Foreword

This year marks the fourth year since the adoption of the Second Science and Technology Basic Plan, in which Japan's basic policies for science and technology are articulated. This is an important juncture for thinking about how to proceed with Japan's science and technology policy, as we exert greater efforts for the promotion of science and technology to firmly ensure that the Basic Plan produces results, and move toward implementation of the Third Science and Technology Basic Plan.

Today, developments in science and technology have brought prosperity to our lives and have vastly expanded the possibilities for human activities, with the result that science and technology is now deeply connected to all parts of our life. On the other hand, global environmental problems, bioethics issues, and other societal issues have also been revealed. Moreover, the relationship between science and technology, and society, will become even closer in the future, and people's thinking about science and technology can be expected to become more diverse.

In this situation, it is important that we obtain the thoughts of all our people about what the course for science and technology should be in the future. As a result, the theme explored in this year's White Paper on Science and Technology is "The Future of Science and Technology and Society," and it contains analysis from a variety of viewpoints of the issues and policies for building the optimum relationship between science and technology, and society.

An optimum relationship between science and technology, and society, cannot be achieved by the government alone, but can be achieved through active cooperation among members of the science community, the world of industry, and all other people in the community. In this regard, it is important for scientists and technologists, as members of society, to engage in exchanges with the people, so as to strengthen mutual trust, and to encourage the people to treat science and technology as issues of personal importance.

It is hoped that this white paper will be utilized by the people as an opportunity to think about and discuss science and technology. The government, as well, will be using this white paper as a guideline for the future promotion of science and technology.

June 2004

Minister of Education, Culture, Sports, Science and Technology

Takeo Kawamura

Preface

This report deals with measures taken to promote science and technology under the provision of Article 8 of the Science and Technology Basic Law (1995 Legislation No.130).

This report introduces, in Part 1 and Part 2, trends in the diverse activities of science and technology, and in Part 3, helps deepen readers' understanding of the measures taken to promote science and technology.

Under the title of "The Future of Science and Technology and Society," Part 1 analyzes qualitative changes in society, such as the realization of economic prosperity and the advance of globalization due to developments in science and technology, and the deepening relationship between science and technology and society, such as the appearance of global environment problems and other new societal issues, and shows the issues and policies needed to build the optimum future relationship between science and technology and society, toward the establishment of an advanced science- and technology-oriented nation. Part 2 compares the science and technology activities of Japan and other major countries, using multiple kinds of data.

1.1 The Deepening Relationship Between Science and Technology and Society

This section proceeds with an analysis of the deepening relationship today between science and technology and society, and offers an overview of the policy responses around the world to this relationship.

1.1.1 Changes in Society Due to Scientific and Technological Progress

Scientific and technological progress has had various effects on society. These effects have not been limited to the improvement of society's material wealth, but have also extended to altering the paradigms under which society operates. Information and telecommunications technology (IT) is one example of a paradigm-changing technology. Furthermore, as progress in science and technology has broadened and enlivened human activity, new issues have appeared in society, and these have in turn led to demands for new sciences and technologies capable of resolving the new issues arising from the changes in society.

Section 1.1.1 offers an overview of the current state of the relationship between scientific and technological progress, and society.

1.1.1.1 Achievement of Societal Prosperity

Science and technology have formed the foundations for progress in society, and have helped to make people's lives more materially prosperous. In particular, since the rise of the Industrial Revolution in the latter part of the 18^{th} century, science and technology have shown accelerated progress in energy, physical materials, information and communications, medicine, and many other sectors, resulting in vast improvements in people's health, economic prosperity, and living conveniences (Figure 1-1-2).

Progress in energy and materials technologies has given rise to a variety of new transport modes, such as the railroad, the automobile, and the airplane, vastly improving human mobility in terms of both time and space. These advances in mobility, joined with inventions in the area of telecommunications technology, such as the telephone and radio, have served to broaden the range of human activities and to expand the scope of human exchanges.

In addition, inventions in machine tools have been linked to advances in energy technology to achieve automation and acceleration of manufacturing processes. The result has been large-volume production of goods in ever-shorter periods of time. Moreover, progress in materials technology has resulted in the ability to produce diverse types of material items.

Meanwhile, progress in medical technology has greatly extended people's average life spans and reduced infant and child mortality rates, resulting in a dramatic rise in the world's population (Figure 1-1-3).

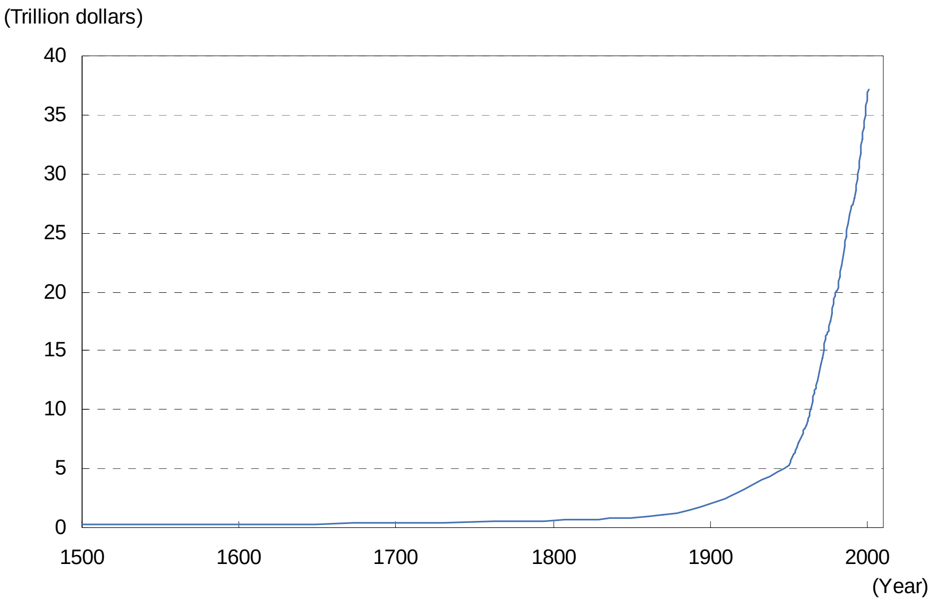


Figure 1-1-2　Long-term trend in world GDP

Source: Survey by the Organization for Economic Co-operation and Development (OECD)

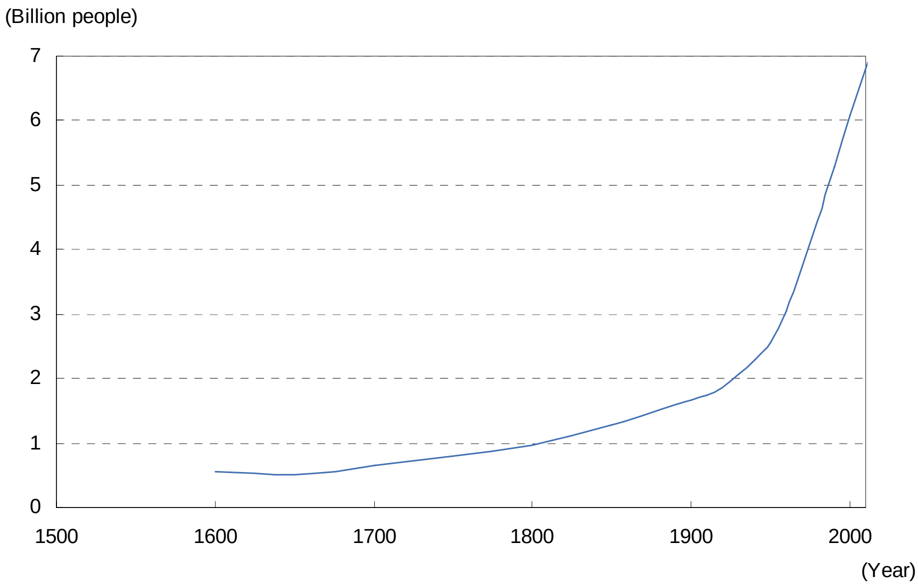


Figure 1-1-3 Long-term trend in world population

Source: Survey by the U.S. Census Bureau

1.1.1.2 Qualitative Changes in Society on a Worldwide Scale

Scientific and technological progress does not merely make people's lives more convenient and prosperous, it has also brought huge changes to how society itself operates.

Two clear examples in recent years of society undergoing a major change are globalization and the IT revolution.

