OUR DREAM

Ecotechnology for future generations

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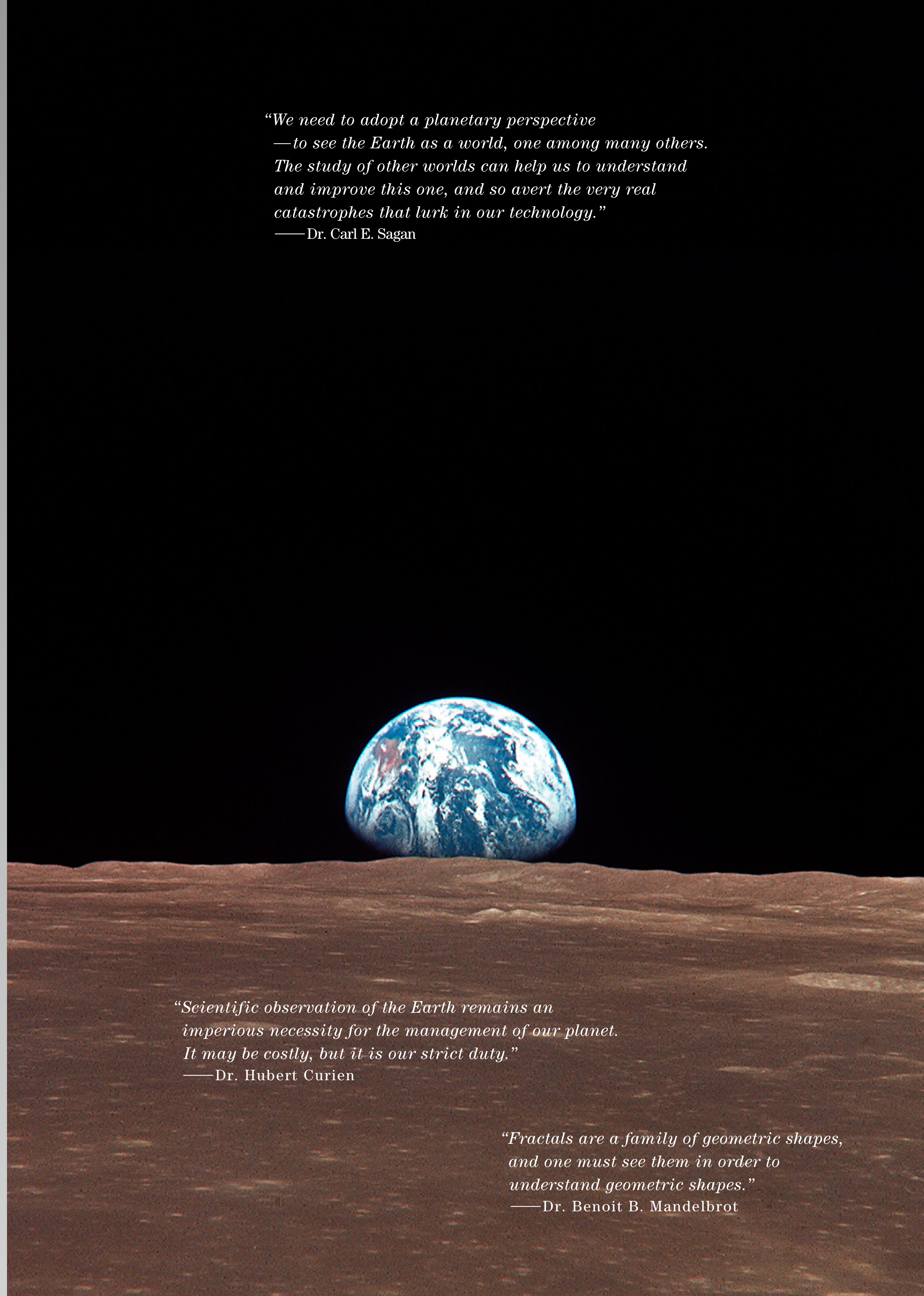


"We need to adopt a planetary perspective —to see the Earth as a world, one among many others. The study of other worlds can help us to understand and improve this one, and so avert the very real catastrophes that lurk in our technology."
——Dr. Carl E. Sagan

"Scientific observation of the Earth remains an imperious necessity for the management of our planet. It may be costly, but it is our strict duty."
——Dr. Hubert Curien

"Fractals are a family of geometric shapes, and one must see them in order to understand geometric shapes."
——Dr. Benoit B. Mandelbrot


"Sophisticated high technology must contribute to the conservation of resources and to energy saving in the interests of mankind."
——Dr. Jun-ichi Nishizawa
"We should learn the technique of management of technological change."
——Dr. Gunnar Hambraeus
"Technological innovation that protects the environment of the Earth."
——Dr. Shuji Nakamura
"Materials science can help to ensure that technological evolution is on the right track."
——Dr. Günter E. Petzow
"Clean up our environment to make the world healthier for us, our children, and our grandchildren."
——Dr. Barry John Cooper
"We have to create machines that are helpful to humans."
——Dr. Ken-ichi Mori
"We use chemicals for the benefit of society with a full awareness of possible hazards."
——Dr. Donald Mackay
"Time will never isolate human beings from nature."
——Dr. Ilya Prigogine
"Shifting society from one that relies on the input of mass materials and energy to one that relies on communication, creativity, and complexity of products."
——Dr. Åke E. Andersson
"We must pay attention to the changes in the parameters of our environment."
——Dr. Hermann Haken
"Strategic study is necessary for our planet's energy future."
——Dr. Umberto Colombo

"Tackling substantive fuzzy problems will produce a humane technology."
——Dr. Lotfi Asker Zadeh

"I have dreamed of a society in which people from different countries, irrespective of the difference in the pace of progress in their respective country, cooperate with each other, advance at their own pace, and lead happy lives."
——Dr. Richard R. Nelson

"Engineers should press forward with development to meet the diversified needs of people."
——Dr. Harold Chestnut

"These advances will transform the way we live, learn, work and govern ourselves. Such capabilities can be used to further increase the gap between the haves and have-nots, or to help the poor, the sick and the illiterate."
——Dr. Raj Reddy

"We need to have technology that fits each region so as to achieve a sustainable end to hunger."
——Dr. Monkombu S. Swaminathan

"Do not fix any form of heavy, solid, and earthbound building on the surface of the Earth."
——Dr. Frei Otto

"Sustainable human development should therefore be understood as progress through quality in every human activity."
——Dr. Aleksandra Kornhauser

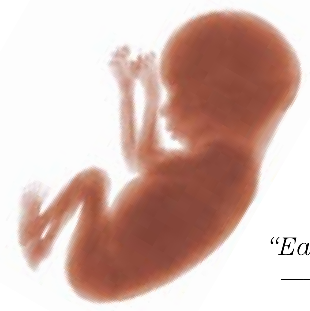
"Life science should lead to a better understanding of what each of us is."
——Dr. Paolo Maria Fasella

"It is possible to reduce the rates of many types of cancer."
——Dr. Bruce N. Ames

"A great variety of these undiscovered microorganisms are distributed on the Earth, indicating the boundlessness of the information they have to offer."
——Dr. Koki Horikoshi

"In case of the engineer, it may mean that the safety of thousands or even the well-being of millions is in his hands."
——Dr. John F. Coales

"Finally, healthy food can only be produced from a healthy environment."
——Dr. Walter C. Willett



"Each and every person is one and only."
——Dr. Jean Dausset

"Classic surgery violates the natural integrity of the human body, and surgeons must respect its natural laws to minimize the effect of such aggression."
——Dr. Philippe Mouret

Ecotechnology for future generations

OUR DREAM

Contents

Honda Prize Laureates

—28 embodiments of ecotechnology

The Honda Prize acknowledges the efforts of individuals or groups who contribute new ideas that may lead the next generation in the field of ecotechnology, and is an international award honoring their achievements. The Honda Foundation does not merely consider scientific and technological achievements from the viewpoint of new discoveries and inventions, but it also takes into account entire processes that would bring out, apply, or share new frontiers in ecotechnology and the broad range of related scientific fields, and has given one award every year.

Paradigm Shift
Sustainability
Innovation
Life Frontier

Preface

The Honda Foundation was officially established in December 1977, approximately one year after it held its first DISCOVERIES International Symposium in Tokyo. Symposiums were subsequently held in Rome and Paris to communicate Honda's unique ideas to the international community. Capitalizing on the experience of the DISCOVERIES International Symposiums, the Honda Foundation started full-scale activities in 1978.

What happened in 1978? In that year, Honda Motor Co., Ltd. celebrated its 30th anniversary, although Soichiro Honda, who was the founder of the company and aged 72 years old at that time, had already resigned as president. Two years before, Honda released the Accord, which is still one of its most popular automobile models. For Japan as a whole, there were two significant events in 1978: the opening of Narita International Airport after much ado and Toyota's achievement in shipping a total of 10 million units in the 42 years since its first automobiles went on sale. At present, a total of some 10 million automobiles are produced every year in Japan.

One of the biggest changes observed in the world over the past 30 years is perhaps the change in people's attitudes toward environmental problems. In 1978, although pollution was causing people serious concern, so-called "environmental problems" were not yet recognized by society. Sustainable development, which has become conventional phraseology today, began to be used 10 years later in 1987. Nowadays, it is regarded as essential to give consideration to environmental problems in formulating governmental policies, in corporate social responsibility, and in people's private lives as well.

Soichiro Honda's strong personality and ideas were incorporated in the activities of Honda Motor and the Honda Foundation as well. In an age where no one had any concept of corporate social responsibility (CSR), Mr. Honda had already based his managerial philosophy on a spirit of public service, and the Honda Foundation was established to communicate its core philosophy of "ecotechnology" widely in line with Mr. Honda's managerial philosophy. It can be said that the Honda Foundation was remarkably ahead of the times in terms of environmental problems. When Honda was criticized for manufacturing mainly motorcycles, which allegedly provided motorcycle gangsters with the means to multiply, Mr. Honda insisted that riding a motorcycle could provide the younger generation with an opportunity to learn about society, and he actually started activities to provide those sorts of opportunities. I believe that Mr. Honda established the Honda Foundation based on the concept of ecotechnology in order to communicate his belief that corporate activities should always contribute both to the natural and the human environments.

This is not something of a myth. I believe that the Honda Foundation has actually proved that Mr. Honda had considerable foresight. This booklet looks back over the 30 years of the activities of the Foundation, during which time Mr. Honda sadly passed away, and is designed to serve as a milestone on the path to creating a new history for the Foundation while passing on Honda's unique ideas to future generations. I hope that this booklet will provide guidelines for the scientists and engineers who will be the leaders of the coming age and will help them deepen their understanding of ecotechnology.

March 2008

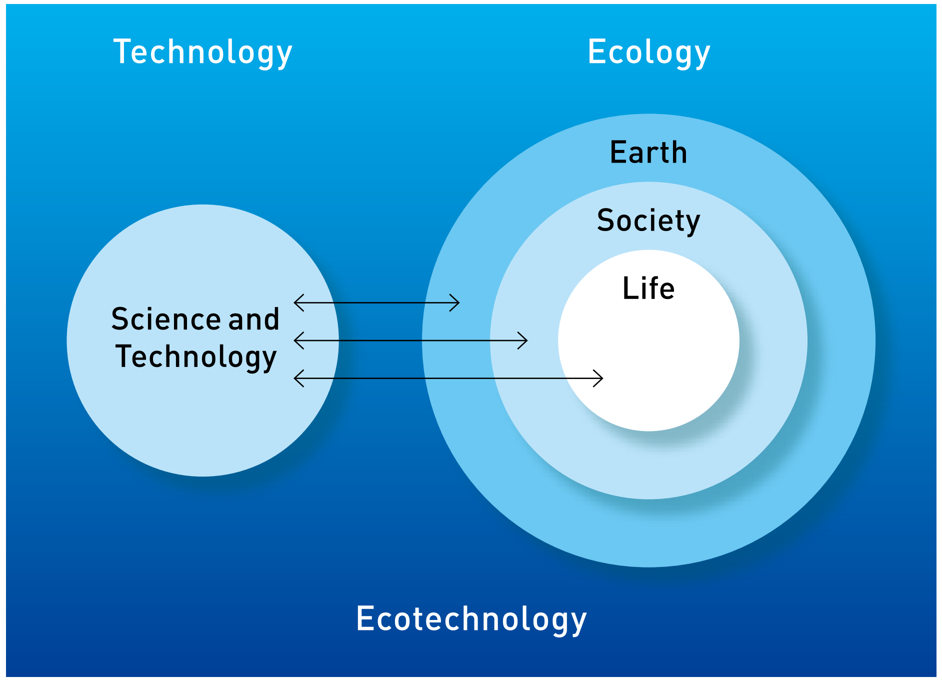
Yoichiro Murakami
Supervising Editor

Advocating Ecotechnology

The concept of ecotechnology, a term coined to represent the combination of ecology and technology, was first introduced to the world at the DISCOVERIES International Symposium in 1980. Ecotechnology implies something more than just "being friendly to the Earth," which is the meaning that people often associate with the word "ecology" today. Ecotechnology is a technological viewpoint developed in response to the needs of the age—a philosophy that shows people new ways to look at, create, and treat things in their lives in society.

Although supporting the economic activities of countries including Europe, the United States, and Japan, industrial development continues to cause environmental problems, and these problems are now threatening the existence of the whole of humankind. It is clear that we need to harmonize human activities with the natural environment across the globe. In addition, we also have to consider how to develop science and technology in harmony with the human environment. Traditionally, geographical and national diversity and other human elements have been excluded from the paradigm of science and technology, but it is now time for us to include these elements as core elements in the paradigm. In other words, the development of science and technology must always be pursued in the light of the welfare of human beings.

In the 21st century, science and technology must be developed in harmony with both the natural and human environments, and the Honda Foundation uses the word "ecotechnology" to generalize this idea. At the Honda Foundation, we regard it as our mission to pursue all the roles that science and technology may be able to play to bring a bright future for humankind.



DISCOVERIES International Symposium 1980 in Tokyo

"Start of Advocacy of Ecotechnology
—Dialogue between Technology and Culture"

The word "ecology" has been in use since before World War II. The word was originally coined as a combination of the Greek words oikos (eco) meaning a house and logos (-logy) meaning knowledge and so ecology literally means "knowledge about houses." The "house" is the very target of ecotechnology. The Earth is indeed a house for all living creatures. Society is constructed of the "houses" built by municipalities and countries. Living organisms are the "houses" of souls. These houses—the Earth, society, and living organisms—affect each other and are now greatly influenced by contemporary science and technology, sometimes benefiting from them and sometimes destroyed and deformed by them. We should consider how to look at, create, and treat these "houses" that now face major risks, and ecotechnology provides us with a guide to an answer.

Paradigm Shift

Advent of the Age of Science and Technology

Concept of Social Responsibility

Paradigm Shift in the 21st Century

Humane Use of Human Ideas

Since the middle of the 20th century, science and technology have advanced increasingly rapidly in close relationship with each other. At present we are witnessing the largest paradigm shift ever since the beginning of human history. Under these circumstances, what can we do to ensure a bright future for our children? Young researchers engaged in science and technology will exert great influence over the everyday lives of individuals, social systems, and even the destiny of the Earth. What expectations and responsibilities should they meet in their work? In Chapter 1, the qualities and moral standpoint that scientists and engineers should possess in this new paradigm for the 21st century will be discussed in depth.

Advent of the Age of Science and Technology

Although it is now difficult to separate science from technology, until the beginning of the 20th century these two fields were following completely different paths.

In the early days, scientific studies were pursued by people who wanted to satisfy their own intellectual curiosity and the results of those studies were evaluated only within a small circle of colleagues who shared the same curiosity, mainly within universities and other similar research institutions. Scientific research was thus an intellectual activity conducted within a closed community, whereas technology has emerged out the world of the craftsman and has always been related to social activities. After the industrial revolution in Europe, society became more open to educating people about technology. In addition, technology made substantial advances through the appearance of great entrepreneurs and inventors, as represented by Thomas Edison.

The development of technology brought great industrial and economical benefits, whereas science remained confined within intellectual circles, exerting little influence on technology. Science was thought of as, and actually was, a set of self-contained activities conducted only by groups of scientists.

The two world wars of the 20th century, however, radically changed our concept of science.

During World War I, some fields of science became closely associated with and formed the basis for newly-emerging industrial fields; for example physics and fluid dynamics with airplanes and chemistry with poisonous gases. These associations brought new technological innovation and people began to recognize that knowledge gathered in scientific investigations could provide a new foundation for the development of technology.

During the Second World War, then U.S. President Roosevelt selected Vannevar Bush, who had served as Dean of Engineering at MIT in the 1930s, as a member of the team he was forming to establish a system that could mobilize anything that could be useful and effective in winning the war. This substantially changed the situation surrounding science. In particular, the Manhattan Project, a representative project implemented under this system, became a prime example of the use of the knowledge possessed by the community of scientists for political and military purposes in the world at large. As a result, theories in atomic physics were put into practice to build nuclear weapons.

In May 1945, just before the end of the war, Dr. Bush submitted his final report, which he titled *Science: The Endless Frontier*. His hope was that the R&D system for science and technology that had been established during the war could be put to use for the good of the nation after the war, to spur on the fight against disease, to improve the life of the nation, and to expand employment opportunities. In its response to this report, the Federal Government drafted a policy to

Known as "the king of inventions," Thomas Edison brought dramatic improvements to the life of the incandescent electric bulb by the type of filament he used. This was in 1879, two years after the invention of the telephone and the phonograph. With the birth of the electric lighting business signified by the "Edison bulb," night was no longer trapped in darkness. With the emergence of the inventor-cum-entrepreneur represented by Edison, technologies that had been handed down through generations of craftsmen became the seeds of businesses that created new industrial structures in the latter half of the 19th century. Technological advancement began to pick up speed. After World War II, nuclear developments, genetic engineering and other technological innovations that were introduced one after another had an immeasurable impact on society. At the same time, the risks generated by these technologies, as well as the environmental destruction they brought, began to expand on a global scale.

Nuclear Test on Bikini Atoll (July 1, 1946)

To show the power of the atomic bomb, the test, in which living organisms in the vicinity of the test site suffered radioactive damage, was disclosed to the public. It is said that in the fission of 1 kg of uranium, each gram of uranium releases the equivalent of the energy required to light a 100-watt light bulb for 28,000 years. Approximately 70 years after the invention of the light bulb by Edison, humankind thus obtained an overwhelming energy source that had the potential to destroy the world.

invest financial resources in scientific and technological research in the interests of the country, rather than just allowing scientists to continue to carry out research to satisfy their own personal curiosity.

This marked the beginning of a new age of science and technology, in which most new technologies are developed from scientific research. The result of this combining of science and technology closely related to the needs of society was the creation of a new field—science and technology—which held the potential to bring great changes to society and which would involve all organizations including industry, government, and academia, and bring drastic reform of the social structure.

Now, in the 21st century, science and technology are approaching an even greater turning point. Both developed and developing countries have science and technology as central to their national policies, not only for industrial and military purposes but also for education, diplomacy, medical care, and the welfare of the nation. Science and technology cross all fields, acting as the driving force for further advancement and growth. Science and technology now have the greatest influence on our societies in the history of human civilization, and it is absolutely critical that we ensure that they develop in the right direction.

"We must pay attention to the changes in the parameters of our environment."

1980 Honda Prize Laureate

Dr. Gunnar Hambraeus

Born in Orsa in Sweden in 1919. Received a bachelor's degree in science from Uppsala University in 1944 and a master's degree in electrical engineering from the Royal Swedish University of Technology in 1945. Served as the editor-in-chief and publisher of *Teknisk Tidskrift*, a technical journal in Sweden and as a consultant to the International Atomic Energy Agency. Professor and managing director of the Royal Swedish Academy of Engineering Sciences since 1971. Became doctor of technology honoris causa at the University of Gothenburg in 1975. Granted various awards, including the Order of the North Star and Legion d'Honneur.

In the 1970s, there arose problems that threatened the future of mankind, including pollution, worsening natural destruction, the threat of nuclear weapons, and violation of bioethics. Science and technology were increasingly criticized as the principal cause of these problems. Amidst this situation, Dr. Gunnar Hambraeus received the first Honda Prize in 1980. He was indeed one of those who had been continuing the activities that were most needed at that time.

Dr. Hambraeus served as technical advisor to the Swedish Embassy in New York from 1950 to the next year and had been the editor-in-chief and publisher of a Swedish technical journal titled *Teknisk Tidskrift* for 15 years from 1953. Through these occupations, he displayed great ability in bringing enlightenment to engineers. In 1971, he became the managing director of the Royal Swedish Academy of Engineering Sciences, which is one of the oldest technological academies in the world. Since then, he has long been playing a role as a bridge between the government, academic circles, and industry in Sweden. After he became chairman of the academy in 1983, he made a great contribution to the promotion of science and technology on a global scale.

With such a distinguished background, the lecture that Dr. Hambraeus gave at the conferring ceremony of the Honda Prize focused on the important roles to be played by governments in harmonizing technology with culture according to the needs of a new age. As an advisor to governments and various administrative agencies, he proposed the following three goals to be achieved by future academies.

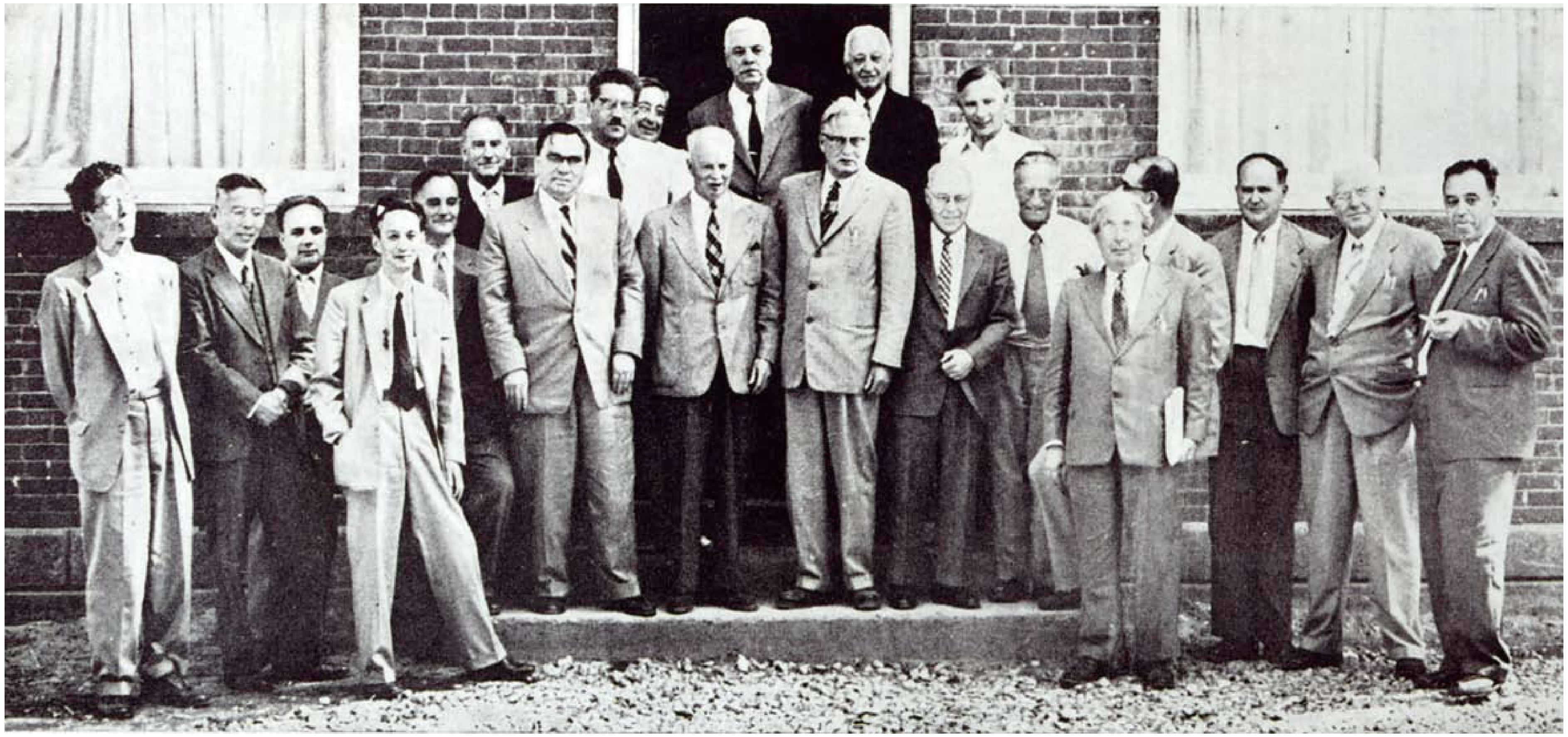
The first objective is the scanning of the scientific technical horizon by the members of academies and the second objective is the creation of a wide and closely-knit network of personal liaisons and contacts for interdisciplinary integration. The third objective is the promotion of a better understanding of science and technology and their potential possibilities, limitations, and consequences among decision makers and the public.

Dr. Hambraeus devoted himself to the attainment of the aforementioned three objectives and achieved great results for the themes. Even now, more than a quarter of a century after his speech, the three objectives still remain as important themes to be tackled by governments.

Concept of Social Responsibility

The first of the Pugwash Conferences on Science and World Affairs (Pugwash, Canada in July 1957)

The Pugwash Conferences on Science and World Affairs were founded by 11 famous scientists on the initiative of Sir Bertrand Russell and Albert Einstein (the Russell-Einstein Manifesto) to work toward the elimination of all nuclear weapons and wars. The first conference was attended by 22 scientists from 10 countries, including Hideki Yukawa, Shinichiro Tomonaga, Iwao Ogawa, Max Born, and Jean Frederic Joliot-Curie. (Photo: Pugwash Conferefces)



The Manhattan Project strengthened the influence that science and technology exerted on society and also changed the mindset of the scientists. As a result of mobilizing knowledge on atomic physics, nuclear weapons were created and inflicted grave damage on our world. The resulting disquiet in the minds of both ordinary people and scientists has forced the societies of the world to recognize their responsibility to society.

After the Second World War, with the fruits of scientific and technological achievement bringing ever more benefits, increasingly events occurred across the world to shake people's faith in the basis of our modern civilization.

In the 1960s, some developed countries had problems with destruction and pollution of the environment, and in the 1970s, environmental problems began to expand on a global scale. In the 1980s, the negative aspects of science and technology surfaced and had a great impact on society, the most representative being observation of a hole in the ozone layer above Antarctica in 1982 and the accident at the Chernobyl Nuclear Power Plant in 1986—said to have been the worst disaster the world has known. Since the end of the 20th century, dramatic developments in the life sciences have generated new ethical problems, including those related to brain death, gene recombination, and cloning technology, leading to the birth of Dolly the Sheep, the first mammal to be cloned.

However, these kinds of accidents and events cannot all be attributed to the development of science and technology alone. In our modern world, regardless of their original intentions, the work done by scientists acting through many different channels has an influence on the lives of all present and future members of society, including national and local governments and companies.

Scientists are now expected to be socially responsible in carrying out their research. They are now required to keep their eyes on how their research activities are used by society, what are the likely social outcomes of their activities, and how the outcomes will influence the lives of ordinary people.

As experts, scientists must always be sensitive to the negative impacts that their research might have on society and make appropriate decisions to avoid them, including decisions on the direction of their research. At the least, scientists are expected to devise methods to control their research and implement those methods when required as part of their ethical responsibilities. Also, in view of the fact that experts with special knowledge and expertise in respective fields are not always the best people to discharge their ethical responsibilities, it is also important that scientists always disclose their research activities and explain the results to the general public.

At the same time, we all have the

World Conference on Science (Budapest, Hungary in June 1996)

At the conference, which was held jointly by the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the International Council for Science (ICSU) and attended by approximately 2,000 scientists and governmental officials from all over the world, discussions were held on science and society in the 21st century, and the Declaration on Science and the Use of Scientific Knowledge was adopted. The declaration advocated the idea of "science in society and science for society" and insisted that the final goal of science should be the welfare of humankind and accordingly, science should play a role in reducing poverty, respecting the dignity and rights of human beings, protecting the global environment, and fulfilling its responsibilities toward present and future generations.

responsibility to recognize how we use and promote science and technology. It is clear that in modern societies, the wholesale use of science and technology to pursue efficiency, convenience, and comfort is no longer viable. In addition, there are global inequalities and issues of fairness between North and South and between West and East. In modern society, we all bear the responsibility to work together with scientists in ensuring that science and technology follows certain ethical rules.

