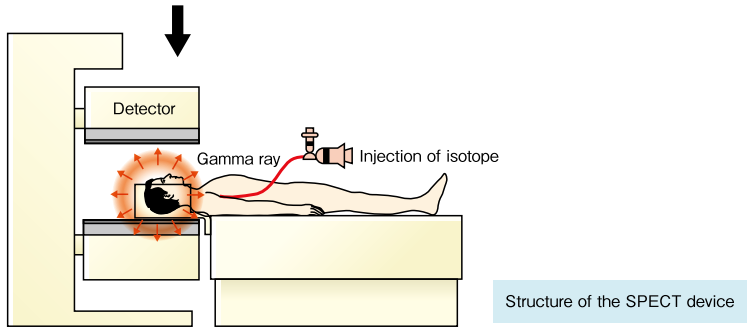
Development as a device for observing physical functions

With his development of the Mark III in 1970 and the Mark IV scanners in 1976, Dr. Kuhl opened up new possibilities in nuclear medicine. X-ray CT later developed as a means of accurately viewing the physical shape of organs while SPECT developed as a technology for viewing the various functions of the body such as vascular flow, metabolism, and neural transmission, among others. Even today SPECT is widely used in hospitals and clinics.

At this time Dr. Kuhl and his team of researchers were also focusing their efforts on the practical application of PET. If the metabolism of glucose, the energy source supporting the body's vital activities, could be captured, the imaging of various biological functions would be possible. However, to make glucose emit nuclear radiation, it would be necessary to label it using positrons rather than radioisotopes, which were generally used at the time. That is why this technique is referred to as "positron-emission tomography" or PET, separate from SPECT.

Principles of SPECT





Structure of the SPECT device

Dr. Kuhl's interest in the use of positron emitters began when Dr. Sokoloff, who was researching animal brains at the National Institute of Mental Health in the United States, used C-14, a positron-emitting radionuclide, to successfully label 2-deoxyglucose, a type of glucose, and measure its concentration distribution through autoradiography. Following on from this success, Dr. Kuhl's group began joint research with Dr. Sokoloff, and Dr. Wolf from Brookhaven National Laboratory and later came to the conclusion that FDG (18F-2-Deoxi-2-fluoro-D-glucose), which labeled F-18, was the most suitable positron emitter that can be used with humans. In August 1976, FDG synthesized at Brookhaven National Laboratory, was sent to the University of Pennsylvania where Dr. Kuhl's group succeeded in realizing the first metabolic imaging of the human brain using a SPECT Mark IV scanner.

The recent development of PET devices using FDG has been proceeding at a rapid pace. This is because PET devices are proving to be highly effective in the early detection of cancer. Glucose metabolism in cancerous tissue is higher than in normal tissue. At the same time, image fusion technology is advancing, and PET-CT, a combination of PET and X-ray CT, is playing an important role in the diagnosis and treatment of diseases such as cancer and cranial nerve disorders.

In these ways diagnostic imaging technologies are making a significant contribution to progress in medical treatment. At the leading-edge of research, the development of various molecular probes is currently underway and molecular imaging, which will reveal the behavior of molecules in living bodies, is becoming a reality. Imaging technologies are not only making a significant contribution to progress in medicine today but are also expected to unravel the mysteries of life as they develop.

Members of the 2009 (25th)Japan Prize Selection Committee

Field I Transformation towards a sustainable society in harmony with nature

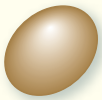
Committee Chairman
Nobuaki Kumagai
President of University of Hyogo
Former President and Professor Emeritus of Osaka University

Panel Chairman
Yoichi Kaya
Director-General, Research Institute of Innovative Technology for the Earth

Deputy Panel Chairman
Itaru Yasui
Principal Fellow, Center for Research and Development Strategy, Japan Science & Technology Agency

- **Keiko Nakamura** — Director General, JT Biohistory Research Hall
- **Kazuhiko Takeuchi** — Professor, Graduate School of Agricultural and Life Sciences, The University of Tokyo
- **Kazuhiro Ueta** — Professor, Graduate School of Economics and School of Global Environmental Studies, Kyoto University
- **Izumi Washitani** — Professor, Graduate School of Agricultural and Life Sciences, The University of Tokyo

Field II Technological integration of medical science and engineering



Panel Chairman
Ichiro Kanazawa
President, the Science Council of Japan

Deputy Panel Chairman
Fumihiko Kajiya
Vice - President, Kawasaki University of Medical Welfare

- **Ung-il Chung** — Professor, Graduate School of Engineering, The University of Tokyo
- **Eiji Kobayashi** — Professor, Jichi Medical University
- **Ryozo Nagai** — Professor, Graduate School of Medicine, The University of Tokyo
- **Gozoh Tsujimoto** — Professor, Graduate School of Pharmaceutical Sciences, Kyoto University
- **Tetsuya Yagi** — Professor, Graduate School of Engineering, Osaka University

(Title when serving on the committee)

Fields Selected for the 2010 (26th) Japan Prize

Area of Studies Ⅰ: mathematics, physics, chemistry, and engineering

Fields eligible for the award: Industrial Production and Production Technology

Background and rationale:

Since the industrial revolution, the remarkable development of science and technology has significantly improved people's standard of living, thereby realizing the creation of a prosperous society not seen before in the history of mankind. Nevertheless, there are still many people in the world who have not reaped the benefits of this prosperity and it has also become clear that we must take into account the fragility of the earth's environment in our pursuit of science and technology. In view of these circumstances, we must continue to strive for further innovation in production technology for the truly prosperous future of mankind.