(Changes in Society Due to Advancing Globalization)

The free movement of people, goods, capital, and information across national borders in vast quantities has accelerated sharply since the late 1980s. This rapidly advancing globalization is already changing the nature of society (Figures 1-1-4 and 1-1-5).

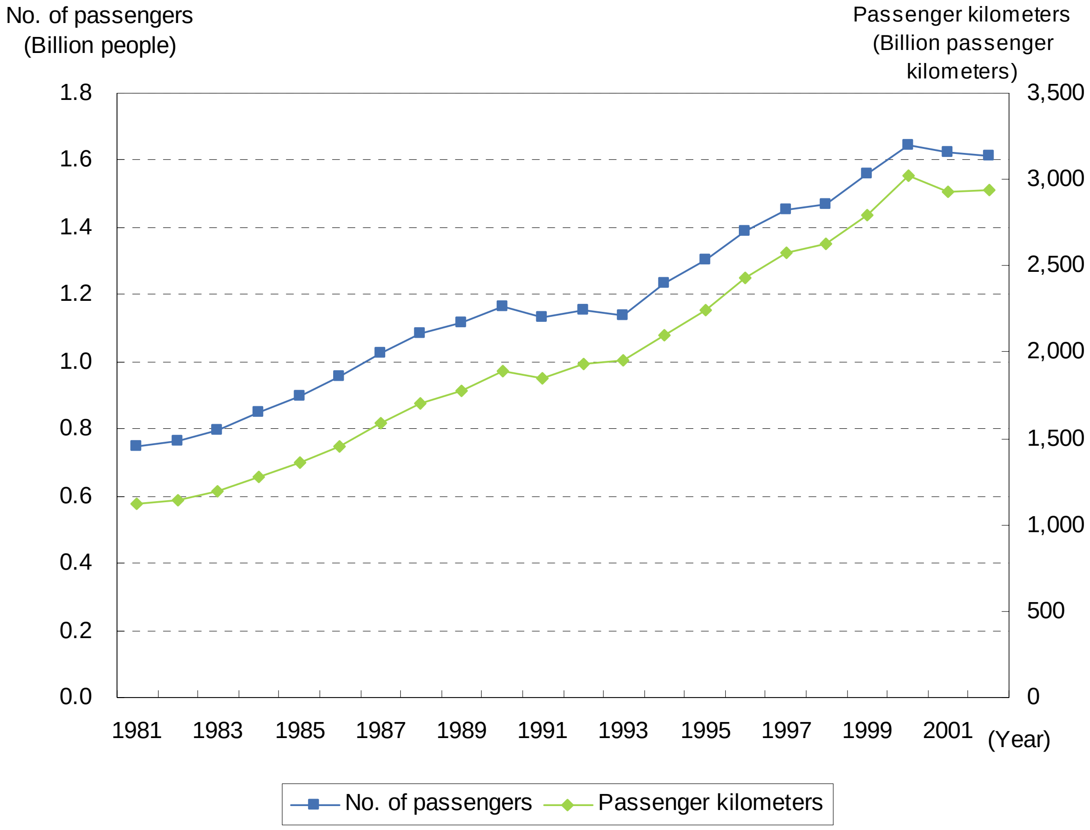


Figure 1-1-4 Trend in world air transport volume (total of international and domestic routes, regular service routes)

Source: Japan Aeronautic Association. "Aeronautic Statistics Outline"

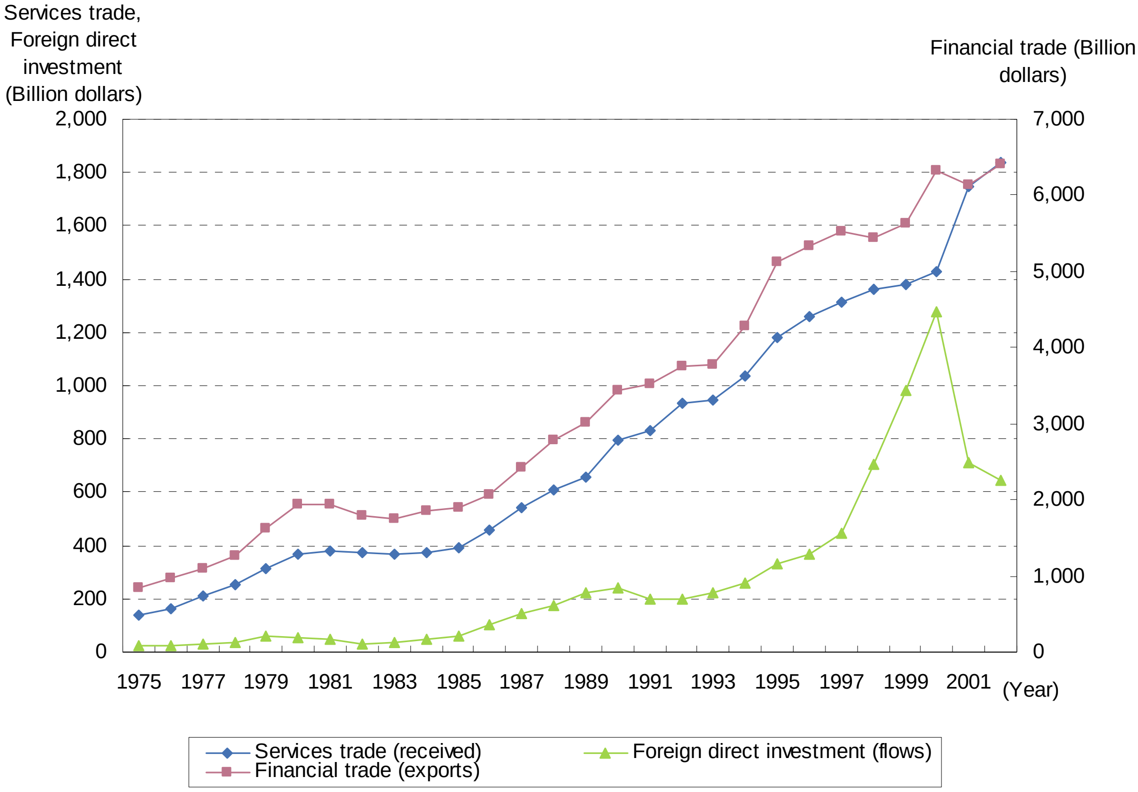


Figure 1-1-5 Trends in world financial trade, services trade, and foreign direct investment

Source: Survey by Ministry of Economy, Trade and Industry

This sudden acceleration of globalization can be traced to the end of the Cold War in 1989, when the political restraints against the international movement of people and goods were relaxed, and when the nations of the former Soviet Union and Eastern Europe abandoned communist-led economies, resulting in expansion of the world's capitalist markets, as well as to the establishment of the World Trade Organization (WTO) in 1995, which served to strengthen the world's free trade and investment systems. These developments form the backdrop for advances in energy and materials technologies, which have led to the appearance of larger scale, faster transport systems, to dramatic progress in information technologies, and to other advances in science and technology.

This rapidly advancing globalization has greatly expanded the realm of individual activities, with international exchanges on a global scale becoming ever more common at all levels of society, from individuals to corporations and regions. The result has been an expansion of trade and investment, and economic development on a worldwide scale, but even more than that, there has been a steady change in the nature of international society itself. In other words, the nation-state once constituted the only entity in international society, and was the medium through which different societies interacted. While the nation-state remains the most important entity, in recent years different levels of societies are increasingly interacting directly with each other without going through nation-state mediation at all.

Globalization has thus served to boost people's prosperity, and to broaden their range of activities, to the point that the very nature of international society is changing. This trend has also given rise to issues that society has never faced before.

For example, the advance of globalization has led to the need for new policies that span international borders, including rules for governing electronic commercial transactions, and better responses to international organized crime. At the same time, the development of international mutually dependent relationships has strengthened ties crossing international borders, so that even such issues as employment, which have previously been considered as purely domestic, must now be treated as issues for the global economy.

Moreover, as seen by the appearance in recent years of such deadly diseases as highly pathogenic avian influenza (Bird Flu), Bovine Spongiform Encephalopathy (BSE), and Severe Acute Respiratory Syndrome (SARS), problems arising in a single region can now spread rapidly to everywhere around the world, and a global watch must be constantly maintained to ensure the safety and security of society.