While scientists and engineers have a responsibility to society at large, we all carry the responsibility of ensuring that science and technology are used in sustainable and pragmatic ways.

"Engineers should press forward with development to meet the diversified needs of people."

1981 Honda Prize Laureate **Dr. Harold Chestnut**

Born in the State of New York in the United States in 1917. Received a master's degree in electrical engineering from MIT in 1940 and entered the General Electric Company. Served as the president of the International Federation of Automatic Control (IFAC) from 1957 to 1959 and as the president of the American Automatic Control Council from 1962 to 1964. In 1973, became the president of the Institute of Electrical and Electronics Engineers (IEEE). Made a great contribution to the world's industrial circles. Wrote many books, including *Systems Engineering Methods* (1967).

From 1940 to 1966, Dr. Harold Chestnut was engaged in research and development as an engineer at General Electric Company. As a researcher working for a company, he believed that engineers should press forward with development to meet the diversified needs of people. Based on this belief, Dr. Chestnut proposed the concept of systems engineering, which incorporates the requirements of system users while considering the abilities and requirements of system developers. He also pursued environmentally friendly development.

In the United States from the 1950s to the 1960s, rapidly-developing computers and the automatic control technology developed for military purposes began to be used in a number of industries. Dr. Chestnut was also engaged in the research of these technologies at the request of the electric industry. At the beginning of the 1960s, however, he also became interested in environmental problems, including environmental pollution and the depletion of resources.

Dr. Chestnut attended the International Congress on the Human Environment (HESC) held in Kyoto in 1975. During his stay in Japan, he visited some local industrial areas where pollution-related problems were being aggravated. He learned from that meeting, as well as from visits to the areas, about some of the local problems that were arising in association with air and water pollution, including noise and pollution caused by the chemical, electrical, and other industries.

In Europe and the United States, people were becoming more aware of environmental problems. Dr. Chestnut thought that technology itself cannot make judgments or select criteria, although these are the basis of human decision-making. Based on this idea, he insisted on the necessity of taking a systematic approach that is reliable and takes the influence and social implications of technology into consideration, and developed his own unique systems engineering methods.

At the conferring ceremony of the Honda Prize, Dr. Chestnut said to engineers across the world as follows:

"Those of us concerned with developing new technology should consider ourselves to have a major undertaking to try to meet the expanding needs of the increasing number of people in the world with its finite resources and environments constraints."

Paradigm Shift in the 21st Century

The problems faced by modern society are caused by a variety of factors, including the effect of our activities on the environment. For example, the drastic increase in the levels of CO_2 in the atmosphere cannot be solved only by focusing on natural phenomena. A realistic solution to the problem has to look at the kinds of societies we live in, our lifestyles, and industrial, economic, and military activities; transportation is also an important factor in this. In the latter half of the 20th century, a new area of study was created that deals with complex systems, and it is anticipated that a new Paradigm shift will emerge for the 21st century.

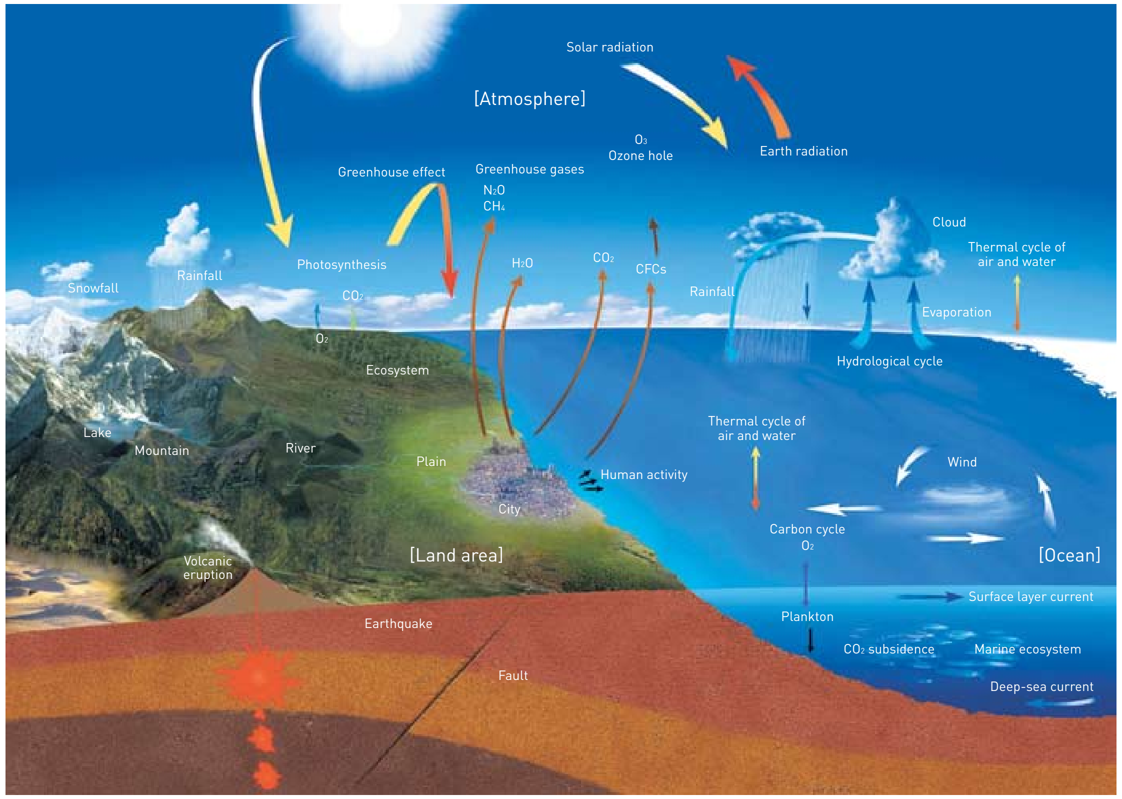
The science of complex systems is developing on many fronts, and it is difficult to summarize them all in a simple way. However, we can say that complex systems are systems in which multiple parameters are related in nonlinear ways, making it difficult to predict the future behavior of the overall system just from the characteristics and relationships between the separate elements.

This definition is not easy to understand, but the area can be clarified by listing specific research targets for complex systems. They include the weather, oceans, ecological systems, life phenomena, artificial intelligence (brain science), large-scale transportation flows, and political and economic systems. These belong to fields that cannot be dealt with using traditional scientific approaches to understanding complex phenomena involving the application of simple rules and principles. Research into complex systems has given rise to an innovative approach and made it possible to gain an insight into the basic nature of complex systems.

While complex systems demand a new scientific approach to systems to which simple rules and principles cannot be applied, chaos theory, which first appeared in the middle of the 1970s, deals with systems that start off following simple rules and principles but gradually deviate from these rules as processes build up over time, due to small errors in the initial values. Chaos theory has demonstrated that it is practically impossible to predict weather accurately on a long-term basis or to predict long-term trends in the foreign exchange market.

Scientific investigations of complexity, including complex systems, were a feature of the latter half of the 20th century and opened up a vision of future progress into the 21st century. Supported by information technology represented by computers and the Internet, these scientific theories are currently contributing to the development and practical use of innovations in science and technology, as well as in nanotechnology. For example, these theories are helping to improve the precision with which we can forecast the weather, simulate the global environmental, and forecast traffic flows. They are also helping us to clarify the mysteries of life, and are advancing research into social systems, including political and economic systems.

A paradigm shift in the 21st century may lead to completely new scientific and technological approaches and give us the kind of science and technology that we really need for the future of our societies.



Global ecosystem

Exchanges of heat and water and various other interactive reactions take place between air and seawater and between air and land. Changes in the weather take place not simply as a result of interactions in nature, but as the product of complex, interrelated exchanges among diverse activities on the planet, including human activities. Major causes of global warming are chemicals such as CFCs that are released into the air with human activity and destroy the ozone layer and greenhouse gases such as carbon dioxide and methane. Unraveling this complexity requires exhaustive study into the carbon cycle processes in which ecosystems on the land and in the sea are closely interlinked. Research is currently underway using a variety of approaches. (Picture: JAMSTEC)

"Time will never isolate human beings from nature."

1983 Honda Prize Laureate **Dr. Ilya Prigogine**

Born in Moscow, Russia (nationality: Belgian) in 1917. Received a master's degree in science in 1941 and became a professor at the Free University of Brussels. Became the director of the Institute Internationaux de Physique et de Chimie in 1959 and became the Regents Professor of Physics and Chemical Engineering at the University of Texas. Became a special advisor to the Commission of the European Committees in 1981. Subsequently served as the representative of the Institute Internationaux de Physique et de Chimie Solvay and the director of the Ilya Prigogine Center for Statistical Mechanics and Thermodynamics at the University of Texas. Granted many awards, including the Nobel Prize in Chemistry (1977).

In the 1970s, Dr. Prigogine proposed the theory of interaction, insisting that a part affects the whole and the whole affects a part. This theory had a great impact on the research fields of biology and life science in addition to its impact on the world of physical chemistry. Furthermore, the scientific approach derived from the dissipative structures theory influences even the fields of humane studies and the social sciences, such as philosophy, sociology, and economics (reter to P. 28) as well as meteorology and oceanography. Together with synergetics founded by Hermann Haken, Dr. Prigogine's scientific approach has come to play an important role for advanced research into complex systems, which is based on theories that are currently among the most important scientific theories.

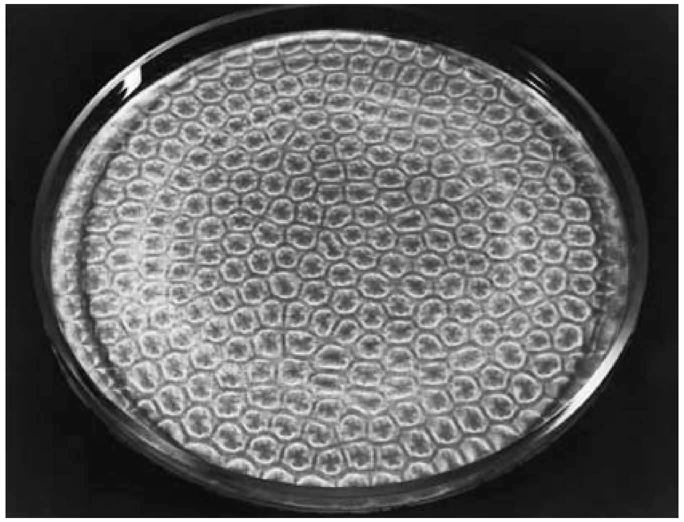
The dissipative structures theory was born from a question that Prigogine had in studying the second law of thermodynamics.

According to the law of increasing entropy, the world (universe) becomes chaotic over time, with things irreversibly broken. The world is destined to halt in chaos. In the biological world, however, living organisms grow and are organized in a more orderly manner. The growth of living organisms was a phenomenon contrary to the law of increasing disorder.

Dr. Prigogine thought in his thermodynamics research that there might be a phenomenon contrary to the law of increasing entropy. For example, if you drop ink into water, the ink spreads according to the law of increasing entropy. The random movement of ink molecules tends to increase entropy. This, however, also means that there is the possibility that some molecules move differently, even if the possibility is low.

An orderly system might be created against the law of increasing entropy by fluctuation. This fluctuation or small incidental order was almost neglected in the field of science before Prigogine.

The whole follows the law of increasing entropy in a closed system in equilibrium where no substances or energy inflow, but in an open system in non-equilibrium where substances and energy inflow and outflow in a continuous manner, a small fluctuation affects the surrounding (whole) structure and the surrounding (whole) structure further promotes the small order. This synergy effect is called self-organization, which might lead to greater order. Prigogine found this possibility and established the dissipative structures theory.



You can observe one remarkable example of dissipative structures when you heat a pan containing liquid evenly from below. If heated moderately, the liquid will be at the second stage (in a linear non-equilibrium state), and heat will be conducted through the liquid. If, however, the pan is heated intensely and the temperature gradient exceeds a specific value, convection cells will be abruptly and spontaneously generated. This is a highly organized molecular movement that occurs when energy from the heat oscillations is transferred to convection flow, which is a macroscopic movement. The newly appearing molecular order represents a huge fluctuation stabilized by an exchange of energy with the external world, and this is the order brought about by a dissipative structure. (Photo: Nobuhiko Misawa [Ocean Research Institute, the University of Tokyo])

Based on the idea that non-equilibrium rather than equilibrium brings about order, Dr. Prigogine eventually proposed to build a new society and science by learning a control method from a new viewpoint beyond the range of thermodynamics research in the field of physics. As a result, he is now included in the list of researchers who led scientific theories for complex systems, which are still developing.

The importance of his theory had been increasing over the approximately 40 years since its first announcement. Living organisms consume negative entropy within themselves and metabolize to form an order. This life system can be included in dissipative systems. In the past, it was believed that the system of living organisms was too complex for human beings to control. Now, however, thanks to the rapid development of nanotechnology, it is becoming possible to control a system on an atomic level. Against this background, the scientific elucidation of the self-organization of life is attracting much attention as an effective means to solve the mystery of life.

Dr. Prigogine says the following about his biggest research theme, the concept of time, in his book titled *Modern Thermodynamics*.

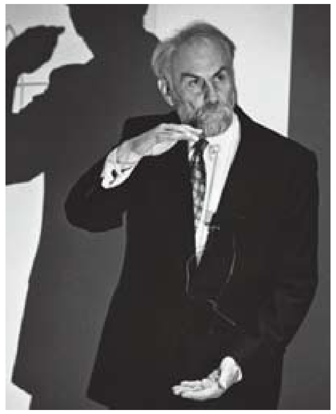
"Time, in particular the direction of time is a basic dimension for life. We have found out that the flow of time is ubiquitous. Time will never isolate human beings from nature."

—28 embodiments of ecotechnology

"We must pay attention to the changes in the parameters of our environment."

1992 Honda Prize Laureate

Dr. Hermann Haken



Born in Leipzig in Germany in 1927. Received a doctorate in mathematics from the University of Erlange in 1951. Became professor of theoretical physics at the University of Stuttgart in 1960 and a visiting professor at the Research Institute for Fundamental Physics, Yukawa Hall, Kyoto, Japan in 1961. After serving as a consultant to Bell Telephone Labs and a consultant to Laboratoire Telecommunications(ITT) in Paris, became a member of the Scientific Board of the Max Planck Institute for Solid State Research in Stuttgart in 1970. Also served as the director of the Quantum Optics Division of the German Physical Society and as a consultant to the German Sciences Foundation. Granted many awards, including the Max Born Prize.

Research into complex systems was started in the 1990s and has become one of the most important scientific research fields in the 21st century. Dr. Hermann Haken gave a powerful drive to research into complex systems with his synergetics proposed in 1978, as did Dr. Prigogine with his dissipative structures theory.

Synergetics is designed to clarify theoretically the formation of order in complex systems and has enabled the scientific research of objects (systems) that were thought to be too complex to take a scientific approach.

In addition to its influence on physics, synergetics has exerted interdisciplinary influence over biology, medicine, engineering, economics, and the social sciences and has contributed to the development of research into complex systems in various academic fields.

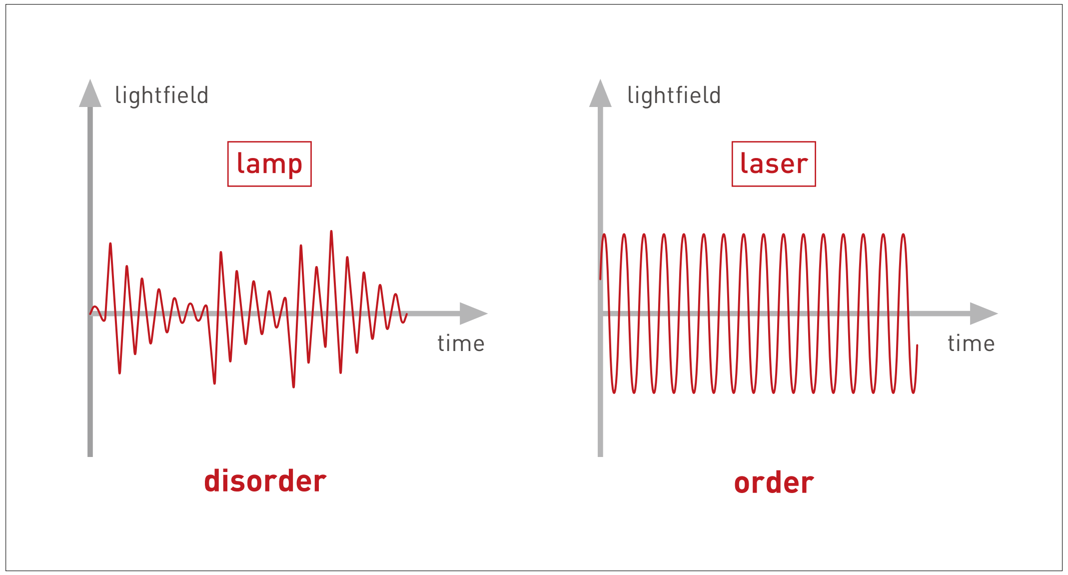
Born in Germany in 1927, Dr. Haken majored in mathematics and physics at university and became professor of theoretical physics at the University of Stuttgart in 1960. As a researcher, he has been walking the high road in the field of physics. He founded the theory of synergetics inspired by his research on lasers.

In creating light with a laser, the laser molecules initially emit light at various wavelengths (frequencies), mutually depriving each other of energy. When a molecule that is emitting a beam of a certain wavelength beats other molecules in the competition for energy, all the other molecules begin to emit beams at the same wavelength as that of the winning molecule.

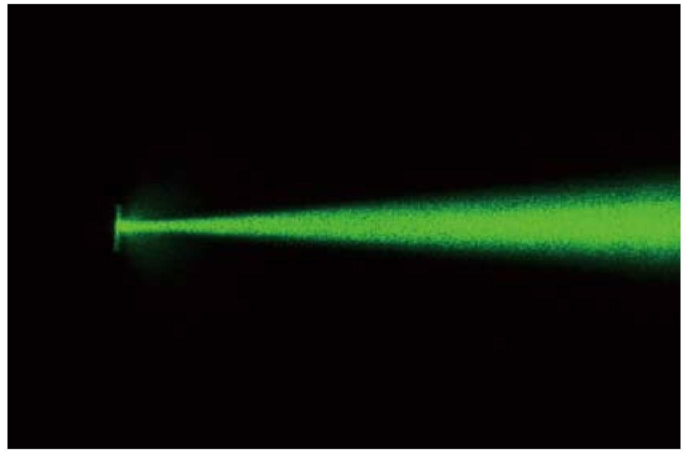
Molecules that were each emitting light in an unrelated and disorderly manner thus begin to cooperate following the newly created "order," as if the light wave of the winning molecule were a mutually determined rule. Dr. Haken named this newly-created rule an "order parameter."

Furthermore, he formulated the slaving principle, which means the unforced "self-organization" of all the molecules according to the order parameter. In other words, Dr. Haken explained theoretically the process in which an order parameter is formed by a specific energy or mode("fluctuation") created in a system and the parameter enslaves and dominates others to create a system that is totally different from the previous one.

In a sense, this process can be called a model of Darwin's "survival of the fittest."



Dr. Haken established synergetics theory based on his research into lasers. Dr. Haken found out that disorderly light waves emitted from an ordinary lamp suddenly change to well-ordered light waves when the energy input to the laser exceeds a critical limit, and he called the light wave that becomes dominant as the optimal wave in the environment an order parameter. Once an order parameter is established, other electrons are "enslaved" to the rhythm of the dominant light wave and then support the existence of the order parameter. This circulative cause-effect relationship is called synergetics.



Synergetics, which has the "order parameter" and "slaving principle" as its key features, has greatly contributed to the treatment of complex systems with regard to the global environment and social sciences.

Dr. Haken says he has no doubt about the necessity of technology for human beings, who want it to meet their needs that emerge one after another and to adapt themselves to every kind of difficulties. Human beings definitely need to find a good balance between ecology and technology or between stability and adaptivity.

In the 21st century, Haken's synergetics is playing an increasingly important role as research into complex systems is advancing and developing. It is almost 30 years since the theory of synergetics was born, and it might indeed be a method or "ecotechnology" to find a good balance between ecology and technology or between stability and adaptivity.

"I have often said that the branches of a tree are themselves little trees; fragments of rocks are similar to masses of rocks, particles of earth to enormous piles of earth. I am persuaded that one would find a quantity of such analogies," said the painter Eugene Delacroix. From lightning and coastlines to feathers and snow crystals--many phenomena we observe in nature share "fractal" characteristics. Benoit Mandelbrot's fractal geometry was able to give mathematical expression to "self similarity in nature" as described by Delacroix. As a theory that finds order in the chaos of nature, applications for fractals in a wide range of fields of science and technology are being studied today.
(Photo: "Moon Over Water. Composite image of the full moon over the sea and rocks")

"Fractals are a family of geometric shapes, and one must see them in order to understand geometric shapes."

1994 Honda Prize Laureate

Dr. Benoit B. Mandelbrot

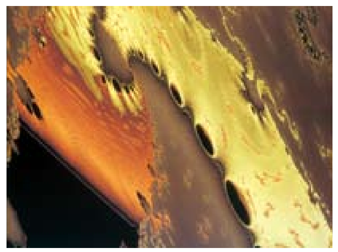
Born in Warsaw in Poland in 1924. Received a doctorate in mathematics from the University of Paris in 1952. Worked as a member of the Institute for Advanced Study at Princeton from 1953 to 1955. Served as junior professor of mathematics at the University of Geneva, University of Lille, and Ecole Polytechnique. Entered IBM's T. J. Watson Research Center in 1958 and worked as an IBM Fellow from 1974 to 1993. Became professor of mathematical sciences at Yale University in the United States in 1987 and became an honorary professor of the university in 2005. Granted many awards, including the Barnard Medal and the Wolf Foundation Prize for Physics.

The word "fractal," which is now used in a range of fields, was coined by Dr. Benoit B. Mandelbrot. He based the term on the Latin word "fractus," which means broken or fractured. According to Dr. Mandelbrot, a fractal is an irregular or fragmented geometric shape that cannot be dealt with in traditional Euclidean geometry. Dr. Mandelbrot announced his "fractal geometry" in 1975, when he was just over 50 years old and working for the Watson Research Center. Subsequently the word "fractal" began to attract much attention.

For example, the entire shape of a river, including how it winds, is very much like the shape of a tributary. As for a cauliflower, the whole and each of the buds have similar structures and the parts comprising the buds also have similar structures. Thus the same structures are repeated at five or more levels of magnification. A fractal is structured with parts, each of which has a similar shape and so it is self-similar.

By using the theory of fractals, which refers to a recursive shape, it is possible to mysteriously create a part that shows the shape of the whole. Using the theory of fractals, you can visualize the complicated shape of a coastline, rocky mountains, fine branches and roots of trees, space comprising numerous galaxies, and any other shapes using computer graphics. In fact in 1980, in the science fiction movie Star Wars, the theory was used to allow computer graphics to create mountains and surfaces on other planets. The theory has since been making a great contribution to computer graphics.

It is anticipated that it will become one of the scientific approaches used to derive order from chaos, and research is continuing. At present, the fractal is developing from a very simple (and short) algorithm to an extremely complex graphic form.



Fragment of a variant of the Mandelbrot set (B. B. Mandelbrot)

Humane Use of Human Ideas

The DISCOVERIES International Symposium held in Rome in 1977: A Combined Oriental/Occidental Approach to the Problems Confronting Planet Earth

The Honda Foundation has been holding international symposiums to enable wide and interdisciplinary discussions on measures to harmonize human activities with the global environment beyond national boundaries. In recent years, these symposiums have been held also in China, South Korea, Vietnam, and India focusing on the rapidly growing Asian region. DISCOVERIES stands for Definition and Identification Studies on Conveyance of Values, Effects and Risks Inherent in Environment Synthesis.

Since the dawn of time, human beings have viewed their world from many different aspects, and have been developing their scientific and technological abilities as a tool to facilitate communication.

In the economic development of the post-war years, however, the advanced countries have tended to use the growth of science and technology to pursue production economies, which generate profit. A cultural and humane viewpoint has long been missing from the basic aims of scientific and technological research, development, and application. As a result, serious problems have emerged related to the environment, energy and resources, and life ethics that have the potential to threaten the future of humankind.

Research to solve these problems needs to extend over a wide spectrum; fundamental solutions will not be found just by collecting the results of scientific and technological research in ever more finely divided areas of expertise. The boundaries between specialized fields of research need to be removed to give the flexibility needed to integrate the results of R&D in pursuit of specific goals. For this, it is necessary to set meaningful and fair targets that are worthy of our uncompromising efforts. In the latter half of the 1970s, the Honda Foundation set out one such target—the Humane Use of Human Ideas.

For example, the ultimate goal of medicine must be to save patients. Similarly, we believe that scientific and technological research should be conducted from an integrated viewpoint, with human happiness as its final target.

Scientists in today's world have already started to look at increasingly complicated events from a global viewpoint, combining the natural sciences with the social sciences. An example of this is the interdisciplinary application of systems theory to the social sciences and global environmental studies. However, even when these integrated approaches generate successful results, there remains the problem of how to translate the results into technology to solve practical problems, and how society can best support reforms in science and technology. Putting scientific and technological innovation to practical use requires a global consensus that transcends all our political, economical, and ideological differences.

Societies of the future may become more polarized and face more difficulties in the search for a balance between individual profit and social order, and between the rights of individual nations and the interests of the world as a whole. In this situation, scientists and technologists will need to review their goals and set new targets.

We need to find a balance between scientific and technological development and the need to protect the Earth, to ensure co-prosperity for all people on the planet. All those engaged in science and technology in the 21st century need to pursue their dreams with a fresh sense of social responsibility and an ethical approach based on a belief that progress in science and technology should bring happiness to human beings. Young scientists and engineers face these kinds of expectations.

Achievement of these ideals will make science and technology truly essential to the survival of humankind.

"In case of the engineer, it may mean that the safety of thousands or even the well-being of millions is in his hands."

1982 Honda Prize Laureate **Dr. John F. Coales**

Born in Birmingham in England in 1907. Received a bachelor's degree in mathematics and physics from the University of Cambridge in 1929. After graduating, served as a scientific officer in the Department of Scientific Research and Experiment at the Admiralty and returned to the University of Cambridge in 1952. Served as professor of engineering at the university from 1965 to 1973 and as the president of the International Federation of Automatic Control (IFAC) from 1963 to 1966. Worked as the president of the Institution of Electrical Engineers (IEE) from 1971 to 1972 and the first president of the World Environment and Resources Council from 1973 to 1976. Played a leading role in a number of international organizations. Appointed Commander of the Order of the British Empire.

Professor John F. Coales served as the president of the International Federation of Automatic Control from 1963 to 1966 and was a world-recognized authority on automatic control technology. In addition, he was highly regarded for serving as a bridge between different technological fields.

Professor Coales served as the president of the Institution of Electrical Engineers (IEE) for two years from 1971 and became the first president of the World Environment and Resources Council in 1973. He thus served as chairman, director, and fellow of various organizations, including councils, academic societies, and research institutes in a range of fields including the fields of electricity, electronics, physics, and agricultural engineering. For many years he played a leading role in a number of international organizations of engineers and made a great contribution to academic circles and the industry with his theory and its applications.

Professor Coales devoted himself especially to the growth of developing countries, paying attention to the role of an engineer in a free economy, because it is important to promote the transfer of technology from developed countries to developing countries to help the latter achieve sustainable growth.

To this end, Professor Coales attributed most importance to the development of leading engineers in developing countries.

The professor realistically pointed out that the situation differs according to the developing country and these countries are facing problems that are different from the ones that developed countries have experienced. He then insisted on the importance of educating leading engineers by helping them accumulate experience in their own countries and acquire the ability to respond to contingencies and lead important technological projects to success.

In his speech made at the conferring ceremony, as a premise to taking on these challenges, Professor Coales said something which is true even today:

"If we are to be successful in developing technology to save the world from penury in the 21st century we must develop the engineering profession to serve the human race with the zeal of missionaries and this can only be done if we work together and support each other irrespective of colour, race or creed or indeed of ideological belief."

"Shifting society from one that relies on the input of mass materials and energy to one that relies on communication, creativity, and complexity of products."

