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受 賞 記 念 講 演 会

Commemorative Lectures
JAPAN PRIZE 2009

財団法人 国際科学技術財団
THE SCIENCE AND TECHNOLOGY FOUNDATION OF JAPAN

13:00	Opening Remarks
13:10	Dr. Dennis L. Meadows Learning to Live Within Limits
14:10	Dr. David E. Kuhl A Slice of Life; 50 Years of Emission Tomography
15:00	Closing

2009 (25th) Japan Prize Laureate

Dr. Dennis L. Meadows (U.S.A.)

Professor Emeritus of Systems Policy
University of New Hampshire
President,Laboratory for Interactive Learning
Born in 1942

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

Learning to Live Within Limits

For almost two years, from June 1970 through the middle of 1972, I was the senior scientist and managing director of a seventeen person team that elaborated a computer simulation model we named World3. The model was created to help us understand the long-term causes and consequences of physical growth in the planet earth's population and material economy. Our results were reported in three books. The first of them, *The Limits to Growth*, was the most widely read and discussed of the three. It was translated into more than thirty languages. It was selected as one of the ten most important books on the environment in the 20th century. And it was mentioned in the formal citation for the 2009 Japan Prize.

Our conclusions in *The Limit to Growth* ignited an explosion of articles, books, conferences, and studies. The responses ranged from outraged criticism to fervent support. I observed then that most of the critics had not actually read what we wrote. They "knew" that we were wrong before reading our analysis, and they looked at our report just long enough to find some justification for their opinion. Unfortunately, most of our supporters had also not read our book carefully. They "knew" we were right, and they looked at our work just long enough to find materials they could use to advocate policies they had supported even before our project. Some readers around the world did study our work carefully. They learned new insights that really changed their lives -altering their views of the world and even the focus of their professional careers. But I found those readers to be a small minority back in the 1970s. Unfortunately the past 37 years have not added many to their ranks. Our work is still profoundly misunderstood and misrepresented by most analysts even today.

I hope the Japan Prize will stimulate a new and more sophisticated analysis of our work, because our conclusions are, unfortunately, being borne out by current events. The current frantic and expensive efforts to solve emerging problems of the global economy are not working. They are either ineffective, or they are making the situation worse by perpetuating the institutions and the theories that caused society's current problems in the first place. To avoid much greater difficulties, we need drastically different policies, policies that are based on better understanding about the dynamics of physical growth in a finite world. That understanding was offered by our initial research.

A detailed prescription of public policy is neither possible nor appropriate here today. But I will summarize briefly what we actually said in that first report, 37 years ago. You will see that our research has both technical and cultural implications. I will restate the main ideas that constitute our real scientific contribution to the growth debate, since these are still missing from the current discussions about sustainable development. Then I will trace the history of my own moral and intellectual development, telling the story of how I acquired the perspectives, the values, and the scientific tools to accomplish this work.

I know that Japanese science and politics are enormously different from those in the United States that shaped my professional development. And I grew up four decades ago, in a very different era. So many of my insights are irrelevant to you. But some of the key events, the main principles, that influenced my work, appear to me to be germane today in Japan as well. I will highlight those ideas that seem especially relevant to the general public and to the young scientists assembled here.

With the benefit of almost 40 years hindsight, I can see that we made a mistake in choosing the title of our book. We are famous for pointing out that there are limits to physical growth. But that was not our essential point. Our unique contribution was rather to tell how prevailing, growth-oriented policies would lead to social disasters in a limited world. We did talk about limits - limits on the amount of nonrenewable resources available, limits on the capacity of the planet to grow food, assimilate pollution, and produce goods. Indeed one chapter was devoted to a summary of data that reflect these limits. But we did not prove there are limits.

If you have faith that technological ingenuity can overcome any obstacle, if you fantasize that the market will always work to provide lower cost substitutes for any goods that grow scarce, or if you expect that some supernatural power will intercede at the last moment to save humanity from the negative consequences of its follies, you will not believe that there are effective limits to growth, and you would not have been forced to change your views by our research. For the members of my team limits were a starting assumption, not a final conclusion. We started from the understanding that it is not possible to have infinite physical growth on a physically finite planet, however bountiful and vast the earth may be.

If you share our understanding, then our analyses offered several important new insights - insights not offered in any subsequent report, even after almost four decades. We showed through our analysis of data and our model-based simulations that:

#1 - policies currently governing demographic and economic growth are inherently exponential. Thus they will raise global population, energy use, and material flows quickly to their respective limits, however high those may be. In 1972 our projections suggested growth would end in this, the 21st, century, and that still seems inevitable to me.