Furthermore, intensifying competition on a worldwide scale due to rapid globalization has resulted in a new class of competitive losers and others left behind by competition, in both developing countries and in the advanced nations, which has raised fears of social instability, and has stimulated critical reactions from those who believe that market principles ignore people's humanity, culture, and traditions. Many people are beginning to rebel against what they view as a market-coerced "global standard."

(Changes in Society Due to the IT revolution)

A major driving force in the IT revolution has been the Internet. The roots of the Internet can be traced back to 1969, when the U.S. Department of Defense set up the ARPAnet for military purposes, and use for private or commercial purposes was prohibited. In 1990, however, the United States lifted all restrictions to the Internet, and its commercial utilization soon began spreading all around the world, which, combined with advances in computer technology, led quickly to a global information revolution. These advances in information technology dramatically reduced the costs and time required for information distribution, and made possible the manipulation of vast quantities of information. There were about 605.6 million people using the Internet around the world as of September 2002 (Figures 1-1-6 and 1-1-7).

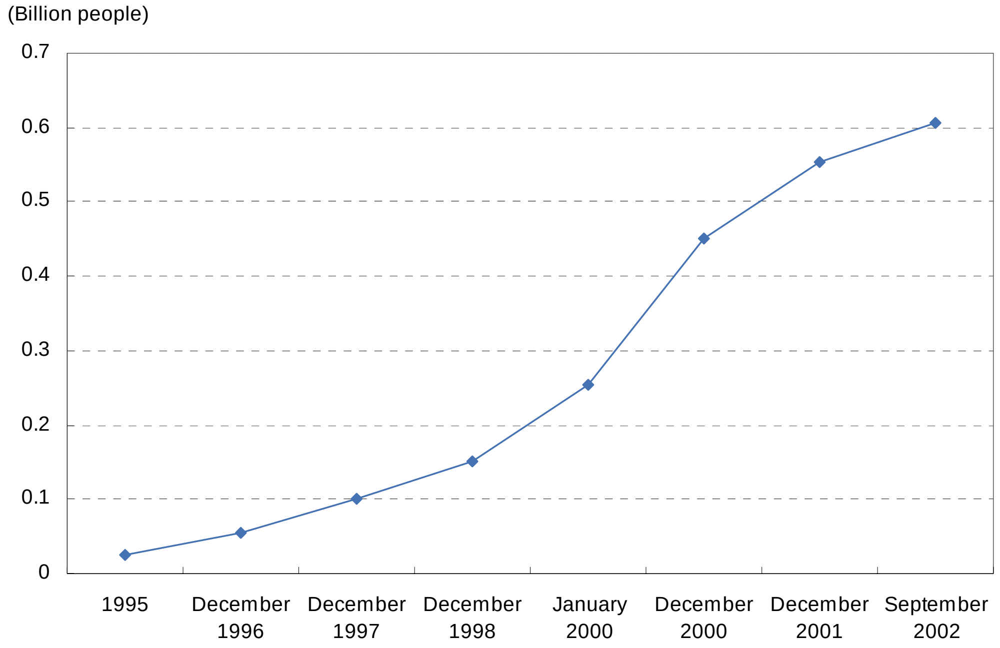


Figure 1-1-6 Trend in the total number of world Internet users

Source: Ministry of Internal Affairs and Communications. "2003 WHITE PAPER Information and Communications in Japan"

(People)

Region	No. of users
Europe	190,910,000
Asia-Pacific	187,240,000
North America	182,670,000
South America	33,350,000
Africa	6,310,000
Middle East	5,120,000
Total	605,600,000

Figure 1-1-7 Number of world users of the Internet, by region (as of September 2002)

Source: Ministry of Internal Affairs and Communications. "2003 WHITE PAPER Information and Communications in Japan"

The effects on society of these advances in IT have not been limited to an improvement in living conveniences, or to increased economic growth through the creation of new industries or improvements in productivity. The ability of computers to connect to the Internet anytime and anywhere is making it possible for the world's people to engage in instantaneous information exchanges with each other, which is leading to an upheaval in the traditional relationships between individuals, between the individual and the corporation, and between the individual and society.

For example, use of the Internet and cyberspace (virtual space) allows individuals to directly collect information about the world without needing to go through media such as newspapers or television, and at the same time to disseminate their own information out to the world as well. People can now go shopping or to work without leaving their own homes, and the result has been diversification of individual lifestyles, and the appearance of new creative activities, so that people in Japan, for example, can interact with other people all over the world to expand the range of their cultural and artistic activities, and cooperate with them in the creation of new artistic works.

On the other hand, the IT revolution has led to all-new societal problems, including the appearance of a Digital Divide (information gap) between generations and between regions, and the issue of information security.

In addition, the IT revolution has led to changes in society on a global scale, and the importance of appropriate responses to these changes, and of the need for international cooperation and contacts, is widely recognized.

In the Kyushu-Okinawa G8 Summit of 2000, Japan took the lead in bringing up information technology as an important issue for discussion, with the result that the "Okinawa Charter on Global Information Society" (IT Charter) was adopted to show the political outlook regarding the future shape of the IT revolution.

The IT Charter states, IT is "one of the most powerful forces for shaping the 21st century," and "its revolutionary effects extend to how people live, how they learn, how they work, and how the government interacts with civil society." In addition, utilization of IT should lead to realization of "a society in which people can demonstrate their own potential, and can boost the possibility of achieving their own hopes." Achievement of this kind of society will, according to the Charter, "allow everybody wherever they may be to participate profitably in the global information society" and "no person should be excluded from this profit."

Furthermore, based on these principles, the IT Charter calls for efforts for the early construction of reliable information networks, the fostering of human resources capable of handling the demands of the Information Age, guarantees of a secure cyberspace, and elimination of the Digital Divide, and shows the direction that should be taken. It also emphasizes the importance of cooperation among nations, international organizations, and private groups to eliminate international disparities.

Moreover, at such international organizations as the Organization for Economic Co-operation and Development (OECD), the World Trade Organization (WTO), and the World Intellectual

Property Organization (WIPO), efforts are ongoing to prepare international responses to such issues as information security, electronic commercial transactions, taxes, privacy, cryptography, and cyber crime prevention.

1.1.1.3 New Societal Issues Arising from Scientific and Technological Progress

While scientific and technological progress has broadened the range of people's activities, and made their lives more prosperous, new societal issues arising from the progress of science and technology have also become apparent.

The most representative example of these issues is undoubtedly the global environmental issue.

The content of global environmental issues can vary widely, from global warming to acid rain, destruction of the ozone layer, destruction of tropical rainforests, and desertification, and a common characteristic of these issues is that they can be traced to increased human activity due to progress in science and technology.

Scientific and technological progress helped mankind to build industrial societies in the 20th century that made wide use of underground resources, and to create prosperous societies and lifestyles. The result, however, was a society based on large-volume production, large-volume consumption, and large-volume waste. But the Earth's resources are obviously not limitless, and there is a limit to the ability of the natural environment to assimilate large volumes of waste. The idea of a "Spaceship Earth," which most vividly demonstrates the Earth's limited nature, was first broached in 1965 by Andrew Stevenson, then U.S. ambassador to the United Nations, who said in a speech that "We travel together, passengers on a little spaceship, dependent on its vulnerable reserves of air and soil." Later, in 1972, the Club of Rome further developed the "Spaceship Earth" concept in stating that there are "limits to growth." In that same year, the United Nations Conference on the Human Environment in Stockholm convened under the theme of "Only One Earth," as the world's people have increasingly come to recognize the limited nature of the planet that they live on.

Since then, discussions about the global environment have proceeded at various levels. At the same time, development has also progressed rapidly, contributing to a deepening crisis for the global environment, a situation made abundantly clear by ever more sophisticated methods of monitoring the globe.

As this situation progressed, it became clear that policies on a global scale were becoming necessary, and the result was the adoption of Agenda 21, an action plan for international efforts to deal with global environment problems, at the United Nations Conference on Environment and Development (UNCED, or the Earth Summit) held in Rio de Janeiro in 1992. Ten years later, in 2002, the World Summit on Sustainable Development (WSSD, or the Johannesburg Summit) was held in Johannesburg to review Agenda 21 and discuss new issues, and the "Johannesburg Declaration on Sustainable Development" was adopted. Sustainable development is a concept that was first incorporated into a report issued in 1987 by the World Commission on Environment and Development entitled "Our Common Future," and asserts that protection of the global environment and development need not be mutually exclusive, but should both be attainable, in the form of development that takes protection of the global environment into account. Sustainable development is now the basic philosophy behind all efforts to deal with global environmental issues today.