1995 Honda Prize Laureate

Dr. Åke E. Andersson

Born in Solleftea in Sweden in 1936. Received a master's degree in economics from the University of Gothenburg in 1967. After serving as associate professor of city and regional economics at the Nordic Institute for City and Regional Planning and as associate professor of economics at the University of Gothenburg, became professor at the University of Umea in 1979. Served as a research leader at the International Institute for Applied Systems Analysis (IIASA) from 1984 to 1986 and became managing director of the Swedish Institute for Future Studies in 1988. In addition, served as an advisor to the Economic Commission for Europe, OECD, and the Swedish Government. Also served as the main editor of the journal *Regional Science and Urban Economics.*

Dr Åke E. Andersson, who serves as the managing director of the Swedish Institute for Futures Studies, received the Honda Prize in 1995 in recognition of his approach to futures studies from the viewpoint of economics. Fifteen years after the first Honda Prize was awarded in 1980, Dr. Andersson became the first memorable person with an arts background to win the Prize. It can be said that his winning the prize symbolizes the advent of an age in which scientific theories and approaches are actively applied to research in the fields of the arts and the humanities, including sociology and economics.

Born in Sweden in 1936, Dr. Andersson received a doctorate in economics from the University of Gothenburg in 1967. Subsequently, he served as associate professor and visiting professor at universities and then conducted research at the International Institute for Applied Systems Analysis (IIASA) in the suburbs of Vienna, Austria from 1978 to 1980.

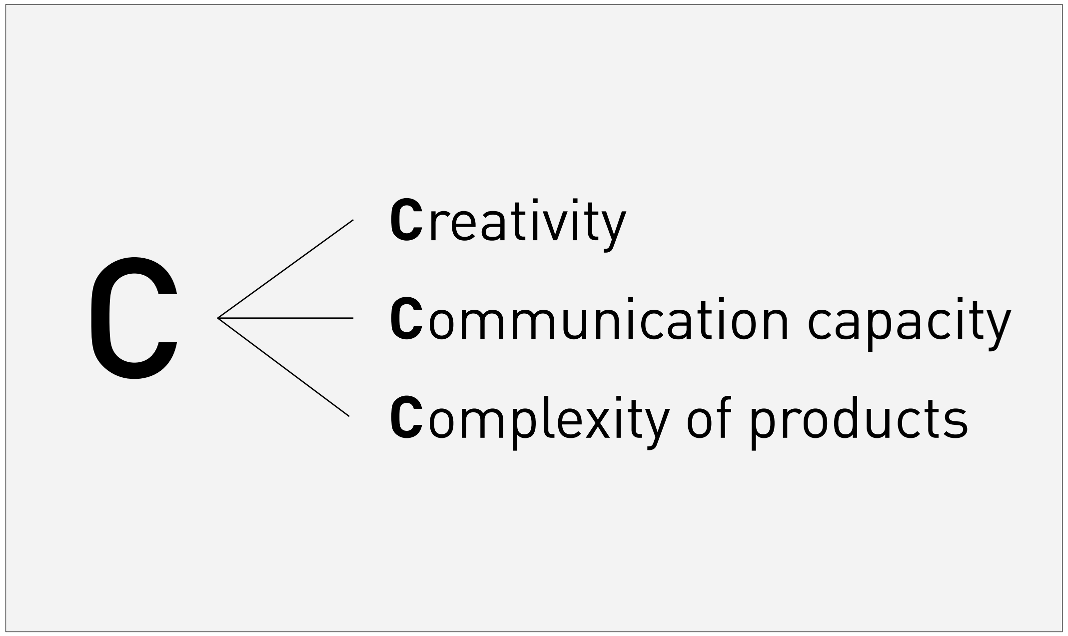
From 1984 to 1986, he served as a research leader at the IIASA, where Dr. Haken, who is the founder of synergetics, was also a member of the research project. Dr. Haken's synergetics theory eventually had a great influence on Dr. Andersson's economic theory.

Amid the aggravation of global environmental problems, Dr. Andersson insisted that the new-generation society should be a "C-society," which is an industrialized society that relies on creativity, communication capacity, and complexity of products, as a theoretical model to achieve global economic development while protecting the natural environment, including forest resources.

Dr. Andersson regarded creativity as a new engine for economic growth in the 21st century. Only creative processes can provide new solutions to make economic growth and global environmental protection compatible.

Increasing complexity of products enhances the value per unit of manufacturing production and so Dr. Andersson analyzed that if the complexity of products increased with the development of science and technology, it would lead to the saving of natural resources.

Furthermore, in order to shift society from one that relies on the input of mass materials and energy to one that relies on the complexity of products, Dr. Andersson thinks it important to promote communication among individuals, companies, and local communities.



It is, however, quite difficult to analyze and study the C-society, which has a complex system featuring creativity, complexity of products, and communication capacity. In dealing with this problem, Dr. Andersson looked to synergetics theory.

Dr. Haken, in his synergetics theory, clarified that rapidly-changing interacting systems are enslaved by slowly but steadily-changing dynamic systems (order parameters). Based on this theory, Dr. Andersson argued that order parameters would play a dominant role in structural changes in society and the economy and in the development and growth of cities as well. He regarded infrastructures as order parameters.

It will take an extremely long time for such infrastructures to function properly. However, once they begin to function, they will exert great influence over society, shifting it to a C-society where society and the economy can be developed with minimal burdens on the global environment.

According to Dr. Andersson, it is necessary to understand that environmental problems are also "slow but steady changes" and in this age of rapid changes, we must continue to make investments in infrastructures without being too much occupied by immediate profits and problems.

Modern technology impresses us with its enormous achievements such as sending spacecrafts to remote planets, mobile phones, GPS, the internet, advanced car technology, high speed trains, and many other things. Our economy is governed by Darwinian principles: competition and survival of the fittest.

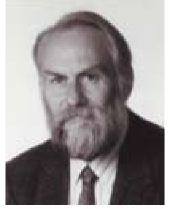
But today, the public becomes aware of new gigantic problems that constitute a threat to welfare and further development of Man, and maybe even to his survival. We realize an increasing destruction of our environment, for instance by the CO_2 problem, huge floods, thunderstorms and unusual dry periods, the poisoning of rivers and lakes, etc. Many animal species are getting extinct. But such processes happen also among us humans at the cultural level. More and more languages disappear, and specific cultural values and habits are being abandoned.

What can we do to counteract these negative developments and preserve our material and immaterial values?

There are some strong movements in the world, supported by governments such as in Japan and Germany towards protection of the natural environment. Scientists are studying a variety of scenarios. In my own field of research, Synergetics, I have studied the behaviour of complex systems, ranging from technical systems such as the light source laser up to economic and social systems. When I apply my results to our present days' situation, my answer is this:

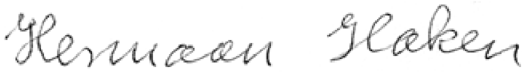
We must overcome blind competition by thoughtful cooperation. Above all we need a new collective attitude shared by many people, aiming at a deep and enduring harmony between ecology, economy, technology and, not to forget, a preservation of our cultural goods. To put it in other words: We need a new paradigm that has evolved over the past years: Ecotechnology. Its realization rests on the young generation, and it is the task of our older generation to help our successors on their way. What I am telling you here was anticipated by the late Soichiro Honda and his foundation.

The Honda Foundation not only propagates the idea of creating a truly human civilization, but it takes active part in this endeavor in a variety of ways. The Honda Foundation will play a seminal role in achieving the "Honda Foundation's Mission: Humane Use of Human Ideas"



Hermann Haken

13th Honda Prize Laureate, Germany



Sustainability

A New Perspective on Global Environmental Problems

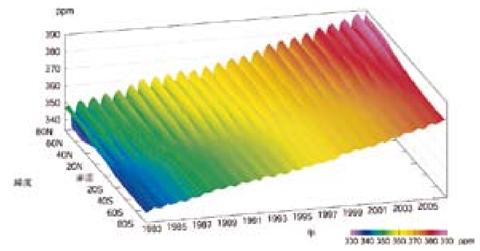
Towards a Goal of Sustainable Development

Think Globally, Act Locally

Sharing the Earth

Industrial activity has brought us environmental problems, and because of these activities, the Earth has been damaged beyond its ability to recover on its own and humankind is now in danger of extinction. In the second half of the 20th century, when the effects of environmental problems were beginning to surface, people began to search for specific solutions to environmental problems on a global scale. At the same time, however, it became clear that various other problems needed to be solved as a premise to solving those environmental problems, including the adverse effects of measures to reduce environmental impact which are the result of certain correlations in the natural environment as well as differences in the economic situations between countries as represented by the North -South problem. In Chapter 2, the direction that scientists and engineers should take in solving global environmental problems will be examined. These problems will not be solved until scientists and engineers cooperate in carrying out their research and collaborate beyond the existing frameworks in developing new technology.

A New Perspective on Global Environmental Problems



Changes in the CO_2 content of the air from the North Pole to the South Pole

The CO_2 content has been increasing year by year. In particular, there are more land areas in the Northern Hemisphere than in the Southern Hemisphere and the CO_2 content of the air is higher in the Northern Hemisphere due to the burning of fossil fuels by human activities. For the period between 1983 and 2005, the CO_2 content of the air has been increasing by roughly 1.6 to 1.7 ppm per year on average for all the latitude bands. For the past 10 years, it has been increasing by 1.9 ppm per year on average. (Source: Japan Meteorological Agency)

Global environmental problems began to attract attention at the end of the 20th century and have been widely reported by the media since the beginning of the 21st century. These problems are now widely known and have enabled us to recognize that the Earth on which we live is a closed system, that the resources needed to support our lives are limited, and that if we continue to allow our economic activities to emit large amounts of CO_2 and to pollute air and water, we will upset the natural balance and damage the environment to the extent that we can no longer live on the planet.

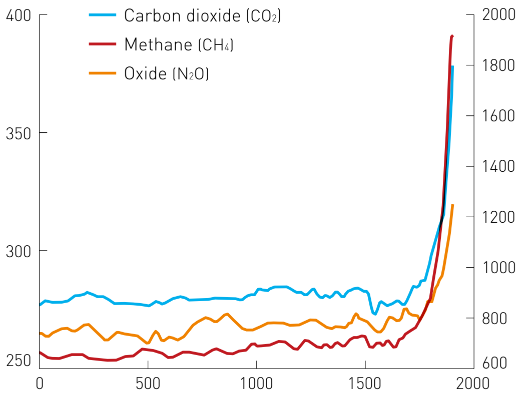
Environmental problems are extremely difficult to solve. The following discusses the reasons why in relation to problems of pollution.

In the 1960s, developed countries including Japan faced pollution problems; our rivers were polluted by wastewater and our air was polluted by smoke from factories. In this polluted scenario, there were those who emitted the pollutants into the air, water, and soil without appropriate treatment—the perpetrators—and those whose health was damaged by those emissions—the victims. It thus became possible to solve the problem by imposing regulations on potential perpetrators.

However, many environmental problems—including global warming caused by greenhouse gases such as CO_2 and the associated changes in rainfall and desertification, the depletion of the ozone layer by CFCs, and acid rain—are the results of our modern lifestyles in which

Changes in the greenhouse gas content of the air from 1750 to 2005

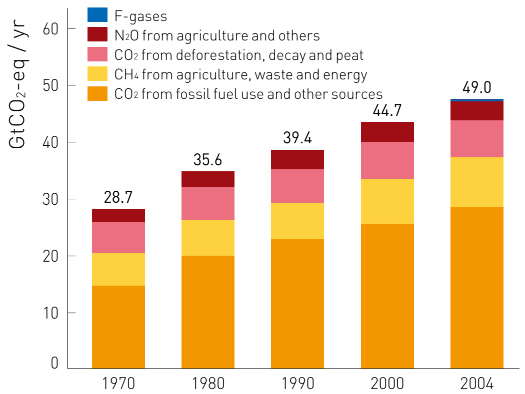
The content of CO_2, methane (CH_4) and nitrous oxide (N_2O) in the world's air has greatly increased since 1750, far exceeding any increase over the several thousand years before the industrial revolution. The IPCC Fourth Assessment Report concluded that there is very high confidence that human activities result in global warming.



Annual emissions of greenhouse gases from human activities for the period between 1970 and 2004

Emissions of greenhouse gases from human activities have been continuously increasing, and increased by 70% between 1970 and 2004.

(Source: IPCC Fourth Assessment Report)



we consume large amounts of energy to make our lives more convenient. Anyone can be a perpetrator, but unlike with pollution, it is difficult to identify specific perpetrators.

There is one more factor that adds to the difficulty of solving environmental problems in that causal correlations have yet to be scientifically demonstrated for many environmental problems.

For example, some scientists still disagree that global warming is caused by CO_2, because global warming is a scientifically unverifiable phenomenon that cannot be described simply. The factors that cause global warming are interconnected at many different levels, and include the uneven distribution of resources and wealth. Future changes in these relationships may even lead to global cooling in place of global warming. Because of this uncertainty, it becomes necessary to create a variety of different scenarios to predict the results of global warming.

If the current worst scenario becomes a reality, our descendents will certainly become the victims of earth environmental problems. This is why it is important to fulfill our responsibilities to future generations in dealing with global environmental problems based on the realization that we must be ready to take action even against risks that may not yet have become apparent.

"Clean up our environment to make the world healthier for us, our children, and our grandchildren."

2002 Honda Prize Laureate

Dr. Barry John Cooper

Born in Bedfordshire in England in 1942. Employed at Johnson Matthey's Technology Center in England from 1964 to 1977. Received a doctorate from London University in 1976 and was subsequently employed by SINTEF, Department of Applied Chemistry at the University of Trondheim, Norway. Began working at Johnson Matthey Inc. in the United States in 1979 and served as a principal scientist, development manager, technical director, and vice president in charge of technology. Now serves as the vice president in charge of diesel emission control systems at the company.

CRT System
Catalytic converters for diesel engines used in heavy duty vehicles were put to practical use ahead of the world in 1995. The converter is now used in public service vehicles in the major cities of the world.

In the 1970s, when air pollution caused by emission gas was being aggravated and becoming a serious social concern, Dr. Barry John Cooper conducted research into catalytic control of emissions from gasoline-powered vehicles at Johnson Matthey Plc far ahead of other researchers. At that time, large amounts of emissions from engines started at low temperatures posed the biggest technological problem, because catalysts do not function well at low operating temperatures. Dr. Cooper conducted more research to enable catalysts to work appropriately even at cold temperatures and also made more technological improvements so that they could remove pollutants more efficiently. Finally, he succeeded in developing three-way catalysts using platinum group metals. The catalysts can remove three pollutants (nitrogen oxide, carbon hydride, and carbon monoxide) at the same time, which represents an epoch-making technical advance.

Three-way catalysts made using platinum group metals have been further improved and continue to be the most powerful means for gasoline engine emission control. At present, it is becoming possible to meet strict emission control regulations by using low-cost catalysts that contain ultra-low levels of platinum group metals.

Dr. Cooper also took on the challenge of developing catalysts to control emissions from diesel-powered vehicles. Emissions from these vehicles contain carbon particles and other particulate matter (PM), which might cause lung cancer. He developed the Continuously Regenerating Trap (CRT) for the control of diesel particulate emissions and this advanced emission gas control technology, which does not lower the fuel economy of vehicles, is highly evaluated across the world.

According to Dr. Cooper's estimate, the amount of pollutants, including carbon monoxide, carbon hydride, and nitrogen oxide removed by the use of the catalyst technology developed by him at Johnson Matthey totaled four billion tons as of 2002, when he received the Honda Prize. If the amount of particulate matters removed from diesel engine emissions is included, the amount of pollutants removed by the catalysts will further increase.

Towards a Goal of Sustainable Development

It is certainly important to continue to develop science and technology and achieve economic growth. However, we cannot just continue to pursue this in the conventional manner. In recognition of this fact, a new concept of "sustainable development" was proposed at a meeting of the World Commission on Environment and Development (WCED) convened by the United Nations in 1987. This concept has led to a consensus on the necessity of preventing further global warming, saving resources, and protecting the environment from pollution, although in discussing sustainable development, some focus more on sustainability and others more on development.

There are several approaches to ensuring sustainable development. A 'wait-and-see' approach is a rational one, and brings effective cost benefits. However, this approach can produce a negative outcome. For example, asbestos has caused tremendous damage as a result of taking a 'wait-and-see' approach despite the fact that the risks associated with the substance were pointed out by doctors as early as the 1880s.

Another approach promoted by UNESCO in recent years is the precautionary principle, which was formulated during the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992. The principle states that even where cause and effect relationships are not clearly proven, precautionary measures should be taken against any possible risks.

For example, following the 'precautionary principle' approach, if you have a tumor on your skin that might be malignant, you will spend time and money to have it removed, even if this is painful or leaves a scar, whereas with a 'wait-and-see' approach, you would wait until the tumor has been examined and proved to be malignant. It is impossible to decide which of these two approaches is better for you until the outcome reveals itself. What is important is to understand both of these approaches and to be flexible in choosing the one that seems to be better in each specific situation.

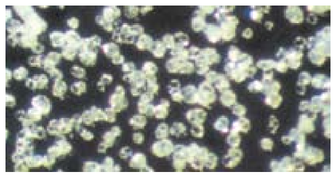
Regardless of which approach you take, it is essential to collect the necessary information in advance. Fortunately, precise environmental monitoring and predictions based on computer simulations have become practical since the end of the 20th century. In the field of natural science, observation and measurement techniques have substantially improved, including monitoring by artificial satellite. The use of data collected using these techniques has in turn improved the accuracy of computer simulations.

Computer simulation is used in most advanced scientific findings and technologies, and this in turn improves the simulation techniques used. The Intergovernmental Panel on Climate Change (IPCC) was founded in 1988 as a part of the worldwide effort to tackle global warming. The panel enables scientists to reach a consensus based on scenarios created by computer simulation and to make

"Sustainable human development should therefore be understood as progress through quality in every human activity."

1999 Honda Prize Laureate **Dr. Aleksandra Kornhauser**

Born in Skofja Loka in Slovenia in 1926. Professor of Chemistry at University of Lijubljana since 1969. Also served as vice-president of the Science Education Committee and the International Council of Scientific Unions, and chairperson of the Chemistry Education Committee and the Federation of European Chemical Societies among others. Established an information system to control toxic waste, and contributed to environmentally conscious production processes and product development. Served as UNDP Lead-Trainer for Environment Sustainable Development, and as a member of the United Nations University Council.



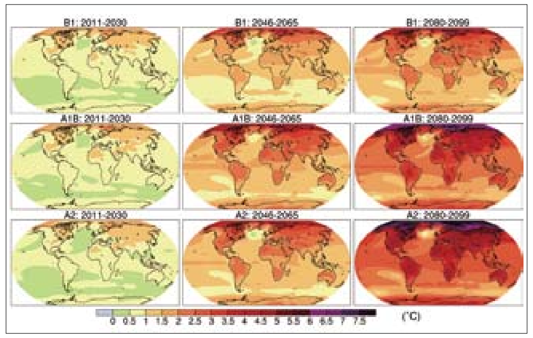
Microencapsulation
Microencapsulation of pesticides and other agricultural chemicals allows the controlled release of active substances into the environment over a long period. The technology ensures the same effect while substantially reducing the use of hazardous substances. It can be applied to a range of fields, and the International Center for Chemical Studies (ICCS) provides various opportunities for interdisciplinary cooperation, and is developing a comprehensive information system for microencapsulation.

As a PhD in chemistry, Dr. Kornhauser has been tackling environmental problems for many years, focusing on the theme of preventing harmful damage to the environment and society. She has been trying to prevent such damage by improving the production processes and quality of chemical products as well as their relationship with human beings at the production and use stages.

Dr. Kornhauser led the research to improve environmental technologies, manage hazardous waste, and develop technology for clean production processes and products, including taking the initiative in a project to develop less hazardous pesticides using natural products. The results of her research are widely applied in the production processes for agricultural products and food and in the chemical, pharmaceutical, and printing industries. In addition, at the initiative of Dr. Kornhauser, a comprehensive information system was planned and built to control and manage the generation of hazardous industrial waste beyond the boundaries of academic fields. In addition to her major role in establishing the system, she also played a leading role in the application of the system in various countries.

Dr. Kornhauser is also an excellent educator and coordinator. She established the International Center for Chemical Studies in Ljubljana in 1980 and invited several hundreds of scientists to the center, where they were able to learn the basics for the development of purification technologies, management of hazardous waste, and process control and preventive measures. Scientists studying at the center later returned to their home countries and promoted local environmental protection activities.

Dr. Kornhauser serves as a key person on a range of international committees and academic societies, including those belonging to the UNDP, UNESCO, the World Bank, and ILO. She is committed to the international and interdisciplinary networking of scientists and to giving support to developing countries in achieving sustainable development. She has also founded the Pro Natura award that commends young researchers who have contributed solutions to environmental problems.



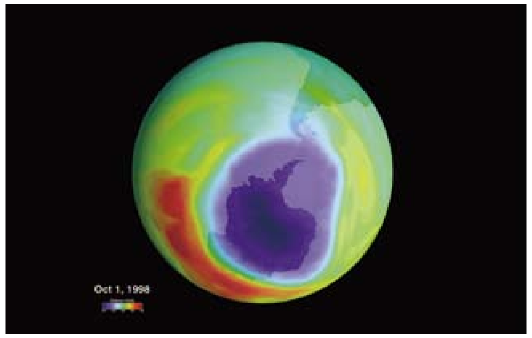
SRES Greenhouse-related gases emission scenarios (B1, A1B, and A2) Annual mean surface warming (surface air temperature change, °C)

Multi-model mean of three time periods, 2011 to 2030 (left), 2046 to 2065 (middle) and 2080 to 2099 (right).

B1: Scenario describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability
A1B: Scenario describes a future world of very rapid economic growth with emphasis on a balance across all sources
A2: Scenario describes a very heterogeneous world

* These scenarios do not include additional climate policies above current ones; more recent studies differ with respect to UNFCCC and Kyoto Protocol inclusion.
* SRES: Special Report on Emission Scenarios, IPCC 2000

(Source: IPCC Fourth Assessment Report)



In 1985, Joseph Farman, a British meteorologist, discovered the existence of an ozone hole above Antarctica through observations made from an artificial satellite. The ozone layer blocks 99% of ultraviolet rays falling on the Earth from the Sun. In response to the discovery, many countries began to implement countermeasures against depletion of the ozone layer. For example, in 1987, 53 industrial countries signed the Montreal Protocol to completely discontinue the use of CFCs, which destroy the ozone layer, by 2000. Humankind is now capable of monitoring the environment from a number of satellites revolving around the earth and possesses the technology to analyze the images taken from the satellites, thereby observing natural disasters and weather patterns and collecting accurate data on temperature distributions and desertification.

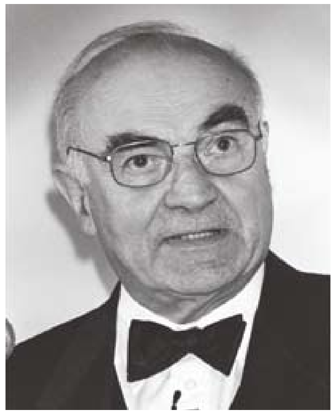
proposals to the policymakers of individual countries.

The progress of science and technology has helped us to recognize that problems that seemingly arise in different locations are actually connected on a global scale. This has provided us with a platform to devise more effective measures in the future.

"Scientific observation of the Earth remains an imperious necessity for the management of our planet. It may be costly, but it is our strict duty."

1998 Honda Prize Laureate

Dr. Hubert Curien



Born in Cornimont in France in 1924. Educated in physics at the University of Paris and became professor of science at the university in 1956. Served as the general director of the National Research Center, France, general delegate for research and technology, president of the French National Center for Space Studies, and chairman of the Council of CERN. While studying and giving lectures on crystallography, played a leading role in the formulation of scientific and technological policies in France and at international organizations. Also served as the minister of science and technology for three cabinets in France. Granted the Grand Officier Legion d'Honneur in France, Knight of the British Empire, and various other awards.

Dr. Hubert Curien started his research career as a crystallographer. At that time in the field of crystallography efforts were being made to increase our knowledge about crystals by observing possible crystalline defects using X-ray diffraction based on the perfect periodicity of the atomic ordering. With the spread of atomic reactors, it became necessary to predict all the damage that might be caused to solid matter by radiation. To this end, it was essential to study crystalline defects.

Dr. Curien studied under Jean Lavel, who indicated a way to carry out experiments on the spontaneous thermal motion of atoms using X-ray diffusion. Being Laval's student, he was able to give a complete description of the phonons in a crystal of iron. He subsequently studied crystallography and gave lectures to students at the University of Paris over a period of 40 years, during which time he paid attention to the merits of controlling small crystalline defects (irregularities) from the aspect of materials engineering. It is possible to control the most important features of crystal substances by the use of these small defects and expand the application of these substances by purposely introducing and perfectly monitoring irregularities.

Dr. Curien is also recognized for his great contribution to space exploration in Europe through his direct involvement in space research. He was thus not confined to the field of crystallography but also studied engineering in general. In view of the fact that simple human errors often lead to serious accidents despite the use of perfect technology, he pointed out the necessity of conducting a range of interdisciplinary research into man-machine relationships and of always reviewing perfection achieved on a certain scale to ensure more scalability and power. He played a leading role not only in France but also internationally in his capacity as the chairman of the European Science Foundation, chairman of the Council of CERN, etc. He greatly contributed to global environmental protection activities through his involvement in determining scientific and technological policies.

With regard to space development, he particularly devoted himself to the promotion of the Earth Observation System using artificial satellites. In the latter half of the 1970s, he launched the SPOT as the president of the French National Center for Space Studies and in 1979 led the development of a space rocket named Ariane, which led to the first successful launch of a satellite in Western Europe. Subsequently he promoted projects designed for observation and management of the Earth as the chairman of the Council of CERN and was designated as the chairman of the Space Agencies Forum for the International Space Year (SAFISY) in 1992.

Research into weather and climate change has been advanced by improvements in computer performance and by the use of simulation technologies based on mathematical models comprising multiple parameters and of data obtained through observation. Research in this field has developed dramatically by the detailed observation of the atmosphere and oceans by the use of artificial satellites and analysis of the results with the use of computer software. The achievements made by Dr. Curien have directly led to the progress of research into the global warming problem and climate change. It became possible to assess objectively the impact of human activities on the global environment and take prompt measures by using artificial satellites to observe the Earth from space. Visualization methods to intelligibly communicate the observation and simulation results have also been advanced.

Finally, in honor of Dr. Curien's contribution to space exploration, the site on which the Huygens probe landed on Saturn's moon Titan in 2004 was named the "Hubert Curien Memorial Station" in 2007.

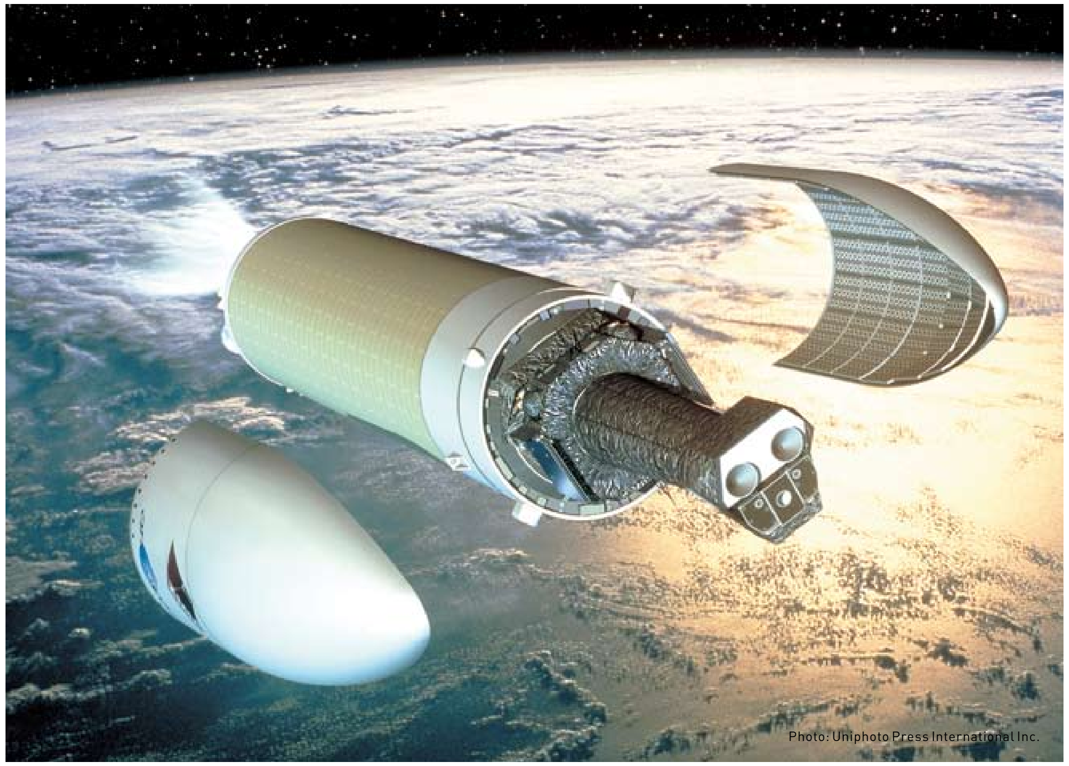


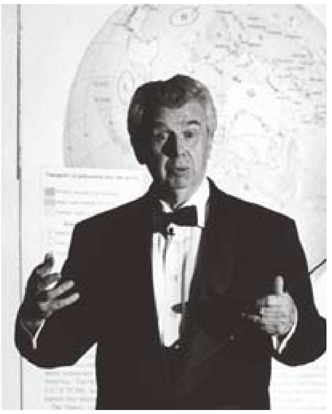
Photo: Uniphoto Press International Inc.