Achievement eligible:

The 2010 Japan Prize will be awarded to honor achievement that brings about remarkable progress in science and technology in the field of *industrial production and production technology* and that makes an outstanding contribution to society by improving the safety or convenience of the lives of people or by overcoming poverty through the creation of new products or industries, or improvement in productivity.

Area of Studies Ⅱ: biology, agriculture, and medicine

Fields eligible for the award: Biological Production and Environment

Background and rationale:

The existence of mankind has depended on the earth's biological resources in various forms in the past and will continue to do so. However, the earth's environment which supports our biological resources has been rapidly deteriorating. Furthermore, while innovations in technology have dramatically increased our capacity to produce food, the world population has been growing at an explosive rate and is surpassing the growth of the production capacity. In addition to protecting the environment and ensuring biodiversity, sustainable production is essential.

Achievement eligible:

The 2010 Japan Prize will be awarded to honor achievement that brings about remarkable progress in science and technology in the field of *biological production and environment* and that makes an outstanding contribution to society in the following ways: improving the everyday life of people, overcoming poverty by significantly increasing food production or improving food production efficiency, maintaining biodiversity, or realizing a pleasant living environment.

Members of Fields Selection Committee

Committee Chairman
Yoshio Yazaki
President, National Hospital Organization

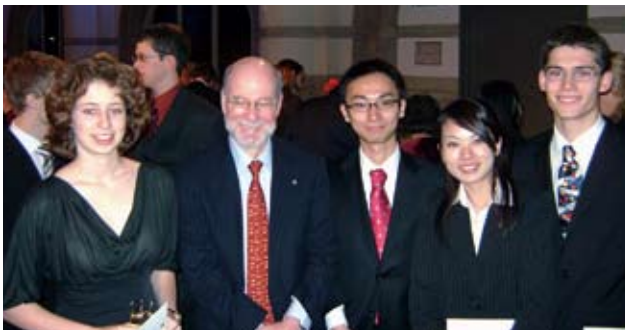
Vice Committee Chairman
Katsuhiko Shirai
President, Waseda University

- **Kazuhito Hashimoto** — Professor, Graduate School of Engineering, The University of Tokyo
- **Yoshihiro Hayashi** — Professor, Graduate School of Agricultural and Life Sciences, The University of Tokyo
- **Yoshio Karita** — Former Grand Master of the Ceremonies, The Imperial Household Agency
- **Nobuhide Kasagi** — Professor, Graduate School of Engineering, The University of Tokyo
- **Tsutomu Kimura** — President, National Institution for Academic Degrees and University Evaluation
- **Hiroshi Komiyama** — President, The University of Tokyo
- **Hiroshi Kuwahara** — Senior Corporate Adviser, Hitachi, Ltd.
- **Hideo Miyahara** — President, National Institute of Information and Communications Technology
- **Kenichi Mori** — Professor, Graduate School of Management of Science and Technology, Tokyo University of Science
- **Noriko Osumi** — Professor, Graduate School of Medicine, Tohoku University
- **Masakatsu Shibasaki** — Professor, Graduate School of Pharmaceutical Sciences, The University of Tokyo
- **Atsuko Tsuji** — Editorial writer, The Asahi Shimbun

(Title when serving on the committee)

TOPIC : Japanese Students Attend the Nobel Prize Award Ceremony

In 1987, the Science and Technology Foundation of Japan instituted a program which began sending two Japanese students to the annual Stockholm International Youth Science Seminar (SIYSS). The event is held during Nobel Prize Week as a means of promoting the international exchange of young scientists, and is conducted under the auspices of the Swedish Federation of Young Scientists and with the support of the Nobel Foundation.



At The Nobel Committee Reception, second from left Prof. Horvitz (2002 Physiology Laureate) , Mani and Matsushita on Dec. 9. 2008

The Science and Technology Foundation of Japan sent Ms. Mai Matsushita of Kobe University and Mr. Tomoyasu Mani of The University of Texas to the 2008 SIYSS. Their report follows:

Mani and Matsushita together with 2008 Laureates in physics, Prof. Maskawa and Prof. Kobayashi

Mani at SIYSS Seminar

As the Japanese contribution to scientific research continues Japanese scientists shared the Nobel Prizes in Physics and Chemistry. Our participation in 2008 Stockholm International Youth Science Seminar (SIYSS), as delegates of Japan, has had a profound impact on our vision towards the future.

In physics, the laureates emphasized the "unique contributions" made by other domestic researchers. The densely interconnected Japan of the early post-war years was different from the globalized nation of the present. The laureates also emphasized the importance of remaining confident and loyal to one one's theory. On the other hand, in medicine, the alternative approaches distinguished the laureates from their competitors. In their competitive research field, they were collaborating with other researchers abroad while at the same time competing with others domestically. In chemistry, the laureates refined their values as pioneers. Their discoveries opened new horizons in contemporary bioscience, establishing a powerful tool for researchers.

Although their vision of science may differ, all the laureates defined the meaning of a pioneers. To keep an open vision going beyond one one's own research-and to continually challenge one one's own theoretical model with confidence and loyalty - builds the foundations of a pioneer in scientific research. Furthermore, the scientific environment is a significant factor for research. We were advised to search for enthusiastic and supportive mentors, colleagues and collaborators.

We express our sincere gratitude to The Science and Technology Foundation of Japan for providing us with the opportunity to participate in the 2008 SIYSS. This valuable experience offered an inspiration going beyond the Nobel Prize, which we hope to exploit for our future as prospective researchers, making this honorable occasion not just a once in a lifetime event.

SIYSS participants form 16 countries attended the 2008 SIYSS