As global environmental issues have evolved, the people's awareness has also evolved. According to a survey conducted by the Institute of Statistical Mathematics, people who believed that "to achieve happiness, mankind must be in tune with nature" first exceeded those who believed that "to achieve happiness, mankind must subdue nature" around the year 1970, when the debate about global environmental issues first began to heat up (Figure 1-1-8).

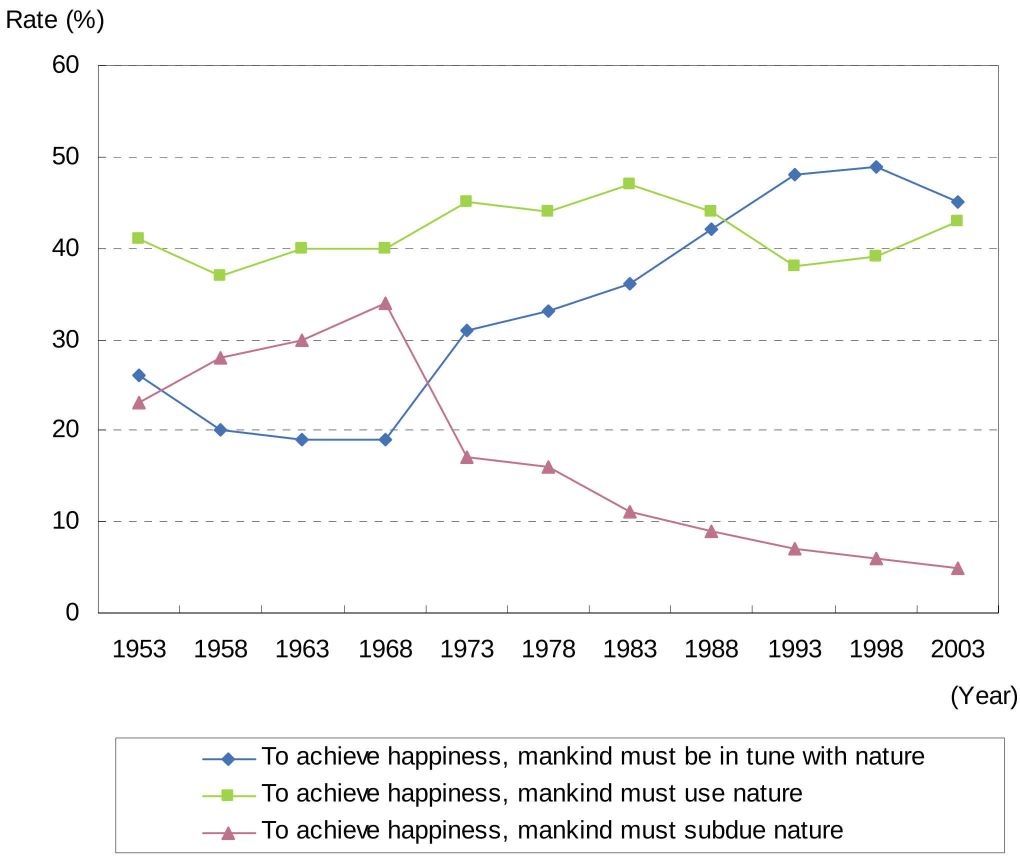


Figure 1-1-8 Relationship between nature and mankind

Source: The Institute of Statistical Mathematics. "Citizenship Research, 11th Nationwide Survey"

Another new societal issue arising from progress in science and technology is in regards to biotechnology. In particular, recent progress in genome analysis is being utilized in the medical and agricultural fields, and the results are expected to contribute greatly to improved human health and the assurance of stable food supplies. These same advances, however, have also raised ethical issues and concerns about safety.

In the area of IT, issues have been raised about a Digital Divide arising between generations and between regions, and also about information security.

As can be seen from the foregoing, various new issues have arisen alongside the progress of science and technology. Moreover, these issues have been made more complex as various ideas were raised in response to the content of specific issues, or to the social standing of different individuals, and have been applied in response to individual issues.

Furthermore, another point that needs mentioning is the fact that science and technology can be the key to responding to these issues. For example, the very existence of global environmental issues first became clear through the development of monitoring technologies, and science and technology is expected to play an important role in resolving such global environmental issues as reduction in the emission of greenhouse effect gases, sulfur dioxides, and nitrogen oxides. And in the area of gene recombination technology, further scientific knowledge is needed regarding its effects.

So far, the majority of people believe that the positive aspects of scientific and technological progress outweigh the negative aspects. Care will be needed, however, to ensure appropriate responses to societal issues that arise alongside the progress of science and technology, so that this attitude is not reversed in the future (Figure 1-1-9).

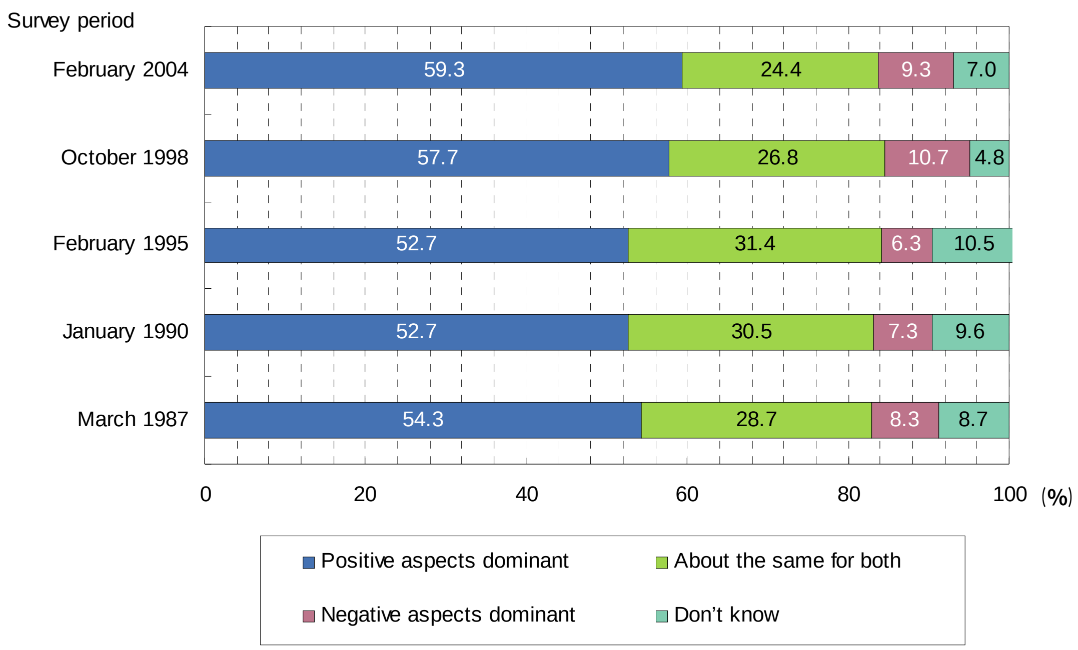


Figure 1-1-9 Positive and negative aspects of scientific and technological progress

Notes: 1. Responses to the question, "Scientific and technological progress is said to have positive aspects and negativeaspects. In general, which do you think is dominant?"
2. In the October 1998 and February 2004 surveys,"Positive aspects dominant" includes "Positive aspects somewhat dominant," and "Negative aspects dominant" includes "Negative aspects somewhat dominant."
Source: Cabinet Office. "Public Opinion Poll on Science and Technology, and Society"

1.1.1.4 Increase of New Factors Threatening Societal Safety and Security

So far, this section has mainly focused on the effect of scientific and technological progress on society. However, if a suitable relationship is to be built between science and technology and society, it is important that science and technology respond appropriately to what society demands.

In the past, societal demands on science and technology centered mainly on people's prosperity, on such things as increasing economic prosperity, health, and other aspects of people's lives.

While demands for a prosperous life remain strong even today, of course, people have responded to changing conditions in recent years at home and abroad with increased expectations for science and technology to ensure the societal safety and security that is a precondition for prosperous societies and lifestyles.