(Upper) **Weather satellite launched by Ariane**
(Lower) **The Ariane rocket**
As president of the French National Center for Space Studies and chairman of the European Space Agency, Dr. Curien successfully led the construction of the Ariane 1 to Ariane 4 rockets. The development of space technology opened up new areas in a range of fields, including telecommunications, weather forecasting, and deep space exploration, and enabled regular monitoring of any place on the Earth.

"We use chemicals for the benefit of society with a full awareness of possible hazards."

2001 Honda Prize Laureate

Dr. Donald Mackay



Born in Glasgow in Scotland in 1936. After receiving a bachelor's degree in applied chemistry, ARCST in chemical technology and chemical engineering from the Royal Technical College, Glasgow, moved to Canada and worked on shock tube research with Professor O. Trass at the Department of Chemical Engineering and Applied Chemistry at the University of Toronto. Subsequently served as a research chemical engineer at the Heavy Organic Chemicals Division of Imperial Chemical Industries Ltd. in the United Kingdom and became professor of chemical engineering and applied chemistry at the University of Toronto in 1967. Professor of environmental and resource studies at Trent University since 1995. Now also serves as the director of the Canadian Environmental Modelling Centre at Trent University.

Dr. Donald Mackay is a pioneer in the field of environmental science. He has long been continuing research to clarify how chemical substances are transferred, spread, and accumulated in the environment, receiving support from the Natural Sciences and Engineering Research Council of Canada (NSERC). According to Dr. Mackay, human beings have made multiple mistakes regarding the treatment of chemical substances due to their lack of knowledge about the behavior of chemical substances and their influence on ecosystems. So far, there are about 20 million chemicals known to man, of which 50,000 to 100,000 have been produced in commercial quantities. Dr. Mackay thinks it unrealistic to simply deny the use of all chemical substances. Instead, he advocates the idea of "Eco-Chemistry," which means to impose necessary regulations on chemical substances based on the results of their evaluation and diagnosis of their harmful effect and to replace them with more environment-friendly ones. He has been studying a method to predict the behaviors of chemical substances by a mathematical approach using computer simulations.

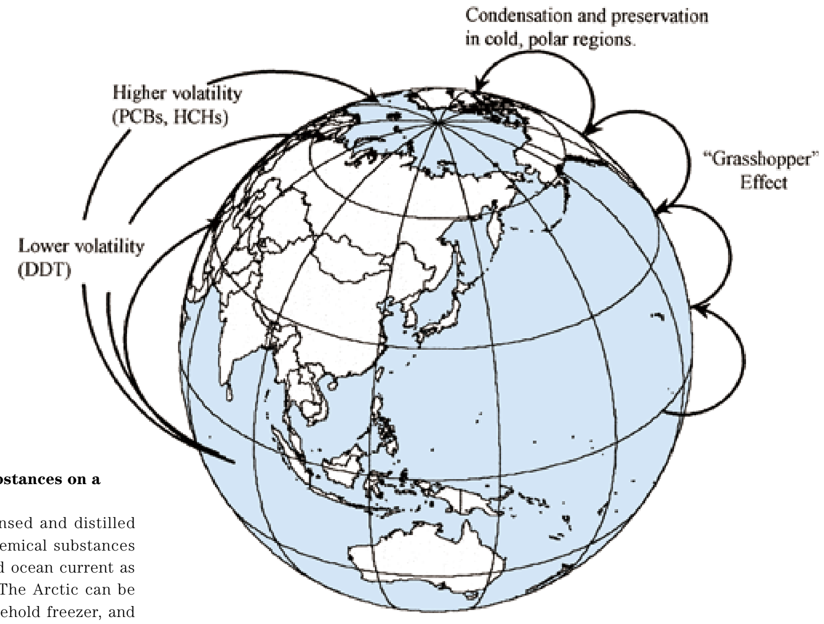
Around 1970, Dr. Mackay conducted research into the behavior of spilled oil following the proposals to produce oil and gas in the Canadian Arctic, which might badly affect the Arctic ecosystems in the event of an oil spill. In the research, he predicted the behavior of spilled oil and found an effective method to deal with it. He used an analytic formula and mathematical model to predict the flow of spilled oil and its environmental impact, which are highly evaluated and still used now.

In the research, he focused on fugacity, which is the pressure or tendency to escape of substances emitted into the environment, which tend to move from one medium to another. Dr. Mackay is the founder of an environment modeling theory based on the concept of fugacity. He made a great contribution to the environmental field with his Mackay Model, which systematically and comprehensively models the behavior of chemical substances in the natural environment, including air, water, soil, and the sea bed.

Estimation using fugacity is utilized by world-class chemical product manufacturers in developing new chemical substances. Dr. Mackay says that he hit upon the use of the concept of fugacity for environmental protection because he had the experience of working in the chemical industry as an engineer. He therefore attributes importance to the roles to be played in environmental protection by industrial scientists. To ensure the accuracy of prediction results, it is essential that those engaged in environmental science collect appropriate emission data, analyze environmental situations, and develop better prediction models, and that governments appropriately manage and regulate chemical substances. To this end, the chemical industry, which produces chemical substances, should play a leading role. Dr. Mackay says that the principle of "EcoChemistry" cannot be successfully implemented without the cooperation of all those concerned.

Dr. Mackay had a great influence on the regulation of chemical substances through his research achievements. Influenced by him, each country began to regulate pollutant chemical substances in cooperation with each other and the Stockholm Convention on Persistent Organic Pollutants was adopted in 2001 with the agreement of 127 countries. This convention is intended to reduce and discontinue the use of specified pesticides and chemical substances and so it is quite meaningful.

The progress of research in this field has revealed that pollutant chemical substances have spread widely to areas far from the areas where they were actually used. For example, pollutants carried by wind and marine currents have long accumulated in the Arctic Circle although these substances were never used there. In the future, it is therefore necessary to conduct simulations and predictions targeting the complex behavior of chemical substances on a global scale and industries and the international community should implement measures based on the results.



Transfer of chemical substances on a global scale
Contaminants are condensed and distilled on a global scale, and chemical substances are conveyed by wind and ocean current as far as the Arctic Circle. The Arctic can be compared to a huge household freezer, and even contaminants, which are preserved there for a long time in good condition, will gradually be condensed.

The photo shows the oil spill caused by the collision between the large tanker Hebei Spirit and a barge off the coast of Taenan, South Korea. The oil spill was one of the largest in recent years.

Think Globally, Act Locally

Our current environmental problems can be roughly divided into the following three types: global warming, problems related to resources (energy, food, and water), and environmental pollution. These three types of problems are interrelated.

The bioethanol issue is one typical example showing the interrelationship between problems.

Bioethanol has been attracting much attention as a way of reducing global warming because it does not emit much CO_2 when burned as a fuel. Because of this, the price of corn, from which bioethanol is made, soared and more farmers began to grow corn instead of oranges and wheat. This in turn raised the price of food other than corn across the world. In countries promoting rapid economic growth, demand for water has been increasing due to industrialization and increases in population, while water pollution has been aggravated because of industrialization. To import food and bio-energy from these developing countries will literally deprive these countries of their precious water resources, because large volumes of water are necessary to grow corn.

Viewed from a global perspective, the bioethanol issue involves almost all the elements of the main environmental problems. Behind this, there has always been the North-South problem, which is further complicating the situation.

Those living in developing countries are most vulnerable to environmental degradation and suffer famine caused by draught. Rich countries can purchase seawater desalination plants but poor countries cannot afford them. It is therefore natural that the developed countries, which are already enjoying affluence and convenience, and developing countries, which are still trying to achieve economic growth, have quite different opinions regarding regulations on CO_2 emissions.

This kind of uneven distribution of resources and wealth is further complicating environmental problems and hinders the implementation of global measures beyond national boundaries.

Although the phrase is often overused, it is indeed necessary to "think globally, act locally" in solving global environmental problems.

As the bioethanol example clearly shows, it is important to think globally in dealing with environmental problems, and we must take a range of approaches to solving them. We face difficult trade-offs between the separate elements of environmental problems because it is now clear that all those elements, including CO_2 emissions, environmental pollution, and food problems are intricately intertwined. Fortunately, simulations have provided more scientific findings, allowing us to capture a global picture of environmental problems and to make effective predictions. In addition, the Internet has made it easier to obtain information on the global environment and to exchange technical information with others who have similar problems beyond regional and national boundaries. In this way, we are gradually establishing an environment that allows us to "think globally."

What we now need is to "act locally"—to think and implement less conflicting solutions to local problems that take into account the social and economic restrictions peculiar to a specific area. It is not always necessary to invest large amounts of money in leading-edge technologies to solve these problems. Adopting those technologies can be effective in some cases, but what is more important in facing the critical nature of current demands is to find solutions that are less conflicting.

For engineers who devise ways of responding to conflicts between the needs of users and consumers under restricted conditions, this approach might just be an extension of the work they already do every day. But it has now become urgent for engineers to successfully develop technologies that will contribute to sustainable development.

In virtually all parts of South Asia, fetching water is the duty of women and children, who spend many hours each day simply to carry water. (Photo: Rajasthan, India) Although the proportion of people who use sanitary water sources has grown in developing countries in general, some 1.1 billion still need access to improved sanitation. (Source: United Nations)

"Strategic study is necessary for our planet's energy future."

1984 Honda Prize Laureate **Dr. Umberto Colombo**

Born in Livorno in Italy in 1927. Received a doctorate in physical chemistry from the University of Pavia in 1950. Served as researcher and chairman of the OECD Committee for Science and Technological Policy and chairman of the European Industrial Research Management Association. Proposed the technological development and waste control policies to secure energy, resources and food in the fourth report of the Club of Rome titled Beyond the Age of Waste (1977). Chairman of the Italian Atomic Energy Commission (CNEN, now renamed the Italian National Commission for Nuclear and Alternative Energy Sources [ENEA]) since 1979. Also serves as the chairman of the EC's Committee for Science and Technology and as the chairman of the United Nations' Advisory Committee on Science and Technology for Development.

Dr. Umberto Colombo has been holding important positions at energy- and science and technology-related governmental agencies in Italy and has also been making proposals to solve global environmental problems in his capacity as chairman of the EC's Committee for Science and Technology and as chairman of the United Nations' Advisory Committee on Science and Technology for Development. Dr. Colombo's papers and proposals communicate his practical and strong will to create a harmonious sustainable society while taking into consideration a wide variety of issues, including those related to science and technology, social systems, conflicts of interest between nations, and the North-South problem.

He became widely known to the public by co-writing the fourth report of the Club of Rome titled *Beyond the Age of Waste* with D. Gabor in 1977. In the report, he insisted on the necessity of creating a sustainable society, which many insist on now.

He attributed special importance to energy issues. Having experienced two oil crises before he received the Honda Prize in 1984, Dr. Colombo thought that human societies were entering an age of transition with regard to energy and technology.

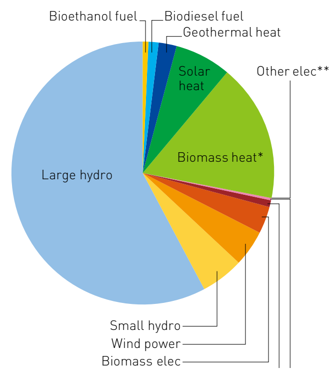
As for energy sources, we experienced several transition periods in the past. First, we shifted from wood to coal because of the depletion of the former. Then we shifted from coal to oil in accordance with the progress of urbanization, because oil is easier to transport and can be more widely applied. Dr. Colombo called this type of transition, namely the shift of a major energy source to a single, more convenient source as "downhill transition." He thought that "downhill transition" and production and distribution systems relying on this type of transition were nearing their limits and that an age of "uphill transition" would come, in which a variety of energy sources would be utilized in a post-industrialized, information-oriented society.

As future energy sources, Dr. Colombo suggested nuclear power, solar power generation, and new energy technology using nuclear fusion. He also proposed the more effective use of natural gas, coal, geothermal heat, oil shale, tar sand, and biomass through technological innovation and suggested the possibility of using wind, waves, currents, and oceanic heat gradients as energy sources. In addition, he proposed the combined use of several energy sources according to their features and advantages. Further,

The photo is taken on Pellworm Island, Germany. Germany is an environmentally advanced country and aims to increase the percentage of electricity generated by renewable energy to 20%, thereby reducing CO_2 emissions by 40% by 2020.

World Renewable Energy 2005

World Renewable Energy 2005



(Data marked with * and ** are data for 2004.)
(Off-grid power sources, geothermal heat pumps, and incineration of renewable flammable waste are not included.)

Renewable energy accounted for 13.1% of the world's total primary energy supplies (TPES) in 2004. Ten point six percent of renewable energy is obtained from biomass and flammable sources, followed by hydraulic power (2.2%) and geothermal heat (0.4%). In the power generation field, renewable energy accounted for 17.9%, most of which was generated by hydraulic power. In recent years, power from sources other than large-scale hydraulic power generators, that is, power generated by "non-hydro" renewable energy sources such as wind power, has been increasing. (Source: IEA Renewable Fact Sheet)

he pointed out that due considerations should be given to safety and the environment in using energy, because its use would have a tremendous influence on the environment.

According to Dr. Colombo, the information, robotics, biotechnology, and new materials industries would require less energy and materials, and the economic system would completely change in the future. It is therefore possible for each country to reduce their use of resources while maintaining its GNP level. He regarded electricity as the most flexible and convenient energy form. In fact, demand for electricity alone has been increasing in developed countries and it has been possible to use a variety of energy sources to generate electricity, including hydraulic power, nuclear power, fossil fuels, geothermal heat, steam, solar energy, and nuclear fusion as well as locally distributed renewable energy sources such as waste, biomass, wind power, and solar cells.

Dr. Colombo hoped that developed countries would share the convenience achieved by the progress in energy technologies with others and would eventually create a society where people were not only physically but also spiritually rich.

In addition to energy sources listed by Dr. Colombo, fuel cells are also now available as new energy. It will take far more time for the practical use of nuclear fusion, which Dr. Colombo proposed. However, the resource saving method proposed by him, namely using a variety of energy sources in a well-balanced and efficient manner in consideration of the local situation, is an excellent and up-to-date method. Now researchers and engineers globally are engaging in fierce competition to develop energy-related technologies toward the achievement of a sustainable society.

Sharing the Earth

Environmental problems cannot be solved without collaboration beyond the boundaries of specialized fields. Specifically, social, economic, and cultural approaches are necessary in addition to scientific and technological approaches. In view of the fact that ordinary people contribute to environmental problems with lifestyles that devour large amounts of energy, it is also important for them to engage fully in solving the problems in cooperation with experts in each field.

While in the past, scientists have been able to devote themselves to pursuing the themes of their choice, with almost no links to the engineers who work closely in association with the economy and society, in recent years scientists are increasingly required to make social comment and some scientists have actually done so.

However, with environmental problems, as a result of scientists pursuing their own path and engineers pursuing targeted technological standards, there have been increasing numbers of unexpected achievements, and computer simulations are a good example of this. Scientists in the natural sciences, including meteorologists, oceanographers, biologists, and chemists encountered computer technology in searching for a tool to support their work. This has eventually led to a substantial expansion of environmental findings. Also, the development of visualization technology, which allows computer-processed data to be displayed more clearly, has helped stimulate the general public's interest in environmental problems.

In the background to these encounters, the progress of information technology represented by the Internet has dramatically increased the exchange of information between people of different backgrounds. The globalization of information has given rise to acknowledgment and utilization of the local knowledge built up over the years in local communities and this will complement the detailed but narrow knowledge of the experts.

People with completely different interests and backgrounds are now tackling environmental problems as a common challenge. They experience both conflicts of opinions and synergy effects, which have the potential to give rise to historically significant discoveries.

Young people who hope to specialize in science and technology should be encouraged to involve themselves in discussions with people who take different positions, have different viewpoints, and work in different fields of expertise. Conflicts of opinion and synergy effects can create the innovative technologies needed for the solution to our environmental problems.

In finding solutions to environmental problems, we must be able to imagine the pain of those people who are actually experiencing these problems and truly empathize with them. We must look on even the problems of other countries as our own problems and try

"Do not fix any form of heavy, solid, and earthbound building on the surface of the Earth."

1990 Honda Prize Laureate **Dr. Frei Otto**

Born in Sachsen in Germany in 1925. Studied sociology and city planning at the University of Virginia and obtained the title of "independent architect" in Berlin in 1952. Became assistant professor and director of the Lightweight Plane Support Institute at Stuttgart University in 1964. Founded Atelier Warmbronn in 1969. Received a doctorate in art and architecture from the University of Washington in 1973 and subsequently became an honorary doctor of science at the University of Bath in the United Kingdom in 1980. Designed the Japan Pavilion at Expo 2000 in Hannover by adopting paper as the construction material and received the 18th Praemium Imperial Prize in 2006.

Olympiastadion in Munich

Dr. Frei Otto began to question the conventional concept of architecture when he joined the German air force during World War II. He was one of the German architects who experienced the Nazi administration and became doubtful about the traditional values of magnificence and immortality. In particular, Dr Otto's works of architecture are characterized by a richness of variability and flexibility and they are also light and beautiful. He often adopted cablenet and membrane structures for his works and is recognized as the world's authority on lightweight tensile structures.

Dr. Otto established the Lightweight Plane Support Institute of Stuttgart University in 1964 and conducted interdisciplinary research with engineers, biologists, physiologists, and philosophers at the institute. By incorporating research results into the field of natural science, he was able to create ultra lightweight, high-performance architectural works, including the West Germany Pavilion at Expo 67 held in Montreal, Canada and the roof of the Olympiastadion in Munich (main venue for the 1972 Summer Olympic Games). Adopting cablenet and membrane structures, he created large spaces with optimal curves calculated by experiments using soap bubbles. Buildings thus made are highly evaluated for their harmony with nature and have had great impact on the architectural industry.

According to Dr. Otto, architecture is a means to protect human beings and nature. Buildings should be something good for all people, in particular for the poor, the weak, mothers and children and should have beauty associated with love. To this end, he basically wanted to take an ecological approach to ensure the coexistence of human beings with the environment and nature instead of trying to control nature. He says, "The youngest ecological system within evolution is the human city which has probably never been genuinely healthy since it came into existence," and insists that the form of the "natural house" and the "natural city" has still to be found today.

What he says is not just theory. In fact, Dr. Otto's lightweight buildings need less than 5% of the materials and energy required for ordinary buildings to perform their functions. He has repeatedly made experiments regarding the impact of buildings as part of human society and the environment. He still has a strong impact on architecture and other fields with his never-diminishing originality.

Image of the Earth setting over the Moon taken from lunar orbit: the image shows the Earth rising and setting over the Moon's horizon, and is the second of its kind following the images taken by the U.S. spaceship Apollo. The photograph was taken with an HDTV camera developed by NHK (Japan Broadcasting Corporation) aboard the KAGURA, a lunar explorer satellite launched by the Japan Aerospace Exploration Agency (JAXA).

to devise solutions based on the recognition that we share a single Earth. This could provide the means to fulfill our responsibility to future generations.

"We need to adopt a planetary perspective —to see the Earth as a world, one among many others. The study of other worlds can help us to understand and improve this one, and so avert the very real catastrophes that lurk in our technology."

1985 Honda Prize Laureate Dr. Carl E. Sagan

Born in the State of New York in the United States in 1934. Received a doctorate in astronomy and astrophysics from the University of Chicago in 1960. Worked at the Smithsonian Astrophysical Observatory and taught at Cornell University as professor of astronomy and space sciences. Founded and became the first president of the Planetary Society in the United States. Played a leading role in the Mariner, Viking, and Voyager expeditions to the planets. Published many science books for the public and one of his books *Cosmos* became a best seller. The TV series *Cosmos* was broadcast in 64 countries.

Dr. Carl E. Sagan was a famous astronomer who was involved in almost all the exploration plans for planets in the solar system. He wrote many science books and articles for ordinary people as well. In particular, in the 1980 television series *Cosmos*, he successfully showed a new perspective on "the Earth in the universe and lives on the planet" to people all over the world. The TV program showed that it is nearly a miracle that the Earth provides habitats for living creatures while various other planets do not, and taught the importance of the global environment. Now we share the idea that the Earth is a closed system, greatly influenced by Dr. Sagan.

Dr. Sagan warned that human beings might cause anthropogenic environmental disasters on the Earth based on his research into other planets. In his paper announced in 1984, he introduced his theory of "nuclear winter." According to his theory, the large volumes of aerosol that would be emitted into the air by a nuclear explosion and large fires in the event of all-out nuclear war would bring a "nuclear winter." Aerosol in the atmosphere would shield solar rays throughout the year and partially invalidate the greenhouse effect, which in turn would rapidly lower the Earth's temperature. As a result, plants would die because they would be unable to photosynthesize and the ecosystem would be destroyed. Human beings would face an unprecedented crisis, and starve to death in the cold. Even after the end of the Cold War, there remains a possibility that a "nuclear winter" might come. Also, Dr. Sagan pointed out that the increase in CO_2 emissions caused by the use of fossil fuels would accelerate global warming through the greenhouse effect. Now research into climate change, especially predictive research using simulations are conducted giving consideration to his warning.

Dr. Sagan said, "It is within our power, purposely or inadvertently, to change the climate of our planet to such an extent as to put into jeopardy our civilization, perhaps even our species." Although he had the idea of "terraforming," which means to transform the environment of other planets into one in which human beings can live, he first of all wanted to protect and enrich the global environment by the power of science and technology.

Message from Honda Prize Laureates

Even today, ecotechnology is often narrowly defined only as a technology, sometimes also called sustainable engineering, which supports the fulfilment of human needs while causing minimal ecological disruption.

And yet, this concept of ecotechnology was already surpassed thirty years ago by the great vision and mission of Soichiro Honda, followed by its dissemination by the Honda Foundation. Soichiro Honda has given ecotechnology a holistic approach which not only integrates the scientific, technological, economic and social dimensions of ecotechnology, but enriches it also with moral, ethical and cultural values. In this approach, ecotechnology has become a comprehensive philosophical concept and a foundation for understanding and pursuing sustainable development.

The role of the Honda Foundation is increasing. We are entering the Century of the Environment: human health, social justice, sustainable economy, security, peace—they all are environmental. This means that we have to change the direction of current spontaneous change; sometimes we have to oppose it.

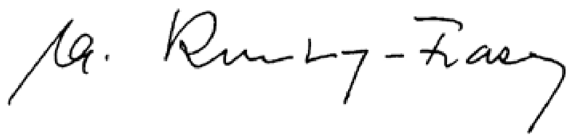
And it is high time for this! The Global population is still growing at a very high rate, many resources are getting scarcer, waste problems bigger and poverty persisting. Global warming, ocean depletion, destruction of the habitats of many animals, uncontrolled introduction of foreign species, are examples of non-linear changes with serious, but often unpredictable, consequences.

Our main hope is to eradicate ignorance which is often a crucial obstacle in development of responsibility. Knowledge is needed like the sun—it must bring light and warmth to everyone. Therefore, it is right that scientists call for the creation and dissemination of new knowledge. However, this is not enough. We have also to do much more to communicate knowledge and transfer it into decision making and work processes.

Science cannot be divided anymore into fundamental and applied science. It has to become a holistic science. It needs fundamental research results—you have to have them, otherwise there is nothing to apply. But this is only the initial phase of modern holistic science in which fundamental research has to be followed by the efforts to recognise opportunities for its responsible use, to create inventions, develop innovations and implement them on a wider scale for the benefit not only of humankind, but of all species, all nature.

The main hope is that the holistic science, and in its scope ecotechnology as defined by Soichiro Honda, will become the guiding principle, the vision and the mission of all, and particularly of scientists and engineers of the future.

Aleksandra Kornhauser
20th Honda Prize Laureate, Slovenia



Innovation

Humans and Machinery —Living in Harmony

New Materials Supporting Technological Innovation

Specificity of Information Technology

Respect for Humans: Always the Center of the Discussion

As a result of technological innovations in the 20th century, technologies have advanced incongruously at a pace that the human beings who use the technologies cannot keep up with. In particular, technological innovations in the information and communications field driven by the popularization of the Internet in the 1990s have changed economic relations, relationships between countries, and the daily lives of individuals. Having entered the 21st century, the speed of technological innovation has further increased, and new materials have been developed one after another. Substantial progress has been made in the field of nanotechnology. Now we have entered an age in which technological developments are made at unprecedented speed and frequency. Technological innovations are beginning to exert a dramatic influence over the direction of social development and over individual values. In Chapter 3, we will discuss what would be a desirable future for technological development.

Humans and Machinery —Living in Harmony

A look at history shows that we have received great benefits from a series of technological innovations. These innovations freed people from hard labor and greatly increased productivity and efficiency. Meanwhile, science and technology developed independently, at least until the end of the Second World War. But later in the century, when technology became linked closely with science, technological developments brought unprecedented benefits.

The combination of science and technology also brought with it unprecedented problems. The conventional idea of the relationship between people and machines, i.e., "people use machines," was demolished. The "man-machine system" is a good example that shows this change.

The man-machine system was suggested by information technology and engineering during the Second World War and put into practical use as a system where the functions of the operator and the machine are integrated. For example, a radar system (machine) captures the enemy plane, an operator (man) reads the information, and an antiaircraft gun (machine) shoots at the enemy on a trajectory programmed by the man. In a man-machine system, "man" and "machine" function as one integrated whole from the input to the output of the system. Man and machine are integrated in the system as components with equal value to increase the efficiency and accuracy of the operation. In a sense, it is a relationship where humans are used by 'technology' as part of the system.

But it is not always easy for a person to control a machine in a consistent manner. While a machine can exhibit a constant performance unless a problem occurs, the performance (or capabilities) of people vary. While a certain person needs only one second to complete an operation with a certain machine, a different person may need three seconds. This means that the performance of the machine cannot be consistent.

The concept of a "foolproof system" was adopted as an important element in the man-machine system. A foolproof system is designed on the premise that the performance (or capabilities) varies between different operators. The capabilities of the operator therefore are set lower than average, but still obtaining the highest efficiency from the machine. This idea suggested the future direction of the man-machine system, i.e., "Not people adapting to machines but machines adapting to users."

When the war ended, the foolproof man-machine system was adopted by civilian industries, and brought with it new problems.

Automation was a technological innovation every factory around the world was eager to adopt. While automation brought drastic increases in productivity, it also brought concerns that people would become just a cog in a machine. When people started seeing themselves as just a cog in the machinery of the production process, they felt a loss of

A US film that was released in 1936 portrayed the unease that was growing amid the working classes as the industrialized countries were expanding economically at spectacular speed, sending a warning of the excesses of capitalism. This was "Modern Times," a film produced, directed, written by and featuring Charles Chaplin (1889-1977). The scene where the leading character working in a factory starts to lose his mind because of the endless routine work and becomes trapped between giant gearwheels, in particular, not only drew laughter for its comical antics but also was a vivid portrayal of the human isolation of workers who were becoming "mere gearwheels" in a larger mechanism. It has become one of the most unforgettable scenes in film history. With the technological innovations since World War II, concerns over "man not controlling machines but being controlled by machines" have been further aggravated. The picture of man as a cog in a machine that Chaplin portrayed as a warning unhappily turned out to be a forecast of what was to become reality in the following decades.

Photo: Pacific Press Service

dignity, and productivity also decreased. As a solution to this dual problem, a new notion brought another technological innovation in the 1970s. The idea of human engineering was introduced as a way to humanize technology.

An example is the production line and the development of factory automation. In efforts to improve efficiency and safety and to provide people with a smooth work environment, effective studies have been carried out on the kinds of work processes that are productive for both people and machines (including industrial robots) and what types of machines and robots should be used.