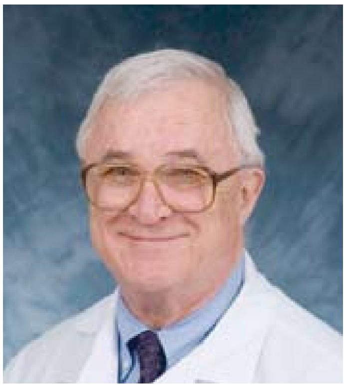
#2 - the limits are erodible. If demands against the planet rise above its carrying capacity, that carrying capacity will decline.

#3 - there are very long delays throughout the structure of social, political, biological, geological, technological, and other factors that govern population and economic growth on this globe.

#4 - exponential growth, erodibility, and delays in the adaptive systems mean that growth will not end gradually and peacefully in the distant future. It will end soon and suddenly through overshoot and collapse. The first result would be much more supportive of society's goals, and it is the outcome that is implicitly assumed by most policy makers today. But a gradual and peaceful decline in growth rates will not occur unless there are drastic increases in leaders' planning time horizons and revisions in their goals, their ethics, and their norms.

In the 1970s the oceans seemed so vast, almost no one could comprehend that human action might put them into peril. Now we realize that the seas are mortally threatened by our actions - by overfishing, warming, contamination, and rising acidity. Until recently it seemed impossible that individual human actions could damage the global economy. Now the unfolding collapse of the global credit markets and the precipitous decline in production threaten all nations.

But the lessons of the oceans and the credit markets have not yet been transferred to politicians' understanding of humanity's options on a finite planet. Indeed the most common policy for solving current economic problems is a desperate effort to get the growth of the physical economy back into its historical, exponential track. I know this policy will not work. Our findings directly contradict key assumptions that underlie the modern trust of the markets and the current faith in technological advance. I will outline those contradictions today.



Dr. David E. Kuhl (U.S.A.)
Professor of Radiology
University of Michigan Medical School
Born in 1929

Achievement : Contribution to tomographic imaging in nuclear medicine

A Slice of Life; 50 Years of Emission Tomography

I have been privileged to play a role in the evolution of tomographic imaging in nuclear medicine. Cross sectional imaging of radioactive isotopes is now an essential component of medical and surgical care and is increasingly important in scientific clinical research. Its development over the past 50 years is a happy story of successful technological integration of medical sciences, chemistry and engineering.

I grew up in Berwick, a small town high above the Susquehanna River in the mountains of Pennsylvania, about 100 miles north of Philadelphia. My father was an engineer with the American Car and Foundry Company. As a 6th grader, my interest in science blossomed. I organized a science club among my classmates who had chemistry sets. It featured regular "seminars" and shared experiments. There were news reports of how radioiodine could be targeted to treat thyroid cancer. I was impressed. In the high school chemistry laboratory, I synthesized a series of radioactive uranyl compounds, successfully built an electroscope, unsuccessfully attempted to build a Geiger counter, and finally decided on a career as a physician-scientist in radiotracer research. Toward that end, I majored in physics at Temple University, and in 1951, entered the School of Medicine of the University of Pennsylvania.

Benedict Cassen at UCLA published on the first rectilinear radionuclide scanner in 1951. Months later, I was awarded a summer fellowship to research radiotracer imaging with such a scanner in the basement of the Radiology Department of the Hospital of the University of Pennsylvania. Our rectilinear scanner had a pair of motors to drive a radiation detector back and forth across a patient and map the distribution of radioiodine in the treatment of thyroid cancer. The standard method of recording then was a tapper to mark radioactivity as dots onto a sheet of paper. Instead, I proposed and constructed a photorecorder that made it easier to detect abnormalities by recording them as controlled shades of gray on x-ray film rather than as points marked on paper. Now physicians could compare pictures of radioactivity on a view box side-by-side with radiographs. Commercial scanners quickly incorporated our photorecorder as a new standard. Nuclear medicine was moved closer to radiology.

After medical school, I interned at the Hospital of the University of Pennsylvania and then served two years in the U.S.Navy heading the Radioisotope Laboratory in the 1400-bed Portsmouth Naval Hospital in Virginia. In 1958, I returned to the Hospital of the University of Pennsylvania as a first year resident in the Department of Radiology. Research time now was even more restricted. New ideas came, in spite if this.

An early insight was that a new emission tomography might help separate radionuclide images as x-ray tomography already helped separate radiographic images. A new cross sectional emission tomography might even provide correct cross section pictures of body radioactivity. Such a process could serve to mimic the results of quantitative autoradiography for exploring the physiology and biochemistry of small internal regions such as in the brain, but this could be done within living patients. A noninvasive scan in a living person would be a significant move beyond the slicing knife in an experimental animal. On 21 August 1959, we performed the first transverse section emission tomography using a milling machine as a translate-rotate scanner, an analog photographic device for back projection of data, and a plastic bottle of [^{131}I]iodide placed deep within a water bath to mimic the patient. In the years that followed, we designed and built the Mark II, III, and IV tomographs. The Mark II scanner was equipped with a collimated ^{241}Am transmission source opposite the detector to produce transmission transverse section imaging. This permitted keying an internal radioactive distribution to surrounding anatomical structure and was a forerunner of x-ray computed tomography (CT). These early single photon emission computed tomography (SPECT) instruments were translate-rotate scanners. They incorporated increasingly accurate computerized methods for back projection reconstruction of counting data and were forerunners of today's positron emission tomography (PET) scanners.