In the domestic arena, for example, the fragility of Japan's large cities has been starkly demonstrated in recent years by incidents that threatened societal safety and security, beginning with the Great Hanshin-Awaji Earthquake of 1995 and other natural disasters, the subway sarin gas attack that same year, the outbreak of toxic E. coli bacteria (O157) in 1996, and other deteriorations in public security.

In the international arena, while the end of the Cold War in 1989 initially led people to believe that the world was headed toward a new area of stability, the multiple terror attacks on the United States on September 11, 2001, the railway bombing terror attack in Spain on March 11, 2004, and many other terrorist incidents have left the world feeling very insecure. There are also threats from emerging or reemerging infectious diseases. Furthermore, the advance of globalization means that risks arising in certain countries or regions can quickly spread to locations anywhere in the world, as can be seen by the global spread in recent years of such diseases as avian influenza, BSE, and SARS.

In response to these myriad risks, people have in recent years become much more concerned about safety and security.

For example, in the "Public Opinion Poll on Social Awareness (January 2004)," a large proportion of respondents thought that security is one area where the situation is getting worse, and the ratio was higher than in the previous survey, conducted in December 2002 (Figure 1-1-10).

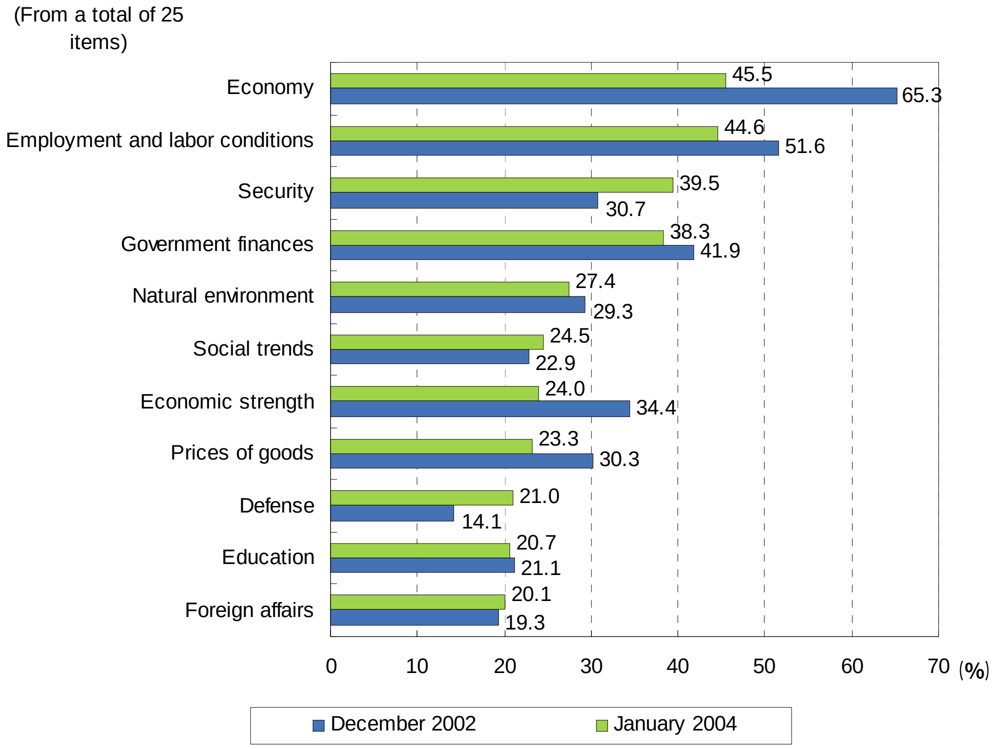


Figure 1-1-10 Areas in which Japan's present condition is getting worse

Source: Cabinet Office. "Public Opinion Poll on Social Awareness (January 2004)"

In addition, in the “Citizen’s Life Preference Survey (FY2002),” in which respondents were asked to rank 60 items related to their lives in order of importance, the top 10 survey result items all related to safety and security (Figure 1-1-11).

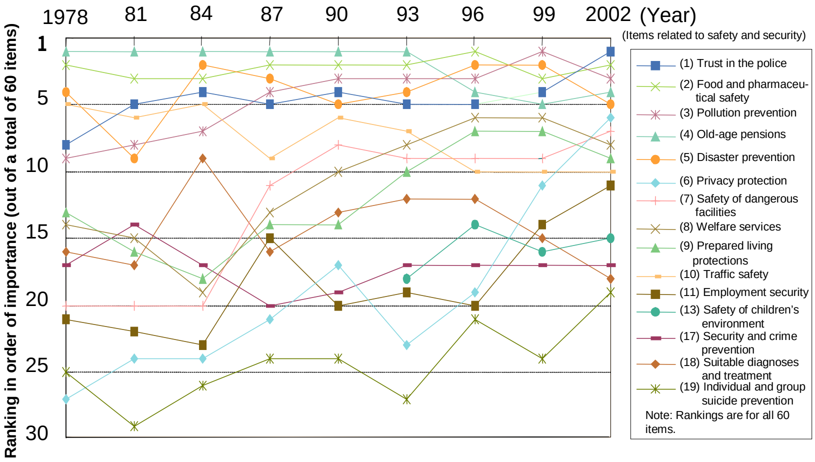


Figure 1-1-11 Trend in order of importance placed on items related to safety and security

Note: Of the 60 items surveyed in the Citizen’s Life Preference Survey , this figure shows the trend over the years in the rankings for items related to safety and security.
Source: Prepared by MEXT based on the Cabinet Office’s “Citizen’s Life Preference Survey (FY2002)”

Meanwhile, a question in the “Public Opinion Poll on Science and Technology and Society (February 2004)” regarding what topic people would most like to hear about from scientists or technologists found that a relatively high proportion of respondents selected “science and technology related to safety and security” (Figure 1-1-12).

These survey results appear to show that society demands further progress in science and technology related to safety and security.

In addition, a varied response from societal systems is needed to ensure society’s safety and security, and it is important that efforts in line with such responses be promoted.

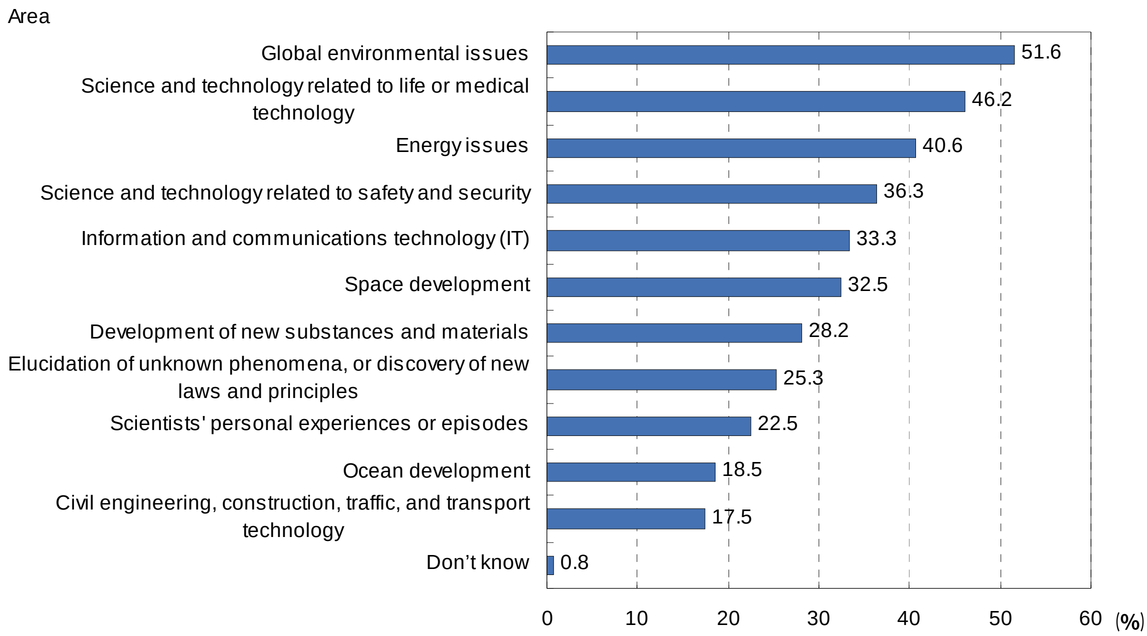


Figure 1-1-12 What sort of topics would you like to hear about from scientists?