Rather than attempting to replace the human worker, importance is placed on the "human interface"; that is, the machine is designed to assist workers and expand their functional capabilities. In short, the focus is on harmonization and collaboration between man and machine.

In today's man-machine systems, the relationship between man and machine that has emerged is moving away from one in which the worker has to keep pace with the machine towards one that restores man as the primary agent.

Human engineering aims to achieve the ideal use of technology; to use the most advanced science and technology to design a machine or system that any person can operate while getting a sense of fulfillment and achievement from using the machine. "Not to have people adapt to machines, but to place people at the center of operation." The idea of human engineering in design and technology forms the core concept of ecotechnology.

"We have to create machines that are helpful to humans."

2003 Honda Prize Laureate

Dr. Ken-ichi Mori

Born in Tokyo in 1938. Dr. Mori graduated from the University of Tokyo (faculty of Engineering) and joined Tokyo Shibaura Electric Co., Ltd. (present Toshiba Corporation) as a member of the Research and Development Center. In 1970 he invented the Handwritten Postal Code Number Reader and Sorter followed by the invention of the Japanese word processor in 1978. For his research Dr. Mori received a number of awards, including the Japanese Patent Office Commissioner Award, the Ohkouchi Memorial Technical Award and the Science and Technology Director General's Prize. In 2003, he became adviser to the Board of TEC Corporation. Also serves as professor at the Tokyo University of Science Graduate School and chief researcher at the Japan Science and Technology Agency.

Pinyin Chinese Character Input System

The First Japanese Word Processor (Toshiba, 1978)

Unlike the alphabets used in Western cultures, the Japanese writing system requires several different sets of characters (i.e., hiragana and katakana, both of which form part of the Japanese syllabary (alphabet) and kanji, the Chinese characters imported from China). Altogether, the number of characters necessary for everyday reading and writing exceeds 3,000. For this reason, development of easy-to-use Japanese input devices at first seemed impossible to everyone. Dr. Kenichi Mori was the exception. He saw the potential demand for Japanese input devices from newspaper companies, magazine houses and government offices, and in 1971 started research to develop a device that (1) would enable any of its users to write Japanese documents faster than writing out by hand, (2) was portable, and (3) could create documents that could be accessed and searched from anywhere. With the aim of developing a device that covered all of these three functions, Dr. Mori developed mechanisms to deal with the problems of homonyms—a characteristic feature of the Japanese language—and compiled co-occurrence dictionaries to study how autonomous words are combined. In 1978, the first Japanese word processor was completed. Although the first model was equipped with only the first of the three functions, advancements in recording media and the invention of liquid crystal displays soon allowed development of small household models by 1985—fulfilling the second function. The third function was realized when the Internet became available. Thus, the three functions required of the Japanese word processor, or the three concepts behind Japanese word processor development, were all accomplished in less than 40 years. This was only possible because Dr. Mori was able to proceed with a clear image of his future devices.

The development of Japanese word processors threw light on the development of word processors in other languages. Specifically, it gave the motivation for many to develop mechanisms to process non-alphabet characters on computers. Dr. Mori's invention was adapted for many other Asian languages as the model for word processor development.

Dr. Mori also has made great achievements in pattern recognition. One achievement he made before starting to develop the word processor has been adopted in studies on handwritten postal code number readers and word processor functions that remember frequently-used characters. These are manifestation of a belief that Dr. Mori always keeps in mind: "We have to create machines that are helpful to humans, not machines that need help from humans."

New Materials Supporting Technological Innovation

One area of science experienced great advancement when science and technology started coming together and a totally new way of research and development opened up. Materials development has been supporting technological innovation for building machines and systems since the end of the Second World War.

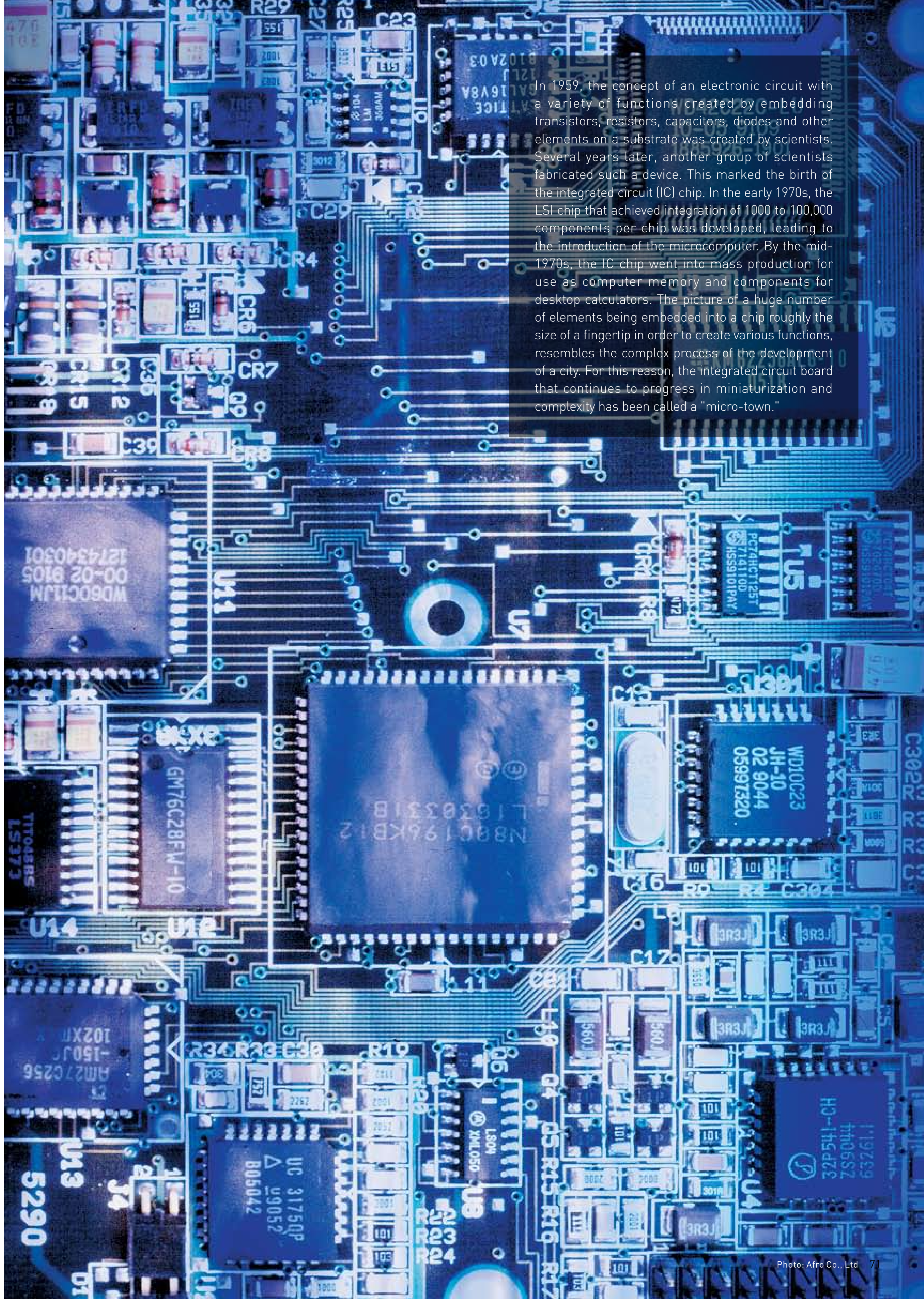
The silicon semiconductor, the essential element in the great advancement of technologies since the 1970s, is one example. It contributed greatly to realizing high-speed, high-performance computers in smaller sizes and lighter weights, while lowering prices to suit mass production. That brought about a wave of advances in electronic devices, from office equipment to household appliances, transforming our lifestyles completely. A great number of other newly-developed materials, such as superconductors, new alloys and ceramics, brought great advancements in science and technology, serving as the driving force for technological innovation in an unprecedented way.

New materials developed by nanotechnology, the largest technological innovation of the 20^{th} century, must be mentioned here. Nanotechnology is the name given to a wide range of technologies in various scientific fields that share the key word "nano" to describe their scale. Nanotechnology is used in medicine, bio engineering, pure engineering, electrical science and many other fields.

In nanotechnology, new materials are developed from unique backgrounds and processes. For example, fullerene was not discovered during the research into new materials, but coincidentally found during a study to produce carbon molecules that are identical to the interstellar molecules in space. When the new material was found, it was used not in the field of space science but in the field of medicine, specifically in pharmaceuticals. In its most recent application, fullerene is combined with protease to produce a substance to suppress the AIDS virus. Even during the process of fullerene synthesis, another material was accidentally discovered; the carbon nanotube is now used in many different areas, including flat panel displays, ultrafine semiconductor devices, fuel cells, and scanning tunneling microscopes.

These new materials, developed with the knowledge and techniques of nanotechnology, are significantly accelerating technological innovation across all fields of research.

Such possibilities for applications of nanotechnology call for sharing information among researchers in different disciplines. Scientists and technicians involved in research and development in nanotechnology often needs the capabilities to collect data and understand studies in other fields or in techniques that are not within their expertise. They may not have the best perspective on potential applications for the new materials and technologies they have created, especially in other fields. Now, in order to develop

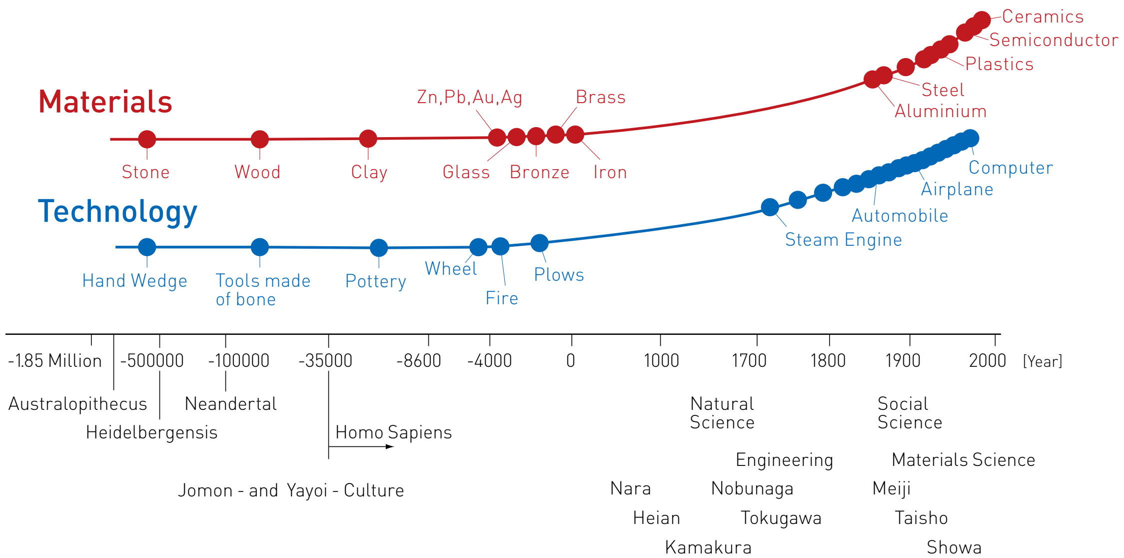


In 1959, the concept of an electronic circuit with a variety of functions created by embedding transistors, resistors, capacitors, diodes and other elements on a substrate was created by scientists. Several years later, another group of scientists fabricated such a device. This marked the birth of the integrated circuit (IC) chip. In the early 1970s, the LSI chip that achieved integration of 1000 to 100,000 components per chip was developed, leading to the introduction of the microcomputer. By the mid-1970s, the IC chip went into mass production for use as computer memory and components for desktop calculators. The picture of a huge number of elements being embedded into a chip roughly the size of a fingertip in order to create various functions, resembles the complex process of the development of a city. For this reason, the integrated circuit board that continues to progress in miniaturization and complexity has been called a "micro-town."

Photo: Afro Co., Ltd

nanotechnology further, information sharing is called for, not only among the researchers who are directly involved in nanotechnology itself, but also among scientists and engineers in every possible field of application.

A society that integrates scientific disciplines and technologies, including nanotechnology, will expand the horizons of science and technology from a rather "self-contained" world to a more comprehensive and inclusive existence. People who work in technology will be able to expand their areas of knowledge to give a more comprehensive viewpoint. They can expect their brainchildren to give birth to other great technological innovations in totally unexpected areas. It will be an era of unlimited possibilities.



Evolution of materials and technology

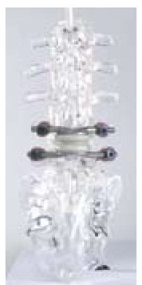
The rise of the evolutionary curve includes a number of discoveries and technological events. New materials such as plastics, semiconductors and superconductors, advanced alloys and ceramics and others are appearing and provide an impetus for technological development.
(From the commemorative lecture at the 17th award ceremony for the Honda Prize in 1997: "New Materials in the Service of Mankind")

"Materials science can help to ensure that technological evolution is on the right track."

1997 Honda Prize Laureate

Dr. Günter E. Petzow

Born in Nordhausen in Germany in 1926, Dr. Petzow received a Ph. D. in materials science from the University of Stuttgart. In 1974, he became an honorary professor of the same university. After serving as the head of the Department of Powder Metallurgy, and head and then managing director of the Department of Advanced Ceramics at the Max Planck Institute for Materials Science, the renowned institute in Germany, Dr. Petzow became Director Emeritus of the same institute in 1994. He is an expert in physical metallurgy, powder metallurgy, various issues in special ceramics, and phase diagrams of alloys and ceramics. He is a recipient of many awards, including the Henry Clifton Sorby Award from the International Metallographic Society.



Ceramics are known for their outstanding strength and light weight. In particular, the fine ceramics that Dr. Petzow has brought into commercial use excel in being assimilated by human tissue and they have been used widely in restorative medicine, for artificial joints and other uses.

Dr. Günter E. Petzow has made significant achievements in materials technology at the Max Planck Institute for Metals Research (one of the 70 plus Max Planck Society research institutes). Studies of powder metallurgy by Dr. Petzow have been applied to various useful devices, including high-temperature turbine blades and artificial joints. Dr. Petzow is the author of numerous important papers and publications on a wide range of subjects, such as phase equilibria between intermetallic compounds, knowledge of peritectic reactions, the constitution and properties of cermets, metallography, high-temperature materials, beryllium and its compounds, liquid phase sintering, particle rearrangement, metallographic etching, toughening of ceramics, Sialon-ceramics, sintering of Si3N4-ceramics, metal-ceramics interfaces and the processing of advanced ceramics. He is the author or co-author of more than 600 research papers and 10 books and the holder of 27 patents.

From the perspective of an expert in materials science, Dr. Petzow warns us that the increase in the demand for materials with the growth in the world's population implies a "looting" of the non-renewable sources on the planet. Spaceship Earth as an economic system thus faces serious problems, he also argues. As a solution to such problems, Dr. Petzow suggests three important approaches: the recycling of materials, the optimization of our use of materials and the development of new materials. Through these approaches, Dr. Petzow emphasizes, we can not only find solutions for ecological issues but also put into use new technologies that have not been possible due to a lack of the appropriate materials.

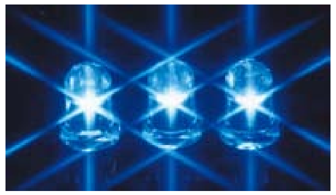
Since its birth, humankind has experienced critical periods of great change, including hunters forming settlements to start farming and the industrial revolution. And now we are at the beginning of a third renovation—ecological renewal. As a tool to successfully achieve ecological renewal, "there is no alternative to technology," Dr. Petzow claims. We must promote advancements in materials science to ensure that technological evolution is on the right track. Then the efficiency with which we use materials will improve, leading to advances in environmental conservation. This is the theory of "ecotechnology" that Dr. Gunter E. Petzow has been advocating in his pursuit of materials science.

"Technological innovation that protects the environment of the Earth."

2000 Honda Prize Laureate

Dr. Shuji Nakamura

Born in Ehime Prefecture in Japan in 1954. After receiving a master's degree from the Graduate School of Technology at the University of Tokushima, Dr. Nakamura joined Nichia Chemical Industries Co., Ltd. While working for Nichia, he invented a practically usable blue LED. Use of LEDs expanded drastically because of their low power consumption and long lifetime. After receiving a Ph. D. from the University of Tokushima in 1994, Dr. Nakamura became professor in the Materials Department of the University of California at Santa Barbara in 2000. He has also served as visiting professor at Shinshu University from 2002 and at Ehime University from 2006. He is a recipient of many awards, including the Millennium Technology Prize from the Finnish government for the invention of the blue LED.



Blue LEDs (Nichia Chemical Industries Co., Ltd.)

A light emitting diode (LED) is a semiconductor diode with high energy-saving features and a long lifespan (semi-permanent). Since its first development in the 1960s, the LED has been used as an alternative light source for fluorescent lights and light bulbs in various devices from traffic lights and cell phone backlights to large displays and DVD recorders. Uses of the LED have been rapidly expanding in our daily life. On the back of this innovation is the development of the blue LED in 1993 by Dr. Shuji Nakamura. Until the middle of the 1980s, out of the three primary colors, only red LEDs could be produced and a yellowish green was the only alternative to green.

Dr. Nakamura was working for a private firm at a time when even the leading semiconductor companies and universities had not been able to develop an LED that emitted blue light. Dr. Nakamura asked the president of the company for the use of the company's resources for this development and to give him an opportunity to study at the University of Florida in the US. The two candidate materials available at that time for an LED that would emit blue light were zinc selenide and gallium nitride, with the former much more popular among researchers for its ability to generate clear crystals. Dr. Nakamura chose the latter because it was unpopular. He did not want to follow everyone else. He first developed an original two-flow metal-organic chemical vapor deposition technique to make high-quality gallium nitride crystals. This invention led him to success in getting gallium nitride, an environmentally sound material, to emit first blue light and then green light. The three primary colors were now available in LEDs.

Even after this breakthrough, Dr. Nakamura kept going and succeeded in getting nitrite to emit short wavelength purple light to replace the conventional red semiconductor laser. This led to the development of a DVD with a large capacity and high resolution. In 2005, in collaboration with a research team at the Tokyo University of Science, Dr. Nakamura succeeded in splitting water into hydrogen and oxygen using gallium nitride and light. This success is expected to lead to another innovation with practical applications.

Specificity of Information Technology

Information technology (IT) was first introduced in the 1950s as the third fundamental concept of the natural sciences to follow materials and energy. In the 1970s, when the discovery of the silicon semiconductor started the drastic advancements in computer technologies, IT innovation also begun.

The most significant innovation in IT must be the birth of the Internet, which is often referred to as the most significant technological innovation since the Industrial Revolution.

The Internet started with ARPANET, a computer network developed by the US Department of Defense. Then in 1986, NSFNet, an academic version of the computer network branched off from ARPANET, linking mainframe computers in universities throughout the world. This allowed information to be shared among scientists and engineers across specific fields and subsequently knowledge building, and the forming of comprehensive, multidisciplinary views.

In 1995, when NSFNet was privatized and Windows 95 was introduced, the Internet became a tool for public use. All existing restrictions were removed, and digitalized information became interactive and able to be shared with real immediacy.

The Internet has had a great influence on the world's economy. From retail shopping to stock trading, a succession of new business models has been introduced. A globalized economy has developed beyond conventional barriers between economic blocs and even regions with different time zones. In our daily life, the Internet has provided us with convenience from many different aspects, while introducing new styles of communication, such as blogs and SNS messaging, as new outlets for self-expression.

The Internet and other forms of IT innovation are so different from their conventional alternatives in nature that the changes brought cover a wide scope of human activities from the values and lifestyles of individual people to whole economies and relationships among nations.

While benefiting our societies in so many significant ways, the rapid advancement of information technologies has started to have adverse effects. The increasing occurrence of psychological problems among people involved in IT is a good example.

A reason for this trend can be explained by the fact that specific tangible outcomes can rarely be seen by IT technicians. Engineers working for automobile manufacturers can see the process and results of their work, and are able to feel they are participating in the whole line. They can even touch the products. But for an IT technician, it is impossible to physically touch the products. They rarely feel the satisfaction of a job completed. It is difficult for them to feel that they have accomplished something. This has had an adverse psychological effect on IT workers.

One problem that has been affecting our daily lives more fundamentally and more widely is the fact that technologies have become "invisible." Unlike the conventional "visible" technologies, research into new materials, nanotechnology, and computerized machine control produces invisible or intangible results.

Today, it is difficult to recognize the extent to which science and technology control our daily life. While enjoying the products of modern technologies, we feel troubled by elements that are blended into our life so adeptly that we can no longer recognize them tangibly. Our lives have changed beyond our expectations and comprehension.

A house is built on empty land. As the number of houses grows, roads are built to connect these houses. The town grows in vitality, with houses, apartment buildings, commercial buildings and others beginning to concentrate. The roads then began to expand and extend with great complexity, swerving between the buildings. Towns that are separated by distance begin to be connected by roads. On these roads, there is movement of motor vehicles and people. Eventually, the telephone is invented, leading to telephone poles and lines being constructed and the birth of a new form of voice communication. Next, the optical cable that is being installed to cover the entire world today is bringing mass digital data exchange, not only of text and still images but also of audio and video. In the mature and highly sophisticated information society of today, where electronic information is exchanged at speeds that are incomparable to personal or human voice exchanges, the current social structure may itself be a giant template of an integrated circuit interconnected by networks.

"Sophisticated high technology must contribute to the conservation of resources and to energy saving in the interests of mankind."

1986 Honda Prize Laureate

Dr. Jun-ichi Nishizawa

Born in Miyagi Prefecture in Japan in 1926. After graduating from Tohoku University School of Engineering, served first as a professor and then president of the university. Was appointed president of Tokyo Metropolitan University in 2005. Dr. Nishizawa has influenced the world of technology across a wide range of fields through development of the PIN diode, static induction transistor and static induction thyristor, as well as through the development of applications for optical communications technology. In 2000, Dr. Nishizawa proposed the use of terahertz waves in the diagnosis and treatment of cancer. Recipient of numerous awards, including the Order of Cultural Merit (Bunka-Kunsho), IEEE Edison Medal and the Grand Cordon of the Order of the Sacred Treasure.

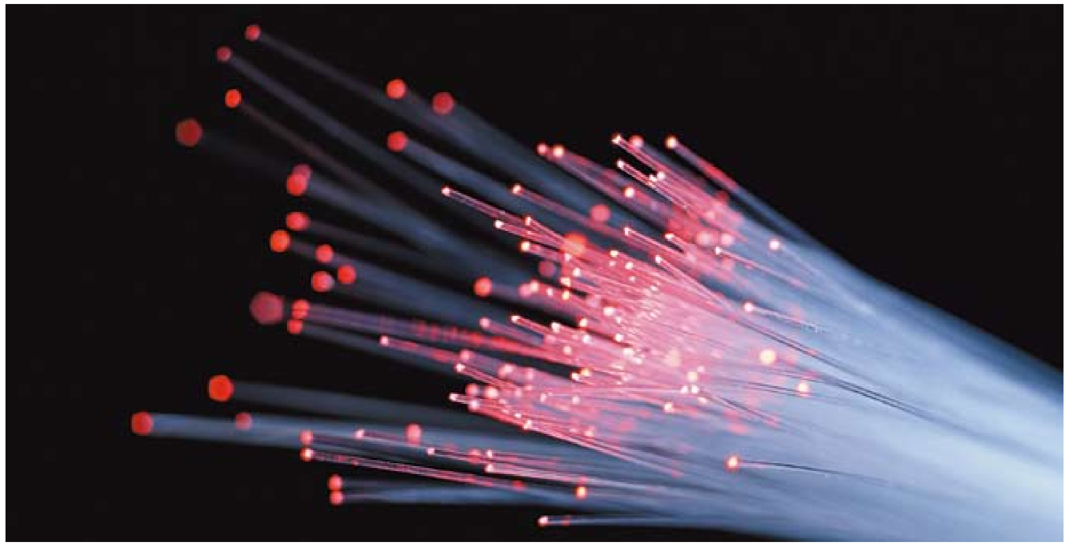
Optical communications have contributed greatly to the foundation of the information-oriented society by allowing high-capacity communication. Three major inventions have made this possible: the photodiode (or PIN diode, an optical sensor that converts light into electrical signals), the semiconductor laser (a light-emitting device that converts electric signals into light), and the optical fiber that carries information in the form of light.

The person responsible for these three developments that complete the framework of current optical communications systems is Dr. Jun-ichi Nishizawa. As his nickname—"Mr. Semiconductor" or "the Father of Optical Communications"—implies, Dr. Nishizawa has carried out unique research projects not only in semiconductor technology, but also across a wide range of other fields. He is an innovator whose achievements still have a great influence in many different fields.

Optical communications has become an indispensable part of our daily lives, and so it is natural to wonder what led Dr. Nishizawa to these great accomplishments in developing the technologies for optical communications. In the early 1950s, when he first started his research into optical communications, Dr. Nishizawa had already hypothesized on the possibility of using a PIN diode (his first research theme and achievement) as the receiver in an optical power detector. He then focused on experiments to amplify microwave pulses using a ruby crystal as the light emitting source. He thought that microwaves could be amplified using this phenomenon, and hypothesized that connecting a source to an external resonator type semiconductor would produce light as a continuous amplified oscillation. In 1957, he published a paper on the semiconductor laser.

When research into optical fiber transmission lines started, techniques to transmit light in space or through any kind of conduit had not been developed. Instead, researchers at that time were attempting to transmit light through copper tubes. However, it was difficult to get copper tubes to serve this purpose. The rough inside surface of a tube contains bumps with a height as large as 0.1 µm. Bumps of this size would bounce back light with a wavelength of less than 1µm, making it very difficult to transmit light. Also, copper tubes were not suited to the mass production of devices.

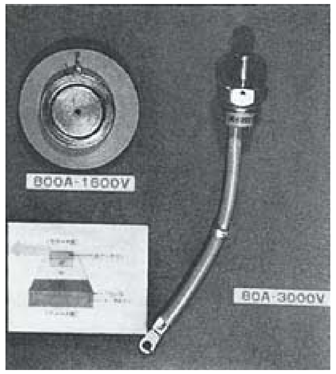
Dr. Nishizawa solved this problem by remembering a technique he had once observed being used to produce glass sculptures. He adopted the technique and used glass fibers to develop a structure that uses the difference between the refractive indices of two different materials. By maximizing the refractive index in the middle of the glass fiber, he was able to prevent light from escaping outside of the fiber. In 1970, he developed a polarizing fiber. The foundations of optical communications were laid down by the innovation and efforts of one researcher.



Optical communications, which forms the basis of today's communications infrastructure, developed from the idea of using the PIN diode (see photo below) that was Dr. Nishizawa's first research project, as a receiver. Later, completion of the transmitter and the optical fiber cable (see photo above) that serves as the communication route made optical communications a reality.

Dr. Nishizawa is distinguishable from the average researcher in recent technological research who tends to pursue a specific theme in a narrow area. His achievements extend beyond the boundaries of academic research. They include practical technologies in a wide range of fields, including the static induction transistor with unsaturated characteristics (the current-voltage characteristics of conventional transistor are saturated) and complete crystallization techniques for semiconductor materials, in addition to the semiconductor laser and the optical fiber technology described here. Dr. Nishizawa has always carried out his research with a sense of responsibility to society—how the new idea or technology can be of practical use in helping people. Born in Japan, where natural resources are very limited, Dr. Nishizawa believes that new technologies should benefit people and contribute to the survival of the human race.

In line with his own principles, Dr. Nishizawa developed a semiconductor device with a 99% efficiency in converting direct current to alternating current. He suggested using this development in hydropower generation and direct current transmission as a means of meeting the world's electricity demands from as far back as 1986. When electricity is transmitted as direct current, instead of as alternating current as in the conventional method, long-distance transmission (approximately 10,000 kilometers) can be achieved over the cables currently in use. If we can meet the global demand for electricity with hydropower generation (i.e., with renewable energy), eco-technology will have made a significant contribution to global society and global energy issues.



"Tackling substantive fuzzy problems will produce a humane technology."

1989 Honda Prize Laureate

Dr. Lotfi Asker Zadeh

Born in Baku in the Republic of Azerbaijan in 1921. After studying electrical engineering at the University of Teheran and the Massachusetts Institute of Technology, he received a Ph. D. from Columbia University in 1949. Dr. Zadeh was a professor at the University of California at Berkeley from 1959 to 1992. He made a great contribution to studies on z-transformations for the analysis of discrete signals. In the 1960s, Dr. Zadeh introduced his fuzzy theory, allowing quantitative expression from existing qualitative languages. Dr. Zadeh's innovations have been applied to various fields, making our information-driven society more human.