A critical accomplishment occurred in 1972. We successfully performed the first absolute quantification of a local cerebral physiological measure in three-dimensions in living persons, specifically, the respiratory response of local cerebral blood volume. For this, we used an injection of ^{99m}Tc labeled red cells, emission tomography with the Mark III SPECT scanner and nearly exact, iterative data reconstruction. This success anticipated the eventual role of PET as a major study method of brain physiology, neurochemistry and behavioral activation.

Soon after this, we began a joint research effort with Louis Sokoloff at the National Institute of Mental Health in Bethesda, and Alfred Wolf in the Chemistry Department at Brookhaven National Laboratory. The goal was to exploit emission tomography so as to extend for human use the new Sokoloff autoradiographic method that measured glucose metabolism in research animal brain using [^{14}C]2-deoxyglucose. [^{18}F]fluorodeoxyglucose (FDG), a positron emitter with a 2-hour half-life, was selected as the most suitable radiotracer for this human use. In August 1976, FDG was synthesized at Brookhaven National Laboratory on Long Island, New York and then was moved quickly to the Hospital of the University of Pennsylvania in Philadelphia. There we successfully imaged and made quantitative measure of glucose metabolism in the living human brain for the first time using a combination of FDG and the Mark IV SPECT scanner. Later, the combination of FDG and PET was destined for an especially important roll in cancer management.

This accomplishment marked the end of my personal role in beginnings at the University of Pennsylvania. Penn had no cyclotron at that time. By now, efficient PET scanners had been developed in several laboratories, notably in St. Louis and Boston, and commercial availabilities were underway. This special form of emission tomography was recognized to have particular advantage in medical research when matched with target-specific tracer chemicals labeled with positron emitters from an on-site cyclotron. In September 1976, I accepted appointment to the University of California in Los Angeles to direct their nuclear medicine program. This laboratory included a working cyclotron and good chemistry facilities. Our new UCLA group then extended the measure of brain glucose metabolism from FDG SPECT to FDG PET and, in the years that followed, helped to establish FDG-PET as a valid study method in degenerative brain disorders and ischemic heart disease. In July 1986, I moved again, now to head the nuclear medicine program at the University of Michigan. This assignment included excellent cyclotron, chemistry and physics facilities and opportunities to build new faculty strengths. Since then the Michigan program has emphasized emission tomography and the identification, preparation and validation of new radioactive ligands intended to permit a more detailed dissection of neurotransmitter abnormalities in degenerative brain disease.

I have been privileged with a long and an interesting career in emission tomography research. I have worked with so many really outstanding people who shared this interest. It has been great fun. Young scientists, the next 50 years will be even more exciting ones for emission tomography research. I recommend it!

The Japan Prize Is…

～ A prestigious international award in the fields of science and technology ～

The Science and Technology Foundation of Japan honors those whose original and outstanding achievements in science and technology are recognized as having advanced the frontiers of knowledge and served the cause of peace and prosperity for mankind. Over the last 24 years, since its inception in 1985, 66 people in 13 countries have received the Japan Prize. A Japan Prize laureate receives a certificate of merit and a commemorative medal. A cash prize of 50 million Japanese yen is also awarded in each prize category.

The Science and Technology Foundation of Japan

The Foundation was established in 1982, aiming to contribute to further development of science and technology. In addition to recognizing outstanding achievements with the Japan Prize, the Foundation has been promoting knowledge and information on science and technology by hosting the "Easy-to-understand Science and Technology" seminars and awarding Research Grants to help nurture young scientists.

"Easy-to-understand Science and Technology" Seminars

The Foundation holds a series of seminars on advanced technologies used widely in everyday-life. In the seminars designed for students and general public, experts in the related fields explain in plain terms the technologies that are also the focus of interest at that time. Since the first seminar was held in March 1989 over 20 years ago, almost 200 seminars have been held across Japan.

Research Grants

The Foundation provides research grants to scientists and researchers under 35 years of age. Every year, the Foundation selects projects in the same fields as the Japan Prize of that year and gives one million Japanese yen for a project. For 2009, 10 projects were selected from each of the two fields and 20 young scientists received the grants.

Stockholm International Youth Science Seminar (SIYSS)

Under the auspices of the Swedish Federation of Young Scientists and with the support of the Nobel Foundation, the Science and Technology Foundation of Japan sends two Japanese students to the annual Stockholm International Youth Science Seminar. Since the program started in 1987, 42 students participated in the event.

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