Note: Response to the question, "What sort of topic on science and technology would you like to hear about from scientists or technologists?"
Source: Cabinet Office. "Public Opinion Poll on Science and Technology, and Society (February 2004)"

1.1.1.5 Relationship between Science and Technology and Society

(Science and Technology and the State)

At the time of the Industrial Revolution, the role of putting the results of science and technology to practical use in society was assumed mainly by entrepreneurs. These entrepreneurs used scientific and technological results for the development of products and improvement of production systems, in order to turn a profit. Where new scientific and technological results led to the creation of new industries, the needs of entrepreneurs also led to the creation of new sciences and technologies. Basically, the interaction between scientists, technologists, and entrepreneurs resulted in scientific and technological progress, and the people of society received the benefits of scientific and technological results.

As the years passed, moving from the 19th century into the 20th century, the situation gradually changed. Entrepreneurial utilization of science and technology, and the resultant dissemination of scientific and technological results to society, grew in size as the scale of economic activities expanded.

Meanwhile, as competition between nation-states became more intense, the state also came to focus on the importance of science and technology as a source of national power from the point of view of national security. As can be seen from the power in the military sphere that science and technology demonstrated in the two world wars, nations everywhere were increasingly recognizing the importance of science and technology to the point that, after World War II, science and technology policy came to be positioned as an integral part of national policy. In this way, the nation-state joined entrepreneurs in the role of promoting science and technology, and putting its results to practical use in society.

Of course, the nation-state was not interested in the products of science and technology merely for the enhancement of national prestige or for military uses, they were also used for the promotion of industry, soil preservation and flood control measures, the development of road and rail networks, the development of sewer and water lines, assurance of energy sources, and many other societal infrastructure improvements. Moreover, much of what was developed for the enhancement of national prestige or for military purposes also turned out to have practical uses in society.

With the end of the Cold War in 1989 and the collapse of the bipolar world structure centered around the United States and the Soviet Union, the situation changed again. First of all, the great power arms race centering on weapons of mass destruction faded away, and the significance of national prestige based on science and technology relatively lessened. At the same time, the collapse of Communism and the rise of globalization promoted unification of the world’s markets, and global economic activities surged ahead. In line with these developments, one of the main objectives for national science and technology policy came to be economic development, with the result that more emphasis was placed on policy than ever. Moreover, utilization of scientific and technological results became increasingly important in social welfare, social infrastructure development, and all other arenas of state activity.

In recent years, furthermore, the occurrence of large-scale natural disasters, the global spread of infectious diseases, and frequent terrorist attacks beginning with the multiple terrorist attacks on the United States in 2001, have focused attention on the ability of science and technology to ensure the safety and security of states and societies in ways that go beyond military power.

(Science and Technology and the Individual)

Until recent years, the relationship between science and technology and the individual, has basically been one of the individual passively receiving the results of science and technology. While the benefits of science and technology have varied to some degree depending on the country or region, they have basically been recognized as being shared all across society, and the reception of people to scientific and technological progress has generally been positive and shared.

In addition, individuals had a relatively wide range of choices in regards to whether or not to utilize the results of science and technology. While the utilization of home electrical appliances such as refrigerators or washing machines, for example, offers everyone the same kind of benefit in terms of reduction of labor, if an individual were for some personal reason to decide not to make use of these devices, the only result would be a missed opportunity to reduce his or her own labor, a situation that would cause little inconvenience to the society at large.

In recent years, however, advancing globalization, as well as the IT revolution and other advances in science and technology, are inducing great changes in the very nature of society, so that individuals no longer have any choice but to be swept along by the effects of scientific and technological advances. For example, further advances in the IT revolution will serve to make communications via the computer or Internet more general than ever, and failure to make use of that technology will not only be simply a matter of inconvenience, but also will represent a drastic narrowing of possibilities for individual activities in the areas of business, research, learning, medicine and welfare, arts and culture, entertainment, and many other aspects of daily living, to the point that even information deemed absolutely essential for life may become unobtainable. In addition, when such activities as electronic trading, Small Office, Home Office (SOHO), and remote medical treatment based on IT become the norm, an inability to use computers or the Internet could severely restrict the range of services that an individual can receive or his or her range of employment choices. Furthermore, the IT revolution will surely boost the value of information in society and life, and with the acquisition and dissemination of information via the Internet becoming the norm, a lack of access to the Internet will severely limit the range of information that an individual can obtain, placing that individual in an extremely inconvenient situation.

With progress in science and technology changing the very nature of society, failure to utilize the results of science and technology could leave an individual incapable of dealing with the new society, and saddled with a narrow range of choices regarding utilization of scientific and technological results.

Moreover, the global environmental problems that have arisen in the wake of the expansion of human activities due to scientific and technological progress adversely affect individuals regardless of their own choices. And as the case of gene-recombinant crops shows, those who benefit from the utilization of scientific and technological results are beginning to steer a different course from those who must bear the risks.

Meanwhile, society's demands on science and technology are rising, as can be seen by the expectations society places on science and technology in regards to the safety and security issue.

The relationship between science and technology and individuals, therefore, is becoming close and inseparable, and is also becoming more diverse, according to the needs of each individual. As a result, the time is approaching when individuals will need to make decisions on how to relate to science and technology. Toward this objective, individuals will need to have an interest in science and technology, and to possess enough knowledge to be able to make an informed decision.

But even though society is already changing in this direction, the "Public Opinion Poll on Science and Technology and Society (February 2004)" found that, in Japan, the people's interest in science and technology was declining.

Slightly more than 50% of respondents, for example, expressed an interest in news and issues that involve science and technology. While a majority, the percentage was lower than the response ratios seen in the survey results for 1990, 1995, and 1998. By age group, interest among people in the age 29 and under group declined particularly sharply year by year (Figures 1-1-13, 1-1-14).

Furthermore, the ratio of respondents who did not feel any interest or enjoyment from contact with science and technology rose from 29.1% in February 1995 to 44.2% in the latest survey (Figure 1-1-15).

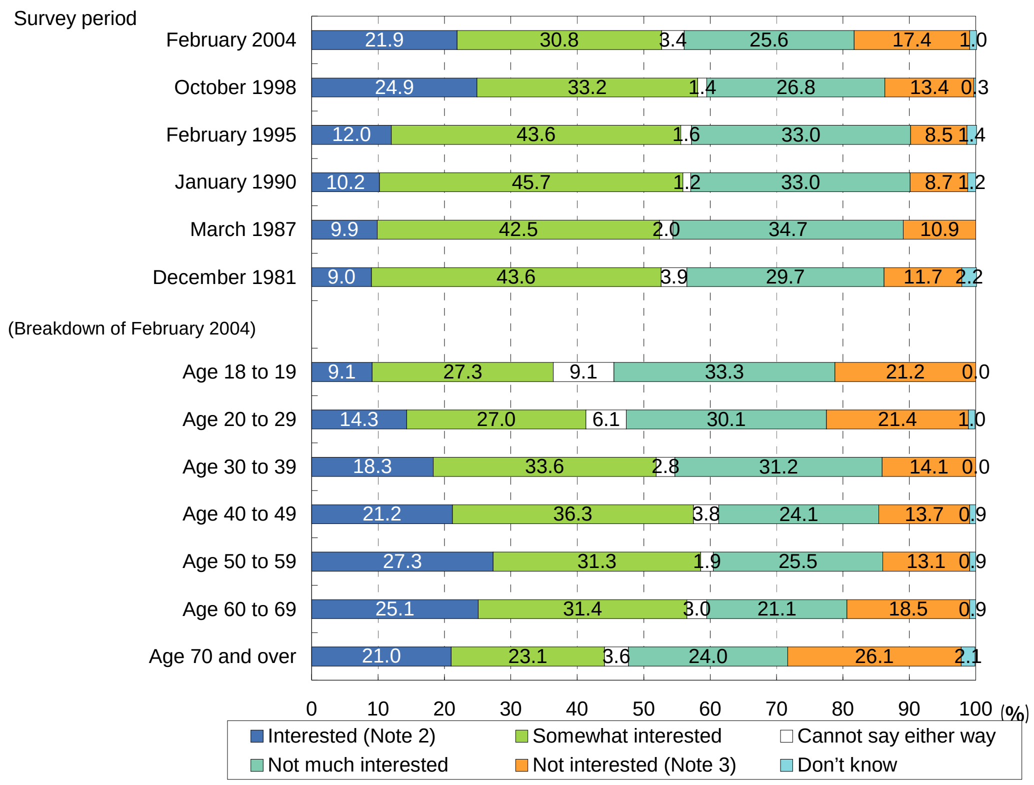


Figure 1-1-13 Interest in news or topics about science and technology

Notes: 1. Response to the question, "Are you interested in news or topics about science and technology?"
2. In the surveys up to February 1995, this response was "Extremely interested."
3. In the December 1981 survey, this response was "Not interested (at all)," and in the surveys from March 1987 to February 1995, it was "Not interested at all."
4. In the March 1987 survey, "Cannot say either way" also includes "Don't know."