This is a subway car on the Nanboku Line in Sendai, Japan—an example of a controller that employs the fuzzy logic. The system has been able to achieve smooth and efficient propulsion and stopping comparable to a human operator. The system has been able to reduce the amount of electric power consumed by several percentage points. (Source: Sendai City Transportation Bureau)

In our everyday conversation, we encounter a number of fuzzy expressions. To gain an understanding of sentences that include fuzzy expressions, just as when fine-tuning a machine, we all use our experience, intuition and "fuzziness," a very human way of information processing. Dr. Rotfi Asker Zadeh proposed "fuzzy logic" in 1965, and this proved to be a first step in applying the theory to machines and computers. In fuzzy logic, any event can have a value between 0 and 1, as opposed to only 0 or 1 as is the case in conventional logic systems. That is, fuzzy theory is a model of thought patterns that are very close to the natural system of thought of the human brain, which is intrinsically fuzzy and has been thought impossible to express with numbers or equations.

In fuzzy logic, (1) truth values are allowed to be fuzzy sets labeled "true," "more or less true," and so on; (2) the quantifiers such as "most," "few," and "usually" are interpreted as fuzzy numbers which serve to describe the absolute or relative cardinalities of fuzzy sets; (3) fuzzy utilities in fuzzy logic are computed by using the connection between fuzzy probabilities, such as "likely" and "unlikely" and fuzzy quantifiers; (4) the role played by hedges such as "very" and "more or less"—a role that conventional natural language cannot deal with—can be dealt with by interpreting them as operators which act on fuzzy predicates.

Thus, fuzzy logic comes much closer to serving as a descriptive model of human reasoning than traditional logic systems. In this way, fuzzy logic opens the door to many applications that fall beyond the reach of conventional logic-based methods as well as methods based on classical probability theory. Successful applications of fuzzy logic have been seen in a wide range of industrial and other areas, including automatic control systems for trains, land management systems, tunnel drilling machines, cranes, incineration plants, and semiconductor manufacturing equipment. When fuzzy logic was first introduced, aside from a small group of scientists who were enthusiastic about it, the majority of researchers with their traditional respect for what is quantitative and precise were skeptical. Today, 40 years later, the controversy surrounding fuzzy logic has not disappeared completely. However, it is now an undeniable fact that this innovation plays an indispensable role in our daily lives.

Respect for Humans: Always the Center of the Discussion

Why have science and technology started to have adverse effects in modern society, against their primary purpose of making people happier? There is no way to pin down the exact reason. But when we see the trend of the whole movement, we can at least say that the unexpected speed of advancement of science and technology in our time has exceeded the ability of people and whole societies to catch up and regain control.

How can we solve this problem? The key is in our history. We have to look at how people dealt with technological innovation in the past.

When the speed of scientific and technological advancement exceeded our expectations, we took an unwanted approach—i.e., we accepted a relationship in which people attempted to adapt themselves to science and technology. This relationship has caused confusion, estrangement and isolation. What is needed in modern society is to stop our struggle to catch up with the ever-accelerating advancements in science and technology. Instead, we must rebuild the scheme to use science and technology to adapt to the needs of its users by embracing the concept of human engineering.

We will then encounter new problems. We have to find a way to bring innovation to our social systems in order to deal with ever-advancing technological innovation. This problem exists within society itself. When society is forced to change against its will due to advancements in science and technology, it will be the members of that society, i.e., people, who suffer. To prevent this suffering, we have to analyze the structure of society itself as a system from the technological aspect and introduce innovations to keep pace with the innovations in science and technology. The most important thing in this is to hold onto our respect for people. We should not bring about any changes that may coerce people to change against their will.

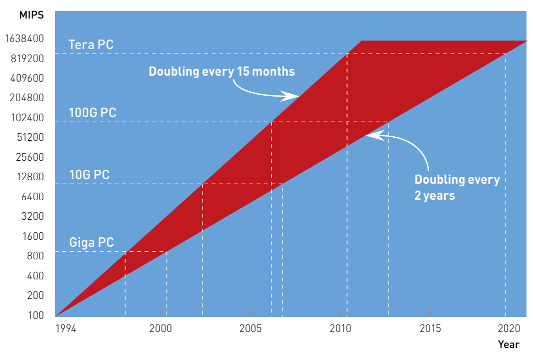
This position is most important for those who are directly involved in social systems innovation—i.e., policymakers, as well as the representative scientists and engineers who serve as potential advisors to the policymakers. Firstly, these leaders must change their views, but that is not enough to bring real innovation to our social systems. Each of us ordinary citizens, members of society, must recognize the problem of how to adapt our societies to meet the changes.

In today's world, many products of science and technological innovation, such as materials and information, have been transformed from something visible and tangible to something invisible and intangible. This trend places more significance on the role of scientists and engineers who are at the frontline of technological innovation.

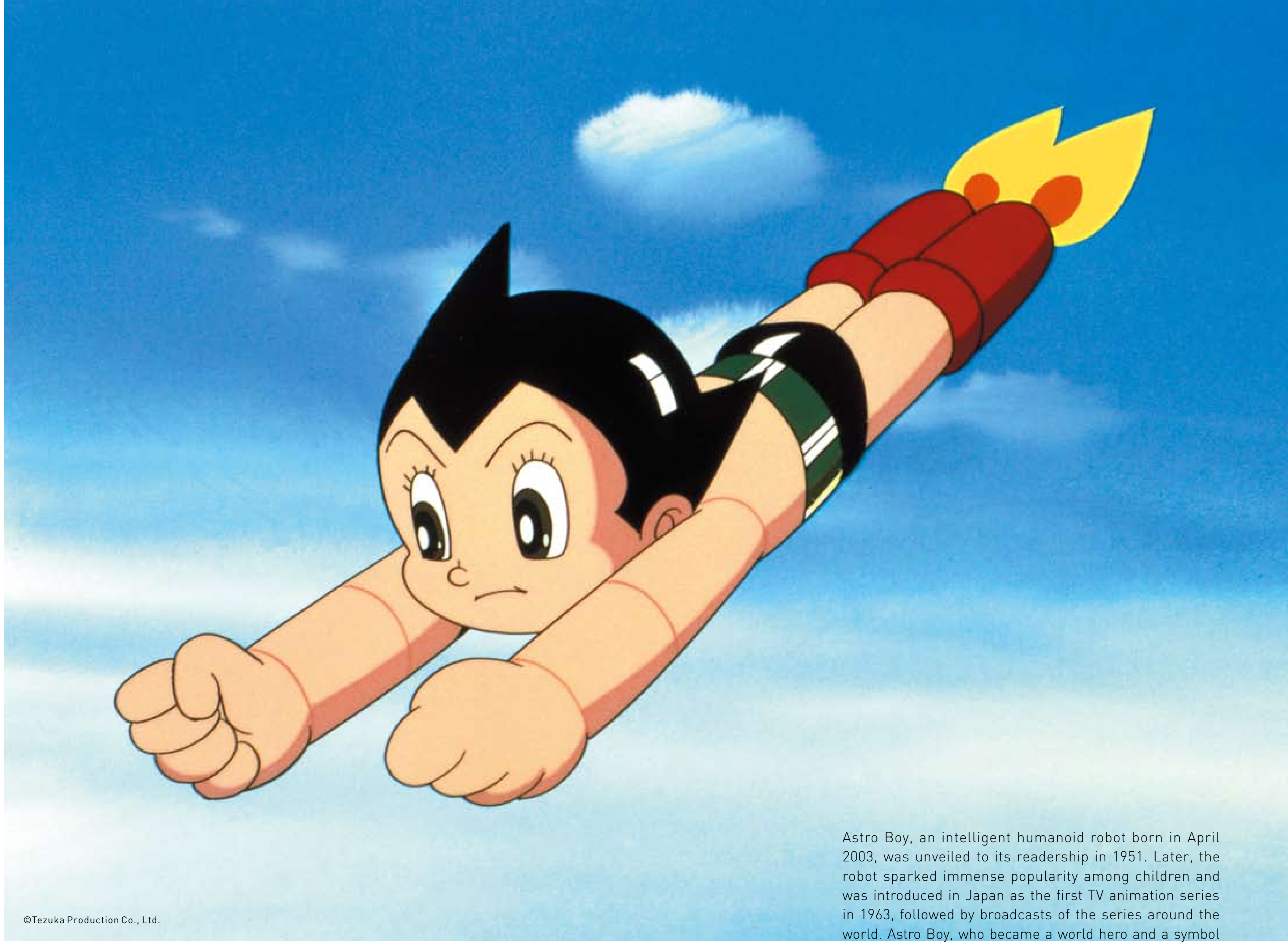
Scientists and technologists must keep evaluating, adjusting and improving a number of the products of rapid technological innovation in the light of the aims of human engineering. It is more important now than ever before because science and technology, the centerpiece of our modern societies, is increasingly becoming invisible.

However, when seen from a different perspective, this means unlimited expansion of the horizon dreamt of by scientists and engineers, including a better relationship between society and people, will be right in front of our eyes in the coming years.

Exponential Growth Trends in Computer Performance



Underlying most of the advances in robotics and intelligent systems is the unprecedented exponential improvement in information technology. In 2000, as predicted, we saw the arrival of a giga-PC capable of a billion operations per second, a billion bits of memory and a bandwidth of one billion bits per second, all available for less than two thousand dollars. Barring the creation of a cartel or some unforeseen technological barrier, we should see a tera-PC by the year 2015 and a peta-PC by the year 2030.
The question is what will we do with all this power? How will it affect the way we live and work?
(From the commemorative lecture at the 26th award ceremony for the Honda Prize in 2005: "Robotics and Intelligent Systems in Support of Societal Needs")



Astro Boy, an intelligent humanoid robot born in April 2003, was unveiled to its readership in 1951. Later, the robot sparked immense popularity among children and was introduced in Japan as the first TV animation series in 1963, followed by broadcasts of the series around the world. Astro Boy, who became a world hero and a symbol of a bright future realized by scientific progress, has been portrayed by its creator Osamu Tezuka like this: "In Astro Boy, I wanted to express how science and technology, which pursue progress without paying much heed to nature and human values, will bring fissure and deviations in society, breeding discrimination and wantonly harming human life, as well as the lives of other creatures. What will happen if advanced technology, including robotics and biotechnology, goes out of control? The theme was that technology, which aimed to bring happiness, might actually trigger extinction and that it is actually starting to happen." (Save Our Mother Earth, 1996)

"These advances will transform the way we live, learn, work and govern ourselves. Such capabilities can be used to further increase the gap between the haves and have-nots, or to help the poor, the sick and the illiterate."

2005 Honda Prize Laureate **Dr. Raj Reddy**

Born in Andhra Pradesh in India in 1937. Graduated from the University of Madras in 1958. Served as professor of computer science and became the first director of the Robotics Institute at Carnegie Mellon University in the US. Dr. Reddy is currently the Mozah Bint Nasser University Professor of Computer Science and Robotics at the School of Computer Science, Carnegie Mellon University. His research into robotics, intelligent systems, human interfaces and other areas have contributed greatly to a range of fields, including education, medicine and welfare services. He has received a number of awards, including the Légion d'honneur from President Mitterand of France and the Padma Bhushan from the President of India.

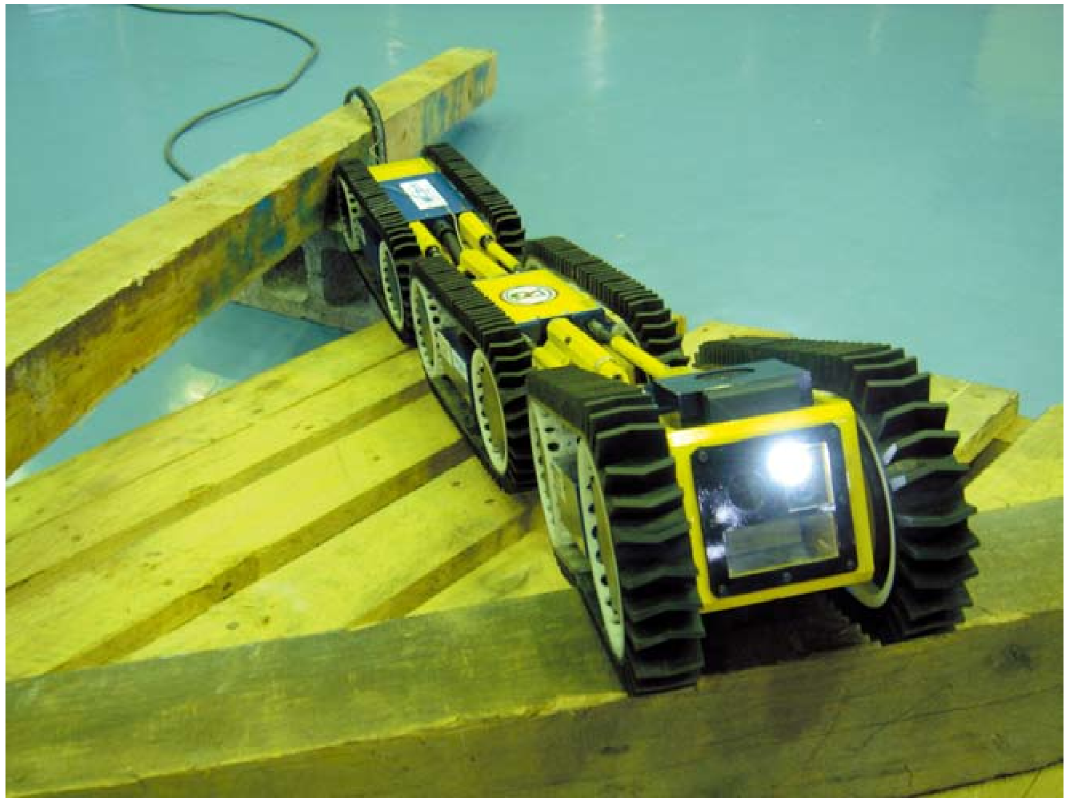
Dr. Raj Reddy, a world leader in computer science and robotics, has always been involved in state-of-the-art research and made great contributions to studies of the human interface, artificial intelligence, speech and vision and other areas. In 1979 he established the Robotics Institute at Carnegie Mellon University and became its first director. With his efforts to invite and train many experts from universities and corporations from every corner of the globe, the institute has now become a world-leading robotics research center with more than two hundred researchers.

Over the past 50 years, robotics and intelligent systems have made great advancements. Underlying most of the advances are exponential improvements in information technology that have produced personal computers working at megaflop and then gigaflop speeds. It should be only a matter of time before we witness the introduction and commercialization of personal computers working at teraflop and petaflop speeds. Once, the main purpose of robotics and intelligent system was to provide solutions to specific technological problems. But with the exponential advances in information technology, the implications have changed radically. Applications of the robotics research lead by Dr. Reddy have been global in their extent, resulting in extensive systems and solutions that greatly affect our lives.

Examples of applications of Dr. Reddy's research into robotics and intelligent systems include: (1) robots that can care for the elderly in aging societies all over the world, (2) rescue robots that can work in disaster situations that are too dangerous or inaccessible to humans, (3) speech and reading tutors that can support the illiterate with advanced speech recognition and synthesis technologies, (4) computer vision and intelligent cruise control to prevent traffic accidents, improve fuel efficiency and reduce driver fatigue, (5) computer systems that enable the illiterate to use voice mail and other functions, (6) digital libraries where anyone can access archived publications, and (7) artificial intelligence to resolve the rural digital divide, such as expert systems and knowledge based systems that can be used in medical diagnosis and therapy applications. From among these applications, Dr. Reddy believes that digital libraries offer the highest prospects. "We can expect digital libraries to become the most used ecotechnology of all," he said in his commemorative lecture at the Award Ceremony for the 26th Honda Prize, citing a collaborative project among several countries, including the US, China and India, which is aiming to finish digitalizing one million books by 2007.

And these technologies will not end in a pipe dream. Challenges, such as the cost of making them available to wider communities, the difficulties of dealing with languages (including technologies that can successfully handle local dialects and the natural speech of children), and the need for a simplified interface to allow wider usability, will be overcome. For a number of these technologies, it is only a matter of time.

Dr. Reddy insists that robotics and intelligent systems will make dramatic advances over the next fifty years. His research is based on the belief that the capabilities of robotics and intelligent systems should be shared equally regardless of nationality, language, age, gender or economic status. Dr. Reddy concluded his commemorative lecture by saying, "It is my hope that the Honda Foundation will lead the way to create eco-technologies for a 'compassionate world in 2050'!"



Robots with artificial intelligence that can provide assistance with tasks that require human skills and behavior are being experimented with and commercialized in a wide range of applications. Shown above is the IRS Soryu of Japan's International Rescue System Institute. It supports exploration and rescue in disaster areas that people cannot enter and was used for field studies in the 2004 Chuetsu Earthquake in Japan. Below is a computer designed for people who cannot read, who will be able to use the computer's audio input to send emails, and in this way the system contributes to filling the digital divide. (Photo: Shigeo Hirose [Tokyo Institute of Technology]/International Rescue System Ins Institute)

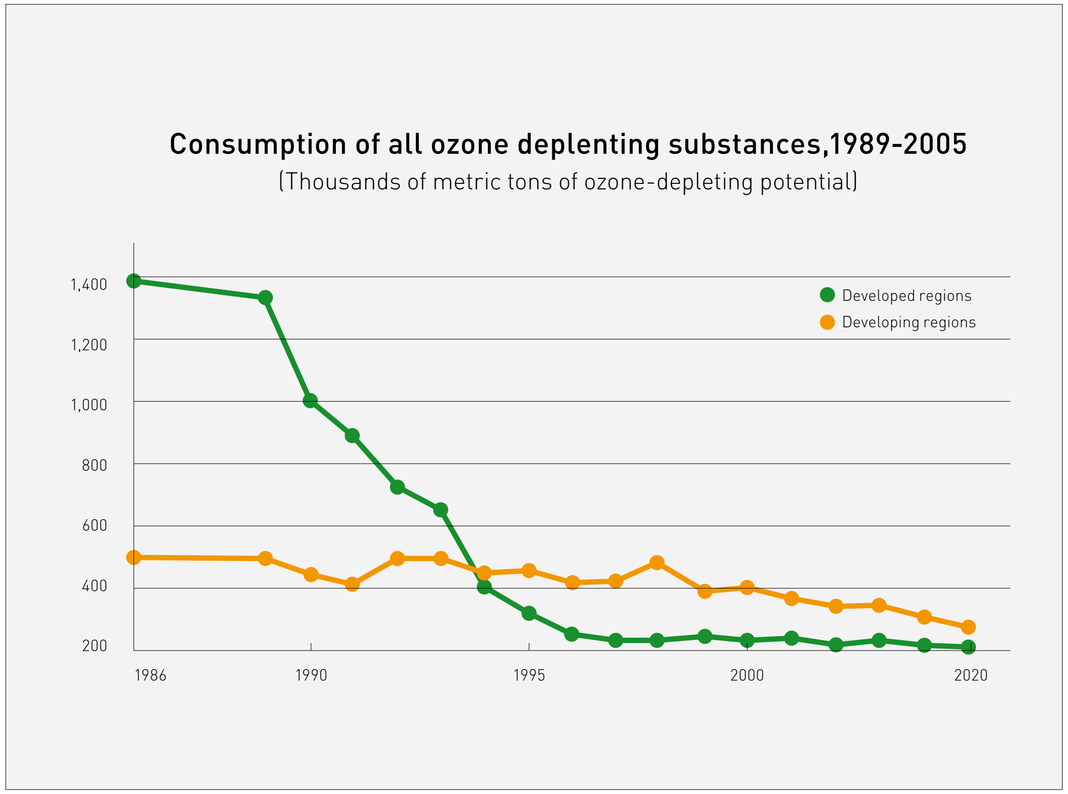
"I have dreamed of a society in which people from different countries, irrespective of the difference in the pace of progress in their respective country, cooperate with each other, advance at their own pace, and lead happy lives."

2006 Honda Prize Laureate **Dr. Richard R. Nelson**

Born in the State of New York in the United States in 1930. After graduating from Oberlin College, he studied at Yale University, earning his Ph. D. in 1956. He served as professor of economics at Yale University from 1968, director of the Institute for Social and Policy Studies at Yale University from 1980 and professor at Columbia University from 1986. He has been professor emeritus at Columbia University since 2005. He is widely known for his research into innovation in technologies and social systems, having substantial influence on industries, the economic world and many other areas. He is author of numerous papers and books, including *An Evolutionary Theory of Economic Change.*

Dr. Richard R. Nelson was the first economist to focus on the roles of advances in technology and innovations in society on the growth and decline of industries and the economy. The question first struck him when he was studying in graduate school at Yale University. What produces the differences in economic growth between different countries? Many countries saw enormous improvements in productivity and standards of living from the late 18th century to the middle of the last century, but others did not. Some nations grew quickly and continued to prosper, and some had just started to grow, while others lagged behind in poverty. What makes this difference? He started studying the process of economic growth and soon realized that technological innovation had never been a subject of study in modern economics. This notion led him to a year studying engineering at the Massachusetts Institute of Technology, where he developed a keen interest in engineering. He eventually reached the conclusion that technological innovation is the actual driving force behind the past two centuries of enormous improvements in productivity. That is, technological innovation, or the process of technological advancement, cannot be ignored in a fuller understanding of the process of economic growth. In 1982, his magnum opus, *An Evolutionary Theory of Economic Change*, was published.

The theory had enormous influence on healthy development and social revolution in the developed and developing countries. By now, innovation has become a keyword in the activities of many nations and corporations across the world. The trend may well be reflected in the number of academic papers in sociology and science published with a title that includes the word "innovation." According to a study by Dr. Nelson, the number of these papers stayed relatively unchanged from 1970 until 1991, when it started to increase drastically. Many factors may have been responsible for these changes. Information and communications technology has advanced rapidly. Globalization has advanced as well. New business models have been established on a global scale. Industrial competition between players in different parts of the world has started. Now innovation is needed, not only to pursue research and development in individual private corporations, but to solve problems on a global scale in various areas, including the environment, resources and energy. The problem of ozone layer depletion may be one good example. When the movement to restrict the use of chlorofluorocarbons gases started, many governments opposed it. But as CFC-substitutes were quickly made available, the opposing countries were willing to include the CFC regulations in their respective policies. That is, a set of enabling technologies made possible implementation of the CFC regulations against ozone depletion. Innovations in science and technology worked effectively for environmental conservation and health development in our societies.



Since the threat to the ozone layer was identified, emissions of ozone depleting substances (ODS) dropped dramatically from 1.5 million tons in 1989 to 89,000 tons in 2005. (Chart: United Nations)

Pakistan has one of the lowest literacy rates in the world (41.5%, according to UNESCO statistics in 2004), and resolving this problem is a major issue. A Christian nun teaches at a school in Karachi, the largest city and state capital.

Dr. Nelson identifies a "society in which people from different countries, irrespective of the difference in the pace of progress in their respective country, cooperative with each other, advance at their own pace, and lead happy lives" as the ideal society. To achieve this goal, we must focus on how to lift the intellectual level of the entire society, Dr. Nelson argues. By providing universal access to quality education, governments will be able to adopt innovative policies supported by the understanding of the majority. That in part explains Dr. Nelson's warning against the Bayh-Dole Act, which the US adopted in 1980 to allow universities to own patents for government-funded innovations. The monopolizing of specific research results of a highly public nature can be a threat to the development of science, he argues.

Message from Honda Prize Laureates

It is an undeniable truth that science and technology will bear increasingly greater importance in the 21st century. Represented by the environmental problems of today, human society is being imperiled by unforeseen threats. The consumption of resources that began with the Industrial Revolution reached a frightening high before we realized what had happened. This has raised concerns that the results of our endeavors may cause serious harm to our children and their children.

Action to address the issues has finally begun today, with scientists at the vanguard. However, this is just an example. Threats to peace in human society are emerging one after another. Not only do we continue to see war and killings as we had seen in the earlier century but we face new threats to individuals, such as 0157 E. coli, SARS and anthrax.

The fundamental principle of science is demonstration of proof. However, unforeseeable threats that emerge in the future should be predicted but not demonstrated, since demonstration means death. We scientists and engineers must deploy science and technology for early eradication of the roots of disaster without imposing any more burden on humankind.

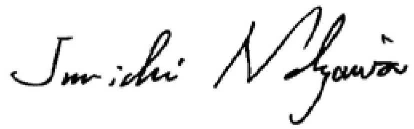
These threats are certainly the dark side of the 21st century and must be stopped by the scientists. At this time we need scientists with wisdom founded on compassionate human love. Without a sense of responsibility to prevent all prospective problems whatsoever in one's area of specialization, it must be extremely difficult for humankind to survive through the threats and crises that are expected to break out successively.

I myself have been working for more than 20 years to carry on the knowledge of our predecessors in addressing global warming that has become a global concern. At the OPEC meeting in Cypress, I submitted a proposal for connecting hydroelectric power plants using direct-current power transmission as an alternative source of energy. This idea, which drew no response at that time, has earned praise from many today. What we have left is to work on full-scale propagation. Moreover, production of vegetable-based alcohol by fermenting corn will only aggravate the problem of food shortages that can be said to have already started. We must urgently speed up our action. It is certain that there is much that we must do.

The achievements that the Honda Foundation has realized over the past 30 years were the product of the hard work and talents of Mr. Soichiro Honda. If Mr. Honda had been where we are today, what would he have done? Looking at myself, I must not forget to ask myself whether what I am doing now is truly adequate.

Jun-ichi Nishizawa

7th Honda Prize Laureate, Japan



Life Frontier

Life Sciences and Ethics

Globalization of Life

The Potential of the Science and Technology in Protecting Life

Science and Personality

In accordance with the progress of science, a spectrum of innovative technologies has been developed in the life sciences. In particular, in the most advanced field in the life sciences represented by genetic engineering, humankind is touching on the realm of God and is about to explore the mysteries of life. For the 30 years since the birth of the Honda Foundation, the results of research into immune systems and gene engineering have been utilized at medical and clinical institutions, in applications that include organ transplantation and genetic treatment, beyond their use in the academic world. In Chapter 4, the progress and possibilities of science and technology as well as the dignity of life will be examined from the viewpoint of ecotechnology.

Life Sciences and Ethics

During the 20th century and at the beginning of the 21st century, life sciences and medicine have experienced a variety of innovations. As a result, the changes in science and technology are now more closely linked to our society and the environment that surrounds us.

For instance, the potential for organ transplants as a medical practice, a procedure in which for centuries the medical world has been seeking success through trial and error, has recently heightened. The discovery of HLA has solved immunological incompatibilities in transplanting organs, the largest obstacle to the procedure, and made it into a medically practicable matter. Organ transplants have thus developed into a "technology."

Development of such medical technologies alone cannot produce a practicable medical procedure, were it not for agreement on social and ethical issues.

The cloning of Dolly the sheep in 1997 has been treated as an ethically controversial issue. The technology to plant a cell nucleus taken from a donor animal into a foreign recipient's embryo after removing the nucleus can be adopted in procedures with humans. While the cloning technology develops rapidly, no agreement or conclusion has been reached on the argument: is it acceptable for science and technology to create humans that share the same gene sequences asexually?

Studies of gene analysis ("genomics") started in the 1990s and have made great achievements at unexpected speeds. The gene sequences for many different species are now known, due to the collaboration of scientist all over the world. Now scientists are focusing on the study of "proteomics"—analysis of the mechanism of protein production from amino acids.

Embryo stem (ES) cells have been attracting attention both for their potential and also because of the ethical problems. ES cell technology has many potential applications in regenerative medicine because of its almost unlimited potential in theory to develop into any kind of tissue ("omnipotence"). When propagated, ES cells may be used in regenerative medicine to form various organs, nervous tissue and artificial skin. With this potential, ES cell technology also brings certain ethical concerns because ES cells are produced from embryos. How to ethically treat the "life" of embryos has been discussed but no agreement has been reached. Meanwhile, the technical skills needed have been developed in many countries in the world.

The advancement of technologies in the life sciences holds great potential to provide many people with happier lives. At the same time, it brings the social and ethical issues of how to define "life"—the attribute that makes each of us a human.