Source: Cabinet Office. "Public Opinion Poll on Science and Technology and Society (February 2004)."

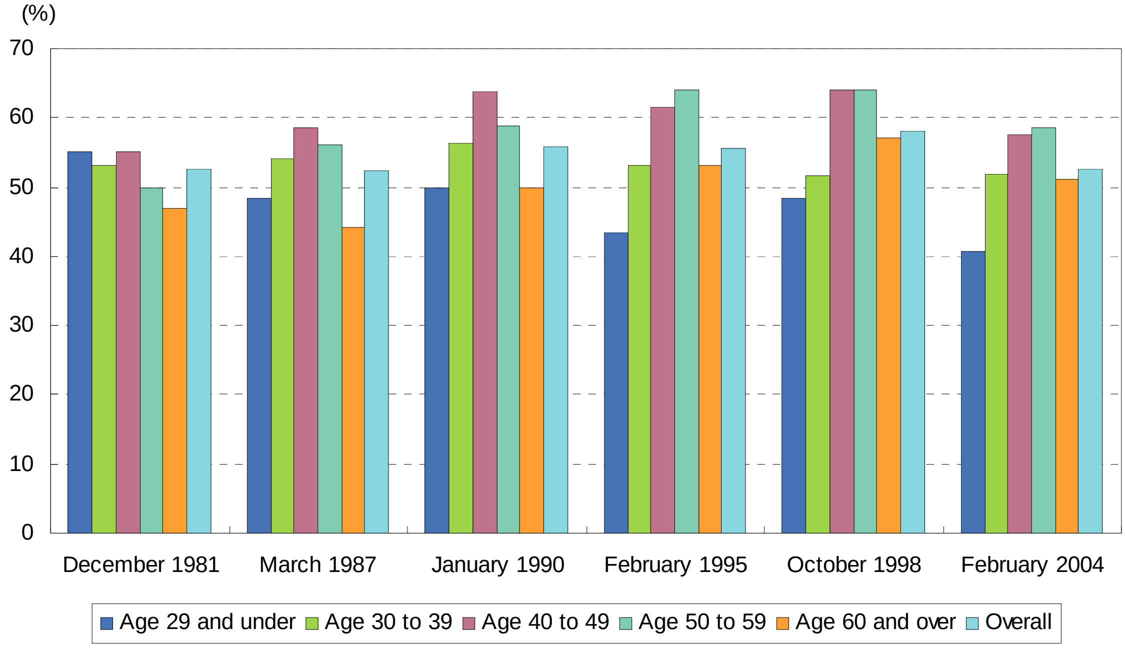


Figure 1-1-14 Trend in degree of interest in science and technology, by age group

Source: Cabinet Office. “Public Opinion Poll on Science and Technology and Society”

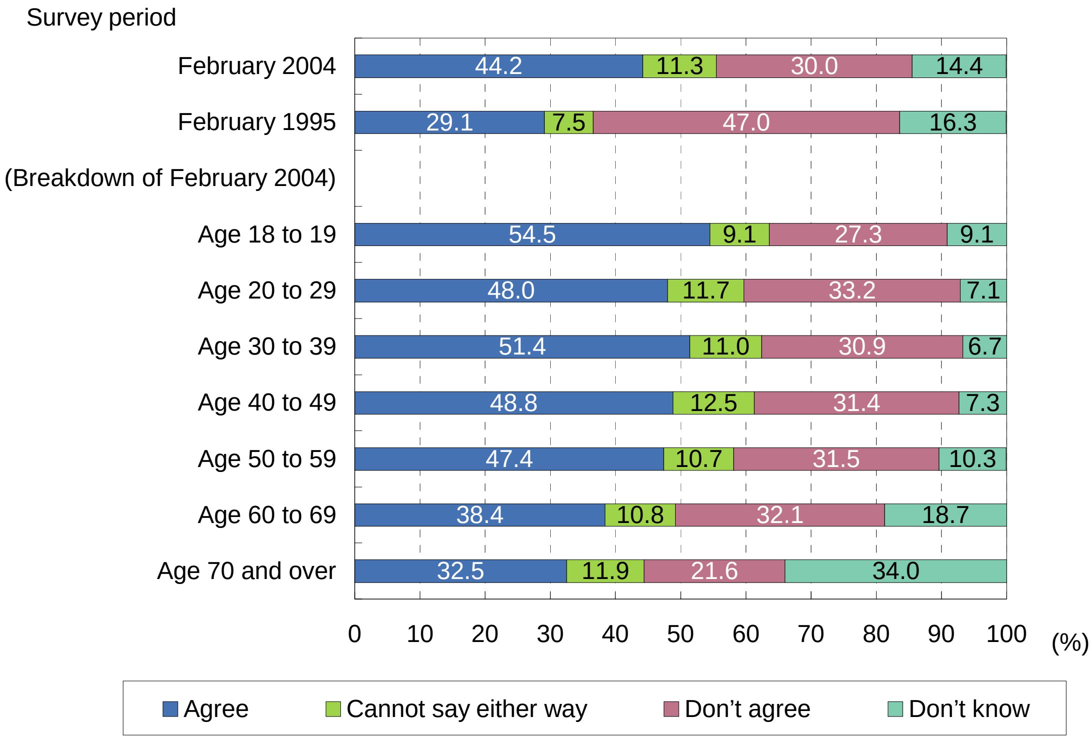


Figure 1-1-15 Cannot feel any interest or enjoyment from contact with science and technology

Notes: 1. Response to the question, "What do you think about the opinion that 'I cannot feel any interest or enjoyment from contact with science and technology'?"
2. In the February 1995 survey, "Agree" is a combination of "I completely agree" and "I agree," while "Don't agree" is a combination of "I don't agree at all" and "Don't agree." In the February 2004 survey, "Agree" is a combination of "Agree" and "Somewhat agree," while "Don't agree" is a combination of "Don't agree very much" and "Don't agree."

Source: Cabinet Office. "Public Opinion Poll on Science and Technology and Society (February 2004)"

As will be seen in the next section, this trend is not limited to Japan, but is also occurring in the United States and in Europe, and appears to be common throughout the advanced nations. Restoring the people's interest in science and technology has become an urgent issue.

(The Need for Building a New Relationship between Science and Technology and Society)

The following can summarize what has been said so far in this section regarding the current relationship between science and technology and society.

First, science and technology has not only made human society more prosperous, it has been the engine driving the evolution of the very nature of society. Moreover, expectations are high that science and technology will continue playing this role in the future, and will also be responsive to new issues that arise as times change, such as ensuring the safety and security of society.

Next, as seen in such areas as global environmental problems and bioethical issues, examples where scientific and technological progress can have both good and bad effects on society already exist, and as seen with information technology, there exist sciences and technologies that are becoming absolutely essential for society and people's lives. In a word, the relationship between science and technology and society, and particularly with individuals, is becoming close and inseparable, and the time is approaching when individuals must think clearly about what kind of relationship they should have with science and technology. Despite this situation, however, people's interest in science and technology appears to be on the decline, at least in advanced countries such as Japan.

What is needed in this situation is for science and technology to respond flexibly to the needs of society as they change over time, or in other words, to become a "science and technology for society."

At the same time, scientists, technologists, and other people involved in science and technology should be aware of the role that science and technology plays in society, and of its influence, and should actively strive to convey information about their own activities to society. They should also try to help people at the individual level to obtain a deeper interest in and knowledge of science and technology, so as to able to utilize science and technology themselves. Moreover, cooperation among the community of scientists, corporations, individuals, and every other level of society should be harnessed to promote science and technology and thus help society to develop. In other words, what is needed is "science and technology in society."

The path that science and technology needs to take in the future is thus "science and technology for society, and in society." Only when these viewpoints are understood can science and technology move on to contribute even more to the future development of human society.