Then should we stop all progress in the life sciences until we find the answer? The answer is clearly "no." Life sciences should maintain their progress regardless of these concerns. We can find the reasons in recent history. In the latter half of the 20th century, we believed that science, including the life sciences and the development of medical technology, would form the basis to produce technologies that would bring us happiness under any conditions. When industrial development progressed, however, various kinds of pollution occurred, damaging the environment. Restoration of the environment has now become possible because of the new science and technologies.

The problems and defects brought about by technology must be solved by technology. Thus, those involved in the life sciences and medical science can no longer stay in their ivory towers.

Any attempt by the life sciences and medical technology to regulate life, the source from which human dignity stems, must be carried out in a socially and ethically sound manner, in harmony with the environment. How we should proceed with this is a question that everyone involved in medical services must answer, and they should do so while seeking a consensus with those who receive the benefits of the life sciences and medical technology.

Dolly, the world's first ewe cloned from an adult mammal cell

When it became known in 1997 that a sheep with a genetic makeup identical to its parent had been born seven months earlier at the Roslin Institute in Scotland, the shock reverberated throughout the world. Dolly, who died six years later in 2003, was given life through technology that transplanted the nucleus of a somatic cell into an embryonic cell. Dr. Ian Wilmut who led the research project has stated that the possibility of human cloning is "technically feasible," suggesting that biotechnology has entered a new phase. This is an issue that continues to be debated to this day.

Photo: The Mainichi Newspapers Co., Ltd

"Each and every person is one and only."

1987 Honda Prize Laureate

Dr. Jean Dausset

Born in Toulouse in France in 1916. After earning an M.D. from the University of Paris in 1945, served as professor at the University of Paris and Collège de France (from 1977). In 1982, founded and became president of the Universal Movement for Scientific Responsibility (MURS). Also served as director of the Research Unit on Immunogenetics of Human Transplantation, Institut National de la Santé et de la Rechetche Médicale, and co-director of the Oncology and Immunohematology Laboratory and the Centre National de la Recherche Scientifique among others. Has received numerous honors and awards, including the Nobel Prize in Physiology and Medicine (1980) and Légion d'Honneur (1984).

The name of Dr. Jean Dausset became known to the world when he discovered human leukocyte antigen (HLA)—the "blood types" of leukocytes. There are many types, and numerous possible combinations. The discovery of HLA, one of the most important tissue matching antigens, had significant meaning not only in terms of his fame but also for the advancement of medical science in the ensuing years.

The discovery of HLA has contributed greatly to predictive medicine. People who have the HLA-B27 antigen are expected to have a 600 times higher risk of developing ankylosing spondylitis than those without the antigen. Predictive medicine has become a field of medical science that serves as the precursor to preventive medicine. Then the discovery of HLA opened the door to organ transplants. The tolerance of the HLA system can be used to identify compatible donors, serving as a base for the development of organ transplants into a practical medical procedure.

In 1984, Dr. Dausset founded the Centre d'Etude du Polymorphisme Humain (CEPH, the Human Polymorphism Study Center in English) with the aim of completing genetic maps and physical maps of the human genome. In other words, the center was founded to pursue the aims of medical science in the 21st century: to identify disease-causing genes for the prediction and prevention of disease. But Dr. Dausset warns us: "It is an illusion if someone thinks that scientists can build a kingdom." This represents the responsibility of scientists very well.

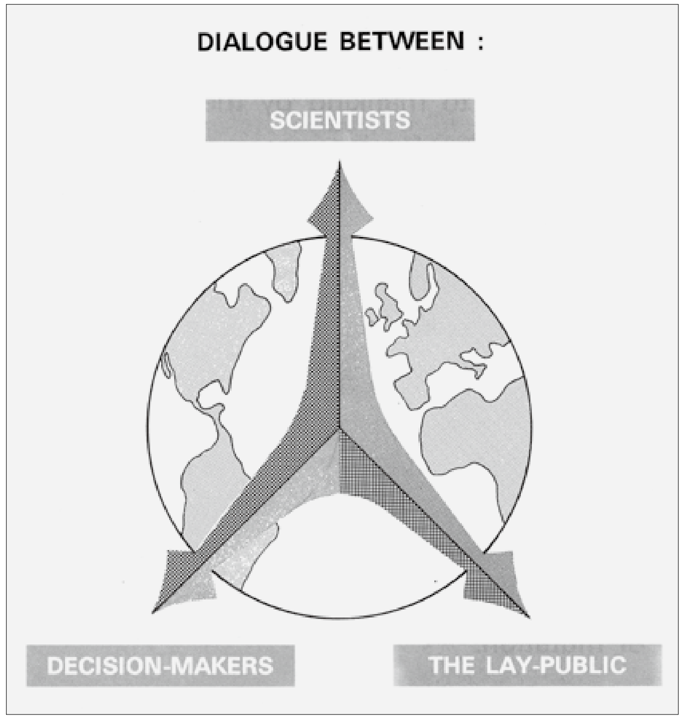
One responsibility of scientists is to expand the extent to which certain knowledge is known—that is to disseminate the knowledge and information possessed by scientists to the public at large. When doing this, it is also important for scientists not to limit that information to the scientists' own "pipe dreams." They also need to tell the public about the risks that come with new technology in the medical and other fields of science. Equally, it is very important to keep processes democratic. Scientists must carry out their studies, especially in the life sciences, based on human ethics.

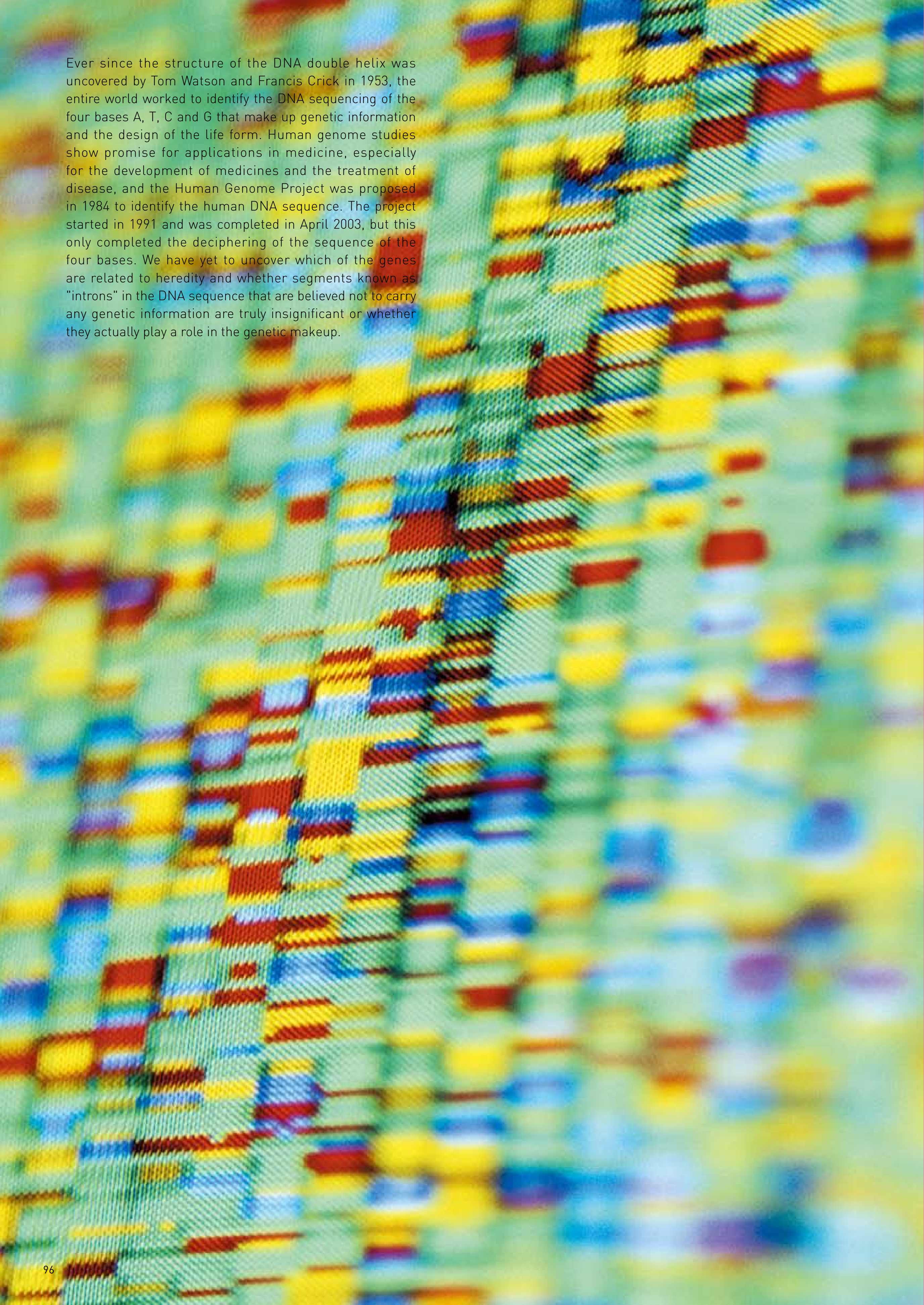
Dr. Dausset is a supporter of somatic cell gene therapy, a therapeutic method to use DNA for non-germline cells. For example, specific genes causing abnormal conditions (i.e., disease) can be replaced with the genes for normal conditions. By injecting nude genes from a harmful factor into the body of a patient, the physician can induce immunity to that factor in the patient, preventing development of the disease.

But Dr. Dausset is against genetic therapy using germline cells, more specifically the kinds of therapy that introduces genes into reproductive cells (embryos), because the introduced gene is passed down to the next generation in the form of life. Dr. Dausset argues that "each person has a specific 'bar code' made up with HLA systems. Each and every individual human has a different combination of genes. Nobody—in the past, present or future—is genetically identical. Each and every person is one and only." That is the unique trait of each irreplaceable person, and respect for others is possible only because of the unique traits of each person, Dr. Dausset argues. For Dr. Dausset, the practice of medicine that goes against human dignity is as immnral as human cloning with the purpose of reproducing copies of human beings.

Dr. Dausset claims that the responsibility of scientists is not limited to the area of medical science, but falls on society at large. This is at least partially because the field of medical science can no longer exist within the field itself. Today life ethics is an issue for every member of society. To this end, Dr. Dausset's achievements that cover the responsibility of scientists and ethics and the life sciences is an important marker for ecotechnology in the 21st century. It is noteworthy that Dr. Dausset, a scientist who changed the study of immunology from its very foundation and led the study of the human genome, is also an avid supporter and promoter of the fine arts and founder of an avant-garde art gallery that opened in 1945.

Universal Movement for Social Responsibility (MURS) organized in 1982 at the urgings of Dr. Dausset is aimed at creating a "trilogue" among scientists, decision-makers and the lay public. Scientists should inform the general public. Public opinion will thus be able to alert the decision-makers in order to make use of scientific progress for the benefit of mankind.



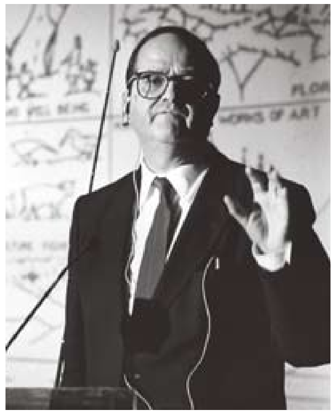


Ever since the structure of the DNA double helix was uncovered by Tom Watson and Francis Crick in 1953, the entire world worked to identify the DNA sequencing of the four bases A, T, C and G that make up genetic information and the design of the life form. Human genome studies show promise for applications in medicine, especially for the development of medicines and the treatment of disease, and the Human Genome Project was proposed in 1984 to identify the human DNA sequence. The project started in 1991 and was completed in April 2003, but this only completed the deciphering of the sequence of the four bases. We have yet to uncover which of the genes are related to heredity and whether segments known as "introns" in the DNA sequence that are believed not to carry any genetic information are truly insignificant or whether they actually play a role in the genetic makeup.

"Life science should lead to a better understanding of what each of us is."

1988 Honda Prize Laureate

Dr. Paolo Maria Fasella



Born in Rome in Italy in 1930. After receiving an M.D. from the University of Rome in 1954, pursued his career in various positions, including as professor at the University of Parma (from 1968) and at the University of Rome (from 1971). Starting in the 1980s, made substantial achievements as leader of various international projects, including the EUREKA program (for cooperative development of advanced technology in Europe) and the Human Frontier Science Program (a program lead by the Japanese government). Served as president of the European Molecular Biology Conference and president of the International Union of Biological Sciences (IUBS).

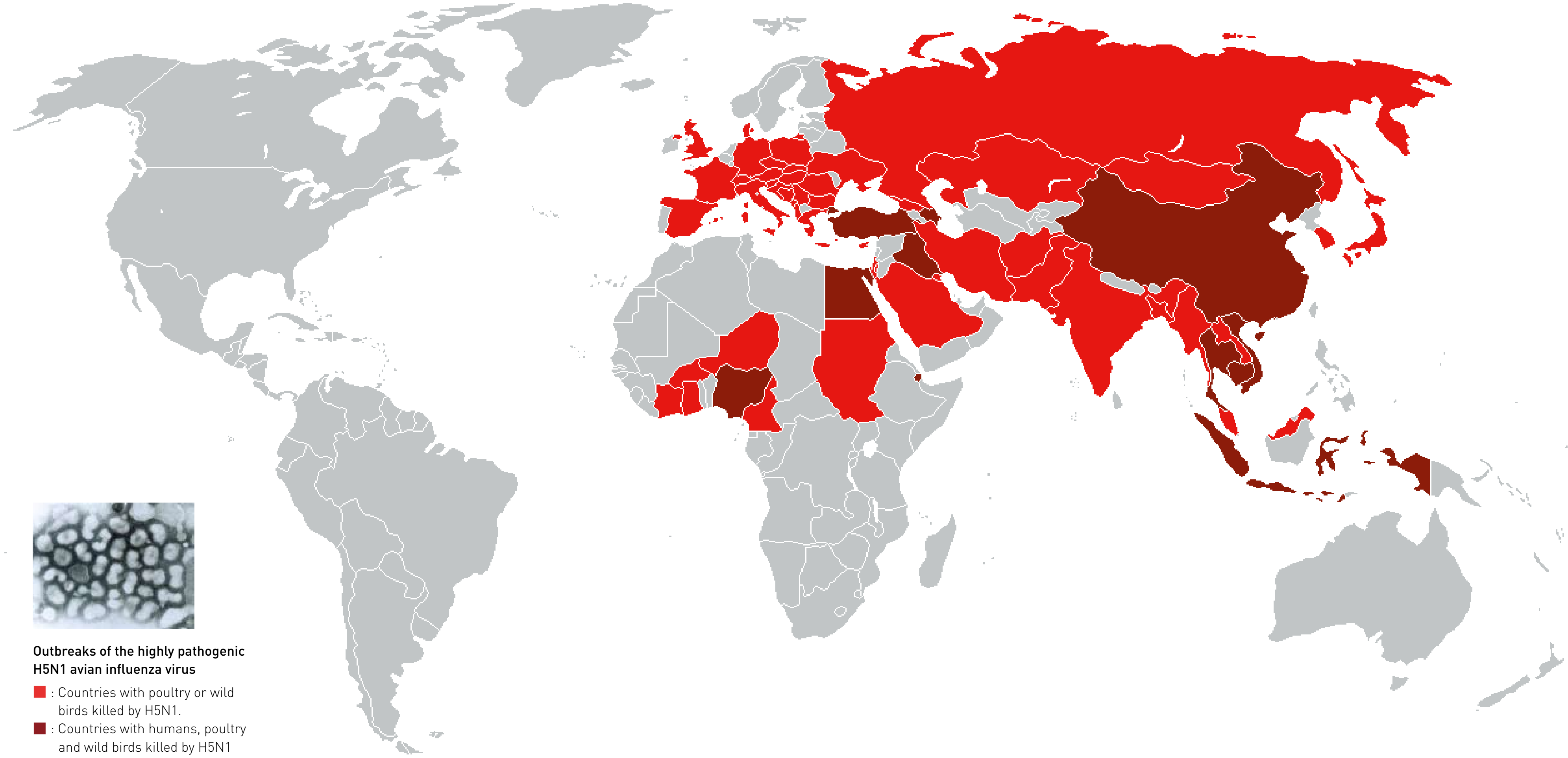
Professor Paolo Maria Fasella contributed greatly to the harmonious development of man and science through his role as a leader in cooperative programs for the development of advanced technology with life science as a foundation. In life science, he was a distinctive leader in genome studies. Specifically, Professor Fasella was responsible for the technical steps for sequencing genomes: (1) genetic mapping, (2) physical mapping, (3) production of DNA fragments of decreasing size, (4) sequencing small DNA fragments, (5) data treatment, (6) development of sequencing technology, (7) molecular rules governing structure-function relations, and (8) application to medicine, agriculture and industry.

Professor Fasella also developed biological information technology focused on neuron synapses in the brain. He focused on the mechanism of the human brain, where information is treated through a series of highly nonlinear steps with more than 10^{11} synapses, and where learning and memory occur through adaptive changes in cells. Based on these studies, he suggested the possibility of a "neurocomputer," a computer system that can learn by itself, by transferring intelligence, feeling and awareness into technology. For Professor Fasella, for technology to be "intelligent" did not mean that it is able to play a game of chess with a human. For him, it meant to have human-like intuition.

Professor Fasella argued that international cooperation is essential for complex and large-scale research projects, especially in genome analysis and in the development of a neurocomputer. As a symbolic case where international cooperation is required, Professor Fasella took the example of the battle against global warming. That is a prime case that cannot be solved without promoting scientific approaches in a globally comprehensive way, Professor Fasella argued. Reforestation and reduction of CO_2 emissions, for example, consist of very complicatedly intertwined factors, and to pursue conservation of the global environment, these factors needed to be untwined on a global scale. The issues regarding the conditions of Spaceship Earth are issues for all scientists throughout the world. That is a significant suggestion for ecotechnology.

Globalization of Life

The highly pathogenic H5N1 avian influenza virus that swept Southeast Asia in 2005 has been confirmed also in Europe and Russia, triggering a world crisis. There have been at least 30 new contagious diseases in the past 30 years, including Ebola hemorrhagic fever in 1976, AIDS in 1981 and SARS in 2003. Globalization has spurred widespread infection, pushing the world into a new phase in the eradication of disease. (Source: WHO)



Outbreaks of the highly pathogenic H5N1 avian influenza virus

■ : Countries with poultry or wild birds killed by H5N1.

■ : Countries with humans, poultry and wild birds killed by H5N1

Globalization is not limited to the worlds of politics and economics. Now, even in the life sciences, a globalized view—globalism—is necessary when seeking solutions to problems.

Medical science spent the first half of the 20th century battling infectious diseases, and in the last half of the century, many infectious diseases associated with the digestive system were successfully treated. With the development of penicillin and other antibiotics, it appeared that many diseases of the respiratory system could be treated. Later, however, species or strains of infectious microorganisms, such as the O-157 strain of E. coli, Staphylococcus aureus and Campylobacteria bacteria, which had not so far made an appearance in our catalog of diseases, started to appear, bringing epidemics. In addition, new viruses such as HIV have been causing new types of infectious diseases, threatening people across all international boundaries.

The rapid spread of infection is closely linked with the sweeping development of transportation and a global economy, bringing the international distribution of large numbers of goods and services. Lassa fever, Marburg disease and new types of influenza are examples of diseases that start in a small corner of the globe and spread across the world almost instantly. It is ironic that it is the rapid spread of these infectious diseases that has highlighted for us the fact that we all share habitats on one small planet.

In developing countries, people are still dying from primitive diseases of the digestive or respiratory system that are considered to have been eradicated in the developed world.

In developed countries, where people have become relatively immune to infectious diseases, cancer, heart disease, diabetes and other forms of "adult diseases" have become a big health concern. The quality of life of people in our aging societies is thus threatened by serious disease. Instead of dying from an infectious disease when young or in the middle of our life expectancy, we are slowly moving though life facing the threat of these invasive diseases right up to our very last breath.

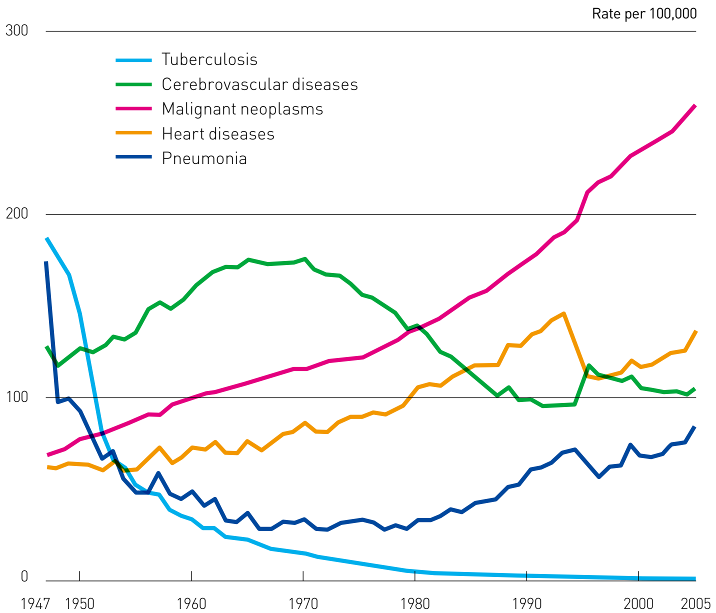
Achievements in the life sciences give hope to the situation, too. The term "adult diseases" has been now replaced by "lifestyle-related diseases," which can be ameliorated by proper nutritious balance, correct diet, limited smoking, hormonal balance and other factors. If the mechanisms behind the correlation of these factors with our health can be elucidated by science and if we can maintain the ideal diet and manage our health with scientific methods, it should be possible to conquer lifestyle-related diseases.

We should not forget, however, that there are no global level solutions available. A balanced diet is possible only in limited areas of the developed world and for a very small proportion of the world's population. Balancing their diet with vegetables, fruits, grains, fish and meat is a mere pipe dream for people who are struggling just to get enough food to survive, let alone to cover the calories needed for the day. Equally important to remember is that many people in the world do not have access to clean water, and thus have a high risk of contracting infectious diseases.

In response to these conditions, strategies for controlling infectious diseases in recent years include political approaches, as seen in quarantine inspection programs at national borders.

Technology to prevent the spread of infectious diseases is also needed, and scientific approaches to eradicate infection-causing microorganisms should be studied. Also important is new medical technology to provide biological defense (e.g., immunity) in treating cases of infection.

Thus many more challenges still await the life sciences and medical science in seeking solutions at the global level.



Trends in crude mortality rate for leading causes of death (1947-2005, Japan)

After World War II, the number of deaths due to contagious diseases such as tuberculosis and pneumonia declined, while the number of deaths caused by cancer, cardiac disease and other metabolic disorders has increased. The top cause of death in the world is cancer, with roughly one out of every five deaths caused by cancer. The death rate is high in industrialized countries, especially in Japan, where the rate is roughly one in three deaths. (Source: National Cancer Center)

"It is possible to reduce the rates of many types of cancer."

1996 Honda Prize Laureate

Dr. Bruce N. Ames

Born in the State of New York in the United States in 1928. After studying chemistry and biology at Cornell University from 1946, started studies in biochemistry at the California Institute of Technology in 1950 and received a Ph. D. Served as professor in biochemistry at the University of California from 1968 and became chairman of the Biochemistry Department in 1983. Served as chief of the section on microbial genetics at the U.S. National Institute of Health and as a member of the board of directors of the National Cancer Institute. Recipient of a great number of awards, including the Charles S. Mott Award of the General Motors Cancer Research Foundation and the Gold Medal Award of the American Institute of Chemists.

Dr. Bruce N. Ames has been studying the environmental factors involved in the development of cancer and aging. The significance of his achievements can be recognized in the results of epidemiological studies showing that reduction of smoking, increased consumption of fruits and vegetables and control of infections have a major effect on reducing rates of cancer.

The epidemiological studies by Dr. Ames cover a wide range of factors. For example, one study indicates that tall women have a higher risk of developing breast cancer. Japanese women, Dr. Ames points out, have a higher morbidity rate for breast cancer in recent years as the average height of the group increases. The results of his research into the relationship between diet and cancer risk are more of a warning. Fibers contained in fruits and vegetables can function as an important factor in reducing cancer cells in addition to antioxidants. Dr. Ames suggests folic acid as an especially important factor. The quarter of the population with the lowest dietary intake of fruits and vegetables has roughly twice the risk for most types of cancer (i.e., cancer of the lung, larynx, oral cavity, esophagus, stomach, colon and rectum, bladder, pancreas, cervix and ovaries) compared with the quarter with the highest intakes. For hormonally-related cancers, the protective effect of consuming fruits and vegetables is weaker and less consistent: for breast cancer the protective effect appears to be about 30%, Dr. Ames points out.

Dr. Ames never fails to exercise his ability to observe the conditions fairly and critically—an essential capability for any scientist. Dr. Ames states, for example, that there is no scientifically-justifiable reason to blame exposure to minute amounts of chemical compounds for increased risks of developing cancer. While many people consider the use of agricultural chemicals in farming to be a contributor to increased risks of developing cancer from the foods they eat, Dr. Ames refutes the idea by pointing out the fact that there is no epidemiological data to support a correlation. Instead, he presents the concern that discontinuing the use of agricultural chemicals would rather increase the risk of cancer for the whole population, because it would decrease the yield of fruit and vegetable crops, raise prices, and as a result make it impossible for people on low incomes to buy and eat fruits and vegetables. Studies by Dr. Ames also point out that continuous inflammation in the body induced by chronic infection can be carcinogenic. Dr. Ames therefore believes that epidemiological studies of humans should lead to a decrease in morbidity for many kinds of cancer.

The Potential of the Science and Technology in Protecting Life

Now in the 21st century, the world population is about to exceed seven billion. And this increase in population is expected to continue in many regions throughout the world. In the developing countries where industrialization is advancing, population concentration rates will accelerate, and in agricultural areas, on the other hand, population concentrations will continue to decrease. No one can prediction accurately how many more people the Earth can support in addition to its current human population. The growth in food production will decline on a global level, and at the same time, we cannot allow the burden on the global environment to increase. The mission of the life sciences is therefore to develop technologies, including those to solve food supply issues, that can protect both human lives and the Earth's environment.

The Green Revolution, a program that was started in India in the 1960s, along with development of the program in the following decades, can serve as a model case for the rest of the world. The idea of the Green Revolution in India is not a mere unidirectional solution-seeking program to increase food production, but a comprehensive program to address higher living standards for people within the carrying capacity of the regional ecosystems. The very idea of the Green Revolution requires application of knowledge in the life sciences to life on Earth while conserving the global environment. In other words, action is needed to implement ecotechnology based on the philosophy that humankind cannot survive without preserving the global environment that supports us.

Scientists facing unpredictable crises in our lives must do so as members of a global movement. That kind of spirit is essential for those who are engaged in the life sciences and medical services.

Are there unknown forms of life in the Universe? Many scientists are interested in this question. Unknown life forms can also exist in the oceans, especially in the deep sea. Studies and research are carried out through ocean exploration. The new findings may bring great benefits to us all.

On average, life expectancy is increasing. This in part implies that the advancement of medical science has saved more lives. On the other hand, lifestyle-related diseases have become a major concern for people living in the 21st century. Now we need to clarify the right kinds of nutritional studies, lifestyles and medical services that will raise our quality of life. We still do not have any clear guidelines, and the life sciences can be a key field of study in laying down principles to this end.

Advancements in genomics and proteomics will bring new types of medical services. The potential applications of regenerative medicine have created many hopes and dreams, and medical science is making steady progress. As members of society, we must watch, monitor and sometimes give suggestions on the ethical, social and environmental aspects

"Finally, healthy food can only be produced from a healthy environment."

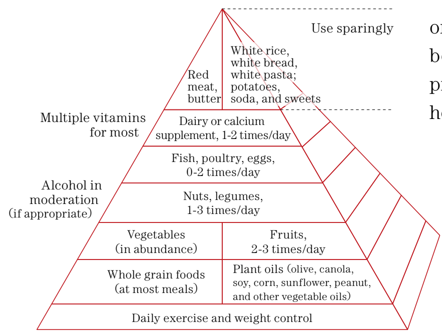
2004 Honda Prize Laureate **Dr. Walter C. Willett**

Born in the State of Michigan in the United States in 1945. Received an M.D. from the University of Michigan Medical School in 1970, and subsequently received his M.P.H. (1973) and Dr.P.H. (1980) from the Harvard School of Public Health, becoming a professor of epidemiology at the school. Dr. Willet is a leading researcher in the field of epidemiology at Harvard. Also serves as the leader of some well-known cohort studies, including the Nurses' Health Study and the Health Professionals Follow-up Study. Recipient of numerous awards, including the International Award for Modern Nutrition and the Charles S. Mott Prize. Has published more than 900 articles and books, including *Eat, Drink, and Be Healthy.*

To study the nutritional determinants of diseases such as cancer and heart disease, the dietary intake of every item of food for a person must be repeatedly measured for a large population over the long term. Conducting such surveys can be very expensive and analysis of the data collected may be very complex. The food frequency questionnaire (FFQ) developed by Dr. Walter C. Willet provides a solution to this problem. After a series of pilot studies, he selected approximately 130 items from the most important items of food in the American diet and included them on the questionnaire. To verify that any statistical significance in the data would be recognized, he studied the accuracy and suitability of the FFQ by comparing the nutritional intake calculated from the FFQ data against records of the actual intake of food items collected from several thousands of people over a four week period. After repeating this comparison four times in a year, the two sets of data showed a significant level of correlation, validating the accuracy of the FFQ.

Dr. Willet also examined the association between dietary intake and factors in the blood known to be influenced by diet. For example, the association between blood levels of homocysteine (a factor that causes cardiovascular disease) and nutritional intake was examined. As the accuracy of the dietary measurements increased through long-term analysis of the data from repeated surveys, a variety of hypotheses and predictions have been put forward on the relationship between diet and the risk of disease. Dr. Willet has been conducting studies into how the risk of contracting a range of diseases are affected by diet, including heart disease, stroke, diabetes, many cancers, kidney stones, gallstones, and degenerative diseases of the nervous system, including decline in cognitive function. Using the FFQ, Dr. Willet has shown that changes in diet can serve as a factor in suppressing or developing symptoms of many diseases, in addition to ethnic or racial (i.e., genetic) factors, which had been considered almost exclusively to be the main factors in contracting these diseases. In this, Dr. Willet has made a major contribution to medicine.

Dr. Willet expresses concern over the influence of the changing environment on the human diet and therefore disease, because "healthy food can only be produced from a healthy environment." The role of ecotechnology in preserving a sound global environment is therefore important in ensuring a healthy diet and consequently the health of the people of the world.

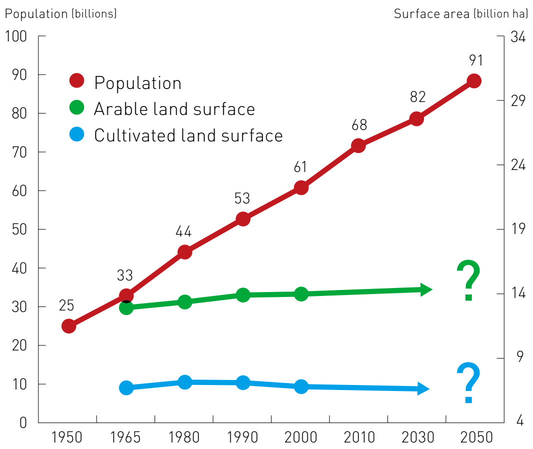


The New Healthy Eating Pyramid
Dr. Willet used scientific evidence to point out various problems with the USDA Food Pyramid that was developed in 1992 by the US Department of Agriculture and spread widely throughout the country. He was quick to point out that trans fats are closely linked to cardiac disease, brain hemorrhage and other ailments long before the acids became widely known. In the "New Healthy Eating Pyramid," intake of vegetable oils such as olive oil, canola, and soy and peanut oil is recommended to decrease amounts of trans fats. (Source: Eat, Drink, and Be Healthy)

of this progress, as well as on the response of political leaders to this progress. In this new age, the life sciences should be able to take on the role of providing the right technologies.

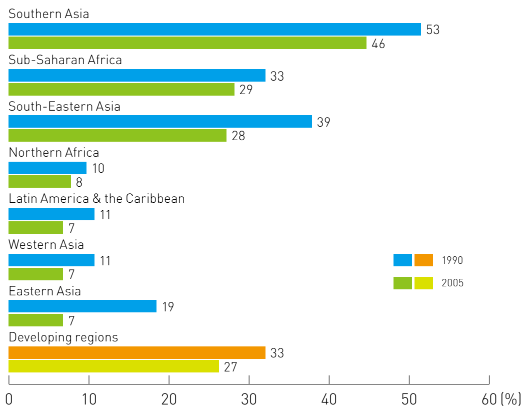
People living in developed countries often fail to remember the people living in developing counties who are suffering from extreme poverty and starvation. When we work on adjusting existing economic disparities, conservation of the natural environment, and alternative forms of national development, we must not overlook the significance of people's livelihoods in all areas, and even non-human life forms.

There is no guarantee that a rosy future awaits humankind. But advancements in the life sciences promise unlimited and unprecedented results, offering us hopes and dreams for our future lives as human beings.



World population and arable land surface/cultivated land surface

The current world population of approximately 6.5 billion is growing chiefly in the developing countries and is expected to reach 9.1 billion by 2050. However, the arable land surface for the entire world remains roughly constant and is not expected to see significant growth. By the mid-21st century, it is believed that food production will not be able to keep up with the population growth and this will result in aggravation of the food supply situation around the world. (Souce: United Nations / FAO (FAOSTAT))



Proportion of children under age five who are underweight, 1990 and 2005 (percentage)

Although the number of children suffering from huger had decreased in East Asia, West Asia, Latin American and the Caribbean region by 2005, many remain in South Asia and sub-Saharan Africa. More than a quarter of the children in developing countries are malnourished. Although malnutrition remains the cause of more than half of all child deaths, other causes are debilitation resulting from contagious diseases and lack of medical care. (Souce: United Nations)

Photo: Uniphoto press international Inc.

"We need to have technology that fits each region so as to achieve a sustainable end to hunger."

1991 Honda Prize Laureate

Dr. Monkombu S. Swaminathan

Born in Tamil Nadu in India in 1925. Received a Ph. D. from the School of Agriculture at the University of Cambridge in the UK and served as director of the Indian Agricultural Research Institute and other positions. Played a major role in the agricultural revival and the Green Revolution in India through development and promotion of crop varieties with high yields in the 1960s. In 1988, founded the M. S. Swaminathan Research Foundation to pursue the Evergreen Revolution for environmental conservation and poverty eradication. Served as president of the Pugwash Conferences for Science and World Affairs, a group of scientists who seek the eradication of nuclear weapons and the elimination of wars.

In the late 20th century, predictions that food production would not be able to catch up with the ever-growing global population were a major concern to the people of the world. And those concerns became fact. The world population quadrupled in the 100 years up to the 20th century. Although it took more than a million years to reach 100 million sometime around the year 1800, the world population increased to 3.8 billion by 1972, and exceeded 6.5 billion by February 2006. When the population reached 3.8 billion, India, where exceptionally rapid population growth continued, was threatened in 1975 with widespread famine. However, this did not happen—because of a national scheme to increase food production.

Programs to increase food production in India have been led by Dr. M. S. Swaminathan under the concept of a "green revolution," an idea first advocated by Dr. William Gadd of the US Department of Agriculture in 1968.

At a meeting of the International Commission on Peace and Food held under Dr. Swaminathan's chair in Madras in October 1991, participants agreed to work to achieve the following targets. A plan was made to address increases in food production and security of employment for the growing population at the same time.

(a) Raise foodgrain production from 188 million tons to 220 million tons by increasing per hectare yields of wheat from 2.3 tons to 3.1 tons and rice from 1.76 tons to 2.15 tons, and bringing another 2 million hectares of irrigated land under high yielding varieties of wheat and rice. The shift of existing crops from ordinary to high yield varieties will increase employment per hectare by 50%.

(b) Triple the area under irrigated cotton to raise total production from 13.3 million bales to 26 million bales. This and other measures generate employment for 11 million persons.

(c) Extend the area under sugarcane by an additional 1.6 million hectares and raise average yields from 60 to 80 tons per hectare with a projection to meet domestic demand and increase exports to 3 to 4 million tons annually by 2000.

(d) Raise fruit production by 50% and vegetable production by 100% to meet the domestic nutritional requirements and to generate 25% exportable surpluses. Raise the average yield to generate Rs. 18,000 per hectare and free 6 million families from poverty.

(e) Raise inland fish production by 4.5 million tons (66% of projected domestic demand) through development of 50,000 hectares of intensive fish farms generating fulltime employment for one million people.

(f) Double mulberry silk production by establishing 500 integrated sericulture estates generating 750,000 additional fulltime jobs.

(g) Expand the area under irrigated oil seeds by 3 million hectares and improve yields to produce an additional 7.5 million tons of oil seeds, including groundnut, sunflower, rape and mustard and safflower.

(h) Reclaim and utilize 4.5 million hectares of wastelands to meet the entire projected demand for industrial wood and provide sufficient animal feed for continued expansion of dairy development programs.

(i) Increase the number of milch animals in the country to generate 11.6 million additional jobs.

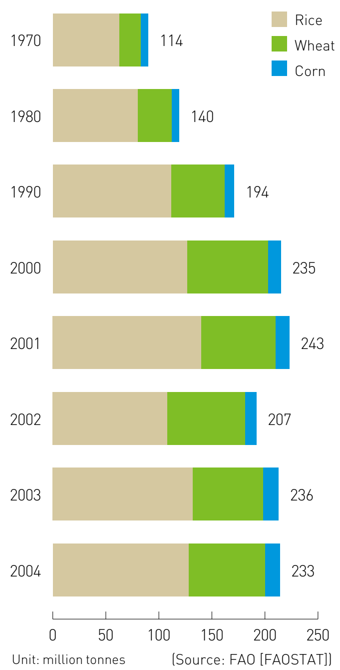
These numbers in Dr. Swaminathan's plan strategically address both food and job security concerns through a long-term vision.

When Dr. Swaminathan pursues a plan, he sees the problems both from the macro and micro levels. That is, he addresses not only land use (from the macro point of view) but also the selection of crop varieties (from the micro point of view). In 1961, Dr. Swaminathan observed a few dwarf wheat lines with short height and long panicles in the International Wheat Rust Nursery samples sent out by the USDA. On being told that the lines came from Mexico, he collected wheat seeds from dwarf lines from Mexico to study the genes associated with dwarf traits. He eventually succeeded in breeding a dwarf wheat variety with long panicles. As a result, wheat production in India increased from 12 million tons in 1964 to 55 million tons in 1990. India's "Green Revolution" was thus successfully developed because of the simultaneous introduction of mutually reinforcing packages of technology, services and public policies.

Dr. Swaminathan holds to the principle of "improving human life within the limits of the carrying capacity of the supporting ecosystems." That is, agriculture that does not impose a burden on the global environment and does not interrupt the natural cycles. In 1990, Dr. Swaminathan took the position of president of the International Society for Mangrove Ecosystems (ISME) based in Okinawa. This is his contribution to conservation of the biological wealth of coastal areas; over 60 percent of the world's population lives within 60 kilometers of the sea shore, Dr. Swaminathan points out.

The JRD Tata Ecotechnology Centre of the M. S. Swaminathan Research Foundation specializes in blending traditional ecological prudence with frontier technologies like biotechnology, information communication technologies, space technology and renewable energy technologies. The Centre carries out various experiments in its research into breeding under various conditions, such as in high temperatures or desiccated environments, as well as conservation projects on various genetic resources.

Cereal Production in India



With the achievements of Dr. Swaminathan and his "green revolution," agricultural output grew every year in India. The drop in 2002 was caused by a major drought. (Source: FAO [FAOSTAT])

"A great variety of these undiscovered microorganisms are distributed on the Earth, indicating the boundlessness of the information they have to offer."

1993 Honda Prize Laureate

Dr. Koki Horikoshi

Born in Saitama Prefecture in Japan in 1932. After receiving a doctorate in agriculture from the University of Tokyo in 1963, served as chief scientist at RIKEN from 1974 to 1991 and director of the Superbugs Project at ERATO from 1984 to 1990. Became professor at the Department of Bio-Engineering in 1988 and professor emeritus at the Tokyo Institute of Technology in 1993. Took the position of professor in the Department of Applied Chemistry at Toyo University. Awarded the Medal with Purple Ribbon from the Emperor of Japan in 1987 and the Gold Medal of the International Institute of Biotechnology at the Royal Society in the UK. Author of numerous books, including *Alkalophilic Microorganisms*. Also serves as president of the International Society for Extremophiles.

In late fall of 1968, Dr. Horikoshi was looking at some Renaissance buildings in Italy, which were very different from Japanese architecture. The architectures and other forms of culture of Italy and Japan developed in significantly different ways in the period from the 14th century to 16th century. Japan and Italy had no official relationship and people in the two countries did not even know of the existence of the other. Even so, the people of Italy and the people of Japan were living their lives simultaneously on the Earth. Then an idea hit him. "There might be whole new worlds of microorganisms in different unexplored cultures," he thought. Up to then, studies in microbiology had been carried out mainly under acid conditions, probably because most foods are acidic. Studies of microbial infections also focused on acidic and neutral conditions.

After returning to Japan, Dr. Horikoshi prepared an alkaline medium, placed in it a small amount of soil from the garden and cultured it at 37°C. He observed various microorganisms flourishing in all 30 test tubes. That was Dr. Horikoshi's first encounter with the new world of alkaline microorganisms. In 1984, the Superbugs Project was launched to study microorganisms under extreme environments. A species of bacteria that can thrive in a solution of toluene, a chemical that can kill normal organisms at 0.1% concentration, was found and named IH-2000. Dr. Horikoshi made a great achievement with Escherichia coli, too. E. coli has three layers of biomembranes on its cell surfaces and 500 to 1,000 species of proteins remain trapped inside the cells. He identified a gene that can make the outer membrane permeable, allowing the proteins to be easily secreted. This led to production of several enzymes, human growth hormones, and Fc proteins from E. coli outside the bacteria.

Dr. Horikoshi also succeeded in the mass production of cyclodextrin, a donut-shaped molecule with seven glucose units derived from starch. Because of the shape, the molecule can be used as a capsule to trap various compounds inside. By doing so, volatile compounds can be treated as non-volatile and unstable compounds can be made stable. The conventional approaches to the mass production of cyclodextrin had not been successful because the enzymes were not thermostable enough for industrial use and toxic organic solvents such as toluene were needed to precipitate the products. The yield had also been low at 20 to 30%. These problems were solved instantly by isolating cyclodextrin-forming enzymes from alkaliphilic bacteria. Mass production became possible with the innovation of thermostable, organic-solvent-free methods. The production cost of cyclodextrin went down from 50,000 yen to 2,000 yen per one kilogram. Now cyclodextrin is used widely in industry, pharmaceuticals, food production and agriculture.

The finding of alkaline cellulase growing under alkaline environments is another epoch-making discovery made by Dr. Horikoshi. Since no cellulase that could be active at pH 10 or higher had been found, the discovery of alkaline cellulase that could decompose only carboxymethylcellulose found unexpected applications, including the development of a laundry detergent containing enzymes. With conventional detergents, it had been very difficult to remove stains from cotton fabrics at low temperatures. When added to the detergent, alkaline cellulase decomposes the stains but does not damage the cotton fabric. The alkaline cellulase found by Dr. Horikoshi is now widely used in household laundry detergents that have captured the market.

A good example of microorganisms living under high pressure is the species that are found in the deep seas. Dr. Horikoshi studies deep-sea microorganisms that live in the soil on the sea bed by taking samples from the deep oceans using submarines such as the Shinkai 6500 and Shinkai 2000. For Dr. Horikoshi, "Finding new life-forms will definitely develop basic science and new biotechnologies."

A new kind of microbiology has developed very rapidly around Dr. Horikoshi's work. This new microbiology is not restricted by the conventional anthropocentric view, but is a microbiology based on studying microorganisms in their optimal conditions for life. Dr. Horikoshi said in his commemorative speech: "A great variety of these undiscovered microorganisms are distributed on the Earth, indicating the boundlessness of the information they have to offer."

DB6906 Morphology cultured under the various pressure

Ground level pressure

400 kg/cm2

600 kg/cm2

The deep-sea explorer Shinkai 6500 with Dr. Horikoshi on board collected microorganisms adapted to high pressure and capable of microbial activity under such conditions. The discovery of life under these extreme conditions holds the potential for new possibilities in biotechnology. (Photo: JAM STEC)

Enzyme detergent (Kao corporation) based on cellulase produced in an alkaline environment was discovered by Dr. Horikoshi. It has become a widely-used and popular enzyme detergent in Japan.

Science and Personality

Studies and research in the life sciences and medical science require unlimited patience from the scientists involved along with competitiveness in the global race for development. Where do scientists find the motivation to continue their pursuit in such a tough environment? Are they motivated solely by the praise and fame they receive from many different sectors when they produce new findings or a new technological development? To be sure, the life sciences and medical science are recognized as being two of the most advanced and beneficial fields of science, and scientists working in these fields certainly receive great acclaim.

Scientific research, however, should not be motivated solely by practical rewards. Instead, it should be motivated by a childlike "curiosity for the unknown," a feeling that many people retain from their early years. Were it not for the curiosity of the scientist, the diverse world of microorganisms would not have been discovered. The simple curiosity of one scientist focused on microorganisms—a form of life found in the soil in any garden—and this led to the discovery of beneficial microorganisms, now essential elements in medicine, agriculture and industry. This is a good example in support of our belief that technological developments that bring happiness to our lives are not always the result of the scientist's desire for fame, and are often the result of simple curiosity. Scientific research is also supported by attitudes and ideas that accept diversity. The scientist who revealed the diverse world of microorganisms was someone who was able to appreciate the difference between his own and another culture.

In both the life sciences and medicine, the personality of the researchers can serve as a very important element in the pursuit of advanced technologies. In fact the approach to and development of research can depend a great deal on the unique personality of the scientist. HLA was discovered because of one scientist's belief that "if red blood cells have different types, white blood cells should also have different blood types." Alkalophilic microorganism were discovered when one scientist recognized the diversity of life forms, and had the idea that "if microorganisms occur in acid and neutral environments, alkaline environments should also support some types of microorganisms." And interestingly enough, both of these pioneering scientists have a profound interest in fine art. They both have a keen insight not only into scientific matters, but also into different cultures and the different ways of expressing artistic sensibilities. In this, the personality of the scientists often acts as an important factor in being a good scientist.

On the other hand, the analysis of the genome was accomplished as a result of the coordinated work of many scientists across the world. Such a large volume of work with very intricate analytical processes could not have

"Classic surgery violates the natural integrity of the human body, and surgeons must respect its natural laws to minimize the effect of such aggression."

2007 Honda Prize Laureate **Dr. Philippe Mouret**

Born in Lyons in France in 1939. Graduated from the University of Lyon medical school in 1957 and passed the Lyon Hospital medical practice examinations. After serving as intern and doctor at the Lyon Hospital, started in private practice in 1968. Since 1981, has worked at a private hospital in Torino, Italy. In addition to assignment to the Ha Noi Ben Vien Viet Phap in Vietnam from 2000 to 2006, has been dispatched to Krishna Hospital in Arnad in India as part of the medical practical teaching project "Into the Field." Performed the world-first practical laparoscopic cholecystectomy in 1987 and opened the path to rapid spread of endoscopic surgery.

Laparoscopic cholecystectomy being performed in 1987.

Dr. Philippe Mouret began his career as a surgeon after studying gynecology and gastroenterology at the University of Lyon. Based on the conviction that "surgery is an act in which one must express respect and address the laws of nature represented by the human body," Dr. Mouret was inspired to apply endoscopy (use of a laparoscope), a tool already used by gynecologists at that time, to surgery in order to minimize stress and damage to the patient to the greatest possible extent.

He opened a private hospital in 1968 in Lyons and refined his skills in laparoscopy treatment and endoscopic surgery, gaining confidence that the device could be used in cases where the common solution was laparotomy. His first case was an operation conducted in 1972 on a patient suffering from intestinal occlusion. In 1983, he performed an appendicectomy. Dr. Mouret's operations drew recognition for less pain and a quicker recovery. However, he was long ignored in surgical medicine at that time because laparotomy was regarded as the common practice.

In 1987, video recordings of surgical operation became possible by attaching a video camera to the endoscope. The recorded laparoscopic cholecystectomy finally transformed surgery into what it is today. Still, he believes that "endoscopic surgery is not a totally new concept. In fact, I believe it is a supplementary tool to mitigate the invasiveness, or aggressiveness of conventional surgery. Its objective is to minimize incision to the least necessary and reduce stress of incision time."

Later, endoscopic surgery spread rapidly around the world. With advances in medical instrumentation and surgical methods, application of the endoscope expanded into stomach and lung cancer operations and to the development of advanced robotics in surgery. However, this involves highly sophisticated equipment and exorbitant medical costs. Dr. Mouret thinks that "the advantages of laparotomy can be utilized most effectively in more common, less complex operations, rather than surgical operations of the highest order in terms of difficulty." He is currently working for its wider use to bring the benefits of the procedure to patients even in developing countries.

been achieved without close collaboration between everyone involved.

Similarly, without collaboration between scientists and engineers that extends beyond the capabilities of any single scientist or the range of a single discipline, development of the life sciences and medicine in the 21st century will not happen. Immunological research is a typical case. It requires long, painstaking efforts with enormous volumes of data, as well as continuous improvements to the accuracy of the research through detailed examination of research methods. In some cases, it also requires the study of unexpected elements, such as the effect of human hormones, the influence of exposure to synthetic chemical substances, and even the association between the height of a person and their risk of developing cancer.

Such detailed research over a wide range of issues, including the relationship between the global environment and people's lives, also relies upon the personalities and capabilities of the scientists and engineers.

Our human attitude to seek happiness should not change, even when social, economic and political factors change with the times, for it forms the essence of the work of all scientists and engineers.

The M. S. Swaminathan Research Foundation(MSSRF) has been engaged during the last 17 years in giving meaning and content to the ecotechnological pathway of food security. This involves concurrent attention to the principles of ecology, economics, ethics, equity, employment, energy and education. MSSRF has developed the Biovillage model of human centered development in order to enhance the productivity, profitability and stability of major farming systems in an ecologically sustainable manner.

I coined the term “ever-green revolution” over 20 years ago to indicate the need for achieving improvements in productivity in perpetuity without associated ecological harm. The pathway for achieving an ever-green revolution is either organic farming or green agriculture. Organic farming precludes the use of mineral fertilizers and chemical pesticides.

Because of demographic pressures, it is necessary to grow more crops per unit of land, water and energy. This can be achieved only through blending traditional wisdom with frontier technologies like biotechnology, information, communication technology, space technology and nano-technology. We must also promote the cultivation and consumption of a wide range of food and medicinal plants, so that there is a diversification in the farming system. In order to stimulate integrated attention to conservation, cultivation, consumption and commerce, it is important that small farm families are trained in ecotechnology. They must be enabled to conserve valuable genetic resources which can be used for creating novel genetic combinations through recombinant DNA technology. They must be paid remunerative prices so that there is an economic stake in conservation.

Finally, we must work for the health and happiness of all human beings by generating bio-happiness through the sustainable and equitable use of bioresources. This will also help to promote bio-partnerships for spreading the ecotechnology movement. Bio-partnerships and bio-happiness should help to eradicate bio-piracy. This is the way for developing priorities in action based on the excellent work done by the Honda Foundation.

M. S. Swaminathan

12th Honda Prize Laureate, India

Afterword

This publication has been compiled to commemorate the 30th Anniversary of the Honda Foundation. Our message is to communicate the heart behind ecotechnology to as many people as possible, and we send it especially to the young people who hold the future of humankind in their hands.

The concept of ecotechnology that the Foundation has promoted since its establishment places importance exclusively on man and society as a collaborative body of people. For this reason, issues of the global environment that have become serious in the 21st century must be perceived not simply as concerns for the planet, but as a problem for humankind on a global scale. Only in recent times have science and technology become a double-edged sword for humankind. Measured against the course of world history, it is only yesterday that we have become aware of these issues. Ecotechnology should be seen as a meta-technology that can give us control over the future of science and technology and make them truly useful.

When the CVCC engine became the first engine in the world to satisfy the requirements of the Muskie Law, something that up to then had been believed to be impossible, was it because of the technical prowess of Soichiro Honda, founder of an upstart automaker? Mr. Honda believed in the power of technology, and it was his devotion to society and his dream as an engineer that were the driving force behind his success.

It is our fervent hope this publication will serve in small ways to inspire young people to take on challenges. In it we present the visions that have driven the work of past Honda Prize Laureates and describe the extent of the heritage they have left our world in pursuing their dreams. I look forward to a bright future for us all, one that is carried forward on the dreams of the young people who are responsible for creating our future.

Lastly, I would like to acknowledge my gratitude to the Honda Prize laureates, the directors and councilors of the Honda Foundation and to everyone who has been involved in the production of this publication.

March 2008

Toshio Ban
Managing Director,
The Honda Foundation

About the Founder

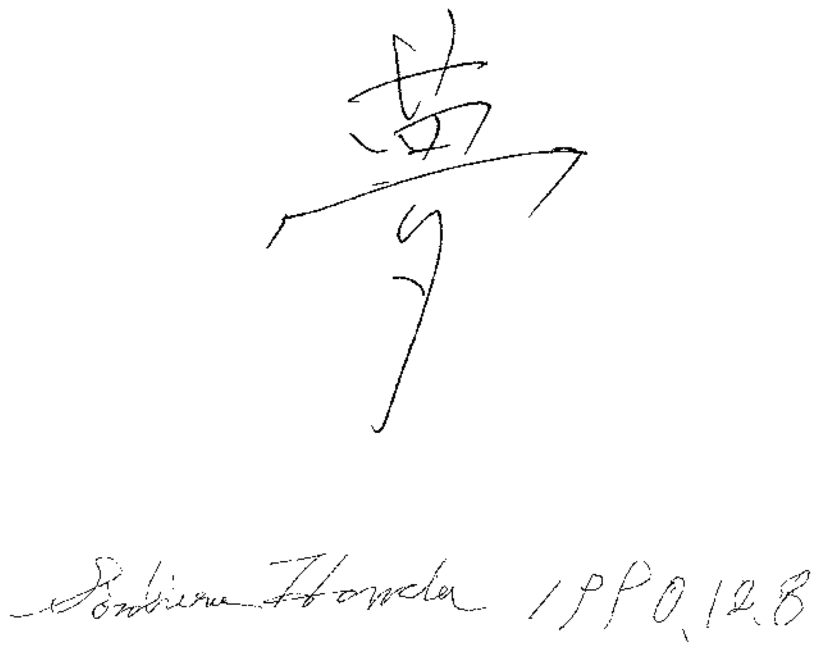
Born as the eldest son of a skilled blacksmith on November 17, 1906, in Komyo Village, Iwata-gun(currently Tenryu-ku, Hamamatsu City), Shizuoka Prefecture, he set up the Hamamatsu Branch of Art Shokai in Hamamatsu City in 1928, where he offered automobile repair and piston ring manufacturing services. Later, the manufacturing division separated as a new enterprise named Tokai Seiki and began development of various types of machinery.

After World War II, he sold the company and set up the Honda Technical Research Institute in Hamamatsu City in 1946. In 1948, he set up Honda Motor Co., Ltd. and became its president. He was personally involved in internal combustion engine research and began production of motorcycles. He later expanded into automobiles leading to the growth of the company as a leading Japanese business corporation. He succeeded in developing the world's first low-emission(CVCC) engine in 1973. He resigned from the office of company president at age 66 and was appointed executive advisor.

After his retirement, he traveled to Europe in 1977 in search of "what problems the world faces." In December 27 of that year, he expressed his motif: "I reached where I am now just through technology. I want to get involved wherever technology can be a solution." With this decision, he founded the Honda Foundation to promote the concept of "ecotechnology" to achieve holistic harmony between the environment surrounding man and his activities.

He passed away on August 5, 1991, at age 84. He received the Grand Cordon of the Order of the Rising Sun and is laureate of the Holley Medal from the American Society of Mechanical Engineers(1980). He also received the Global 500 Award from the United Nations Environment Programme(1987) and the Golden Medal of the Federation Internationale de l'Automobile(1990) among others. He was the first Japanese to be inducted into the US Automobile Hall of Fame in 1989.

The award ceremony for the Honda Award given in recognition of meritorious contribution to ecotechnology takes place every year on November 17, Soichiro Honda's birthday.



Whether it be learning or technology, everything in this world is nothing more than a means to serve people.
I think the most important thing of all is to have love for people.

Soichiro Honda

OUR DREAM

Ecotechnology for future generations

Published in March 2008.

* Photographs of the Laureates were
taken at their award ceremonies.

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