1.1.2 World Policy Trends Related to Science and Technology and Society

Section 1.1.1 discussed how scientific and technological progress has further deepened the relationship between science and technology and society. This next section features an introduction of trends around the world in response to the above changes, using as a representative example the global environmental problem of global warming. The section also includes an introduction of trends in regard to "science and technology for society, and in society," as seen in the World Conference on Science convened in Budapest in 1999, and in science and technology policies drawn up in the United States and European countries.

1.1.2.1 Contribution of Science and Technology to the Global Warming Problem

Global environmental problems are new issues facing society as a result of the expansion of human activities as science and technology has progressed. One such issue, in particular, is the global warming problem, which provides an example of scientists first clarifying the mechanism and tracing its origins, and then, as scientific knowledge accumulated in the course of further progress in science and technology, using the provision of climate change monitoring data and future forecasting data as an opportunity to establish a framework for international society as a whole to engage the problem and move toward a solution.

(Discovery of the Global Warming Phenomenon, and Progress in the Accumulation of Scientific Knowledge)

Global warming refers to the phenomenon of rising worldwide temperatures and a changing climate caused by high and rising concentrations of carbon dioxide and other greenhouse gases in the atmosphere due to increased human activity. A theory elucidating the mechanism for this warming effect was first described by the Swedish physicist Svante Arrhenius near the end of the 19th century.

In 1958, Charles Keeling of the U.S. Scripps Institution commenced periodic monitoring of carbon dioxide concentrations in the atmosphere at the Mauna Loa Observatory in Hawaii. The data collected through this monitoring showed conclusively that carbon dioxide concentrations were rising, and scientists everywhere redoubled efforts to research global warming in their own regions (Figure 1-1-16).

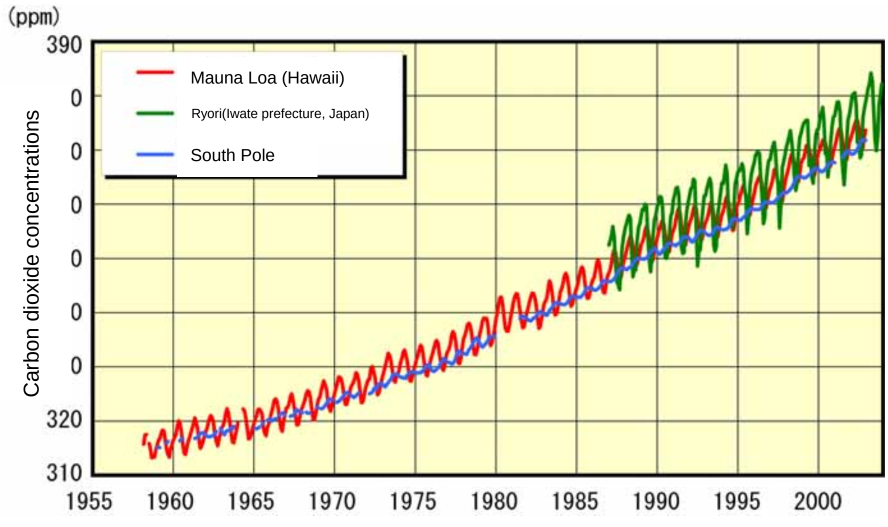


Figure 1-1-16 Trends in carbon dioxide concentrations in the atmosphere

Source: Japan Meteorological Agency. "Climate Change Monitoring Report 2003"

As the monitoring data accumulated, scientists spoke out about global warming and began raising the alarm. In 1985, the United Nations Environment Programme (UNEP) hosted the Villach (Austria) Conference, the world's first international conference of scientists on global warming. At this conference, the scientists issued a statement that "the rise in the average global temperature by the middle of the 21st century could well be on a scale not seen since the dawn of humanity," marking the first time scientists had joined together to issue a warning to society about global warming.

Up to that time, only scientists had sounded the alarm about global warming, and government policymakers had yet to become involved in the global warming discussions.

(Contribution of Scientific Knowledge to Policymaking)

Since the Villach Conference, the global warming problem has come to be widely recognized in society, and scientists and policymakers are at last working together to promote discussion of the global warming problem.

The main role in this effort has been played by the Intergovernmental Panel on Climate Change (IPCC), established in 1988 by the World Meteorological Organization (WMO) and UNEP. The IPCC, which is composed of both scientists and policymakers, is the first such organization to operate at the governmental level, and was established for the purpose of gathering and assessing the latest scientific, technological, and socioeconomic data regarding climate change, and for assisting national governments.

The First Assessment Report published by the IPCC in 1990 stated "average earth temperatures will rise by about 3 degrees by the year 2100. In order to hold concentrations in the atmosphere at current levels, carbon dioxide emissions will need to be cut by more than 60%," and concluded that "continued accumulations of man-made greenhouse gases in the atmosphere will result in climate change that will have unavoidably serious effects on nature and on human systems." In response to this report, the United Nations General Assembly approved a decision in 1991 to launch the Intergovernmental Negotiating Committee to discuss the "Framework Convention on Climate Change," and the convention was adopted in the following year of 1992 at the fifth resumed session of the negotiating committee. Later that year, the Framework Convention on Climate Change was readied at the United Nations Conference on Environment and Development (the so-called "Earth Summit" in Rio de Janeiro) for signing.

Later, the IPCC continued gathering and reviewing scientific knowledge, releasing the Second and Third Assessment Reports in 1995 and 2001, and revising and improving its climate change forecasting models. While some areas of uncertainty remain, the reliability of these forecasting models has improved greatly (Table 1-1-17). This is clearly expressed in the report descriptions. The Second Assessment Report, for example, asserted that "identifiable human effects have appeared in the general global climate," and the report was used as a basis for the adoption of the Kyoto Protocol, which made reduction of greenhouse gases legally binding, is at the Third Conference of the Parties (COP3) held in Kyoto in 1997. Furthermore, the Third Assessment Report released in 2001 clearly stated that "according to more powerful evidence obtained in recent years, virtually all of the global warming monitored in the last 50 years has been due to human activity" (Figure 1-1-18).

Table 1-1-17 IPCC forecast figures for global warming

	1st Assessment Report (April 1990)	2nd Assessment Report (December 1995)	3rd Assessment Report (March 2001)
Carbon dioxide density in atmosphere	About 800ppm	750 - 1000ppm	540 - 970ppm
Average ground temperatures	Rise of about 3℃	Rise of 1.0 - 3.5℃	Rise of 1.4 - 5.8℃
Average ocean surface level	Rise of about 0.65m	Rise of 0.13 - 0.94m	Rise of 0.09 - 0.88m

Source: IPCC. "Assessment Report"

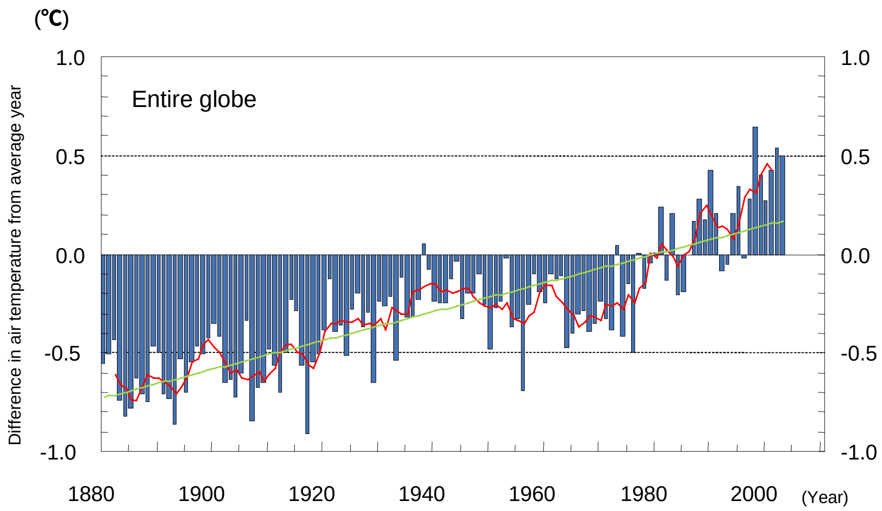


Figure 1-1-18 Changes in global ground temperatures (1880 to 2003)

Note:The bar graphs (blue) show the difference in air temperature for each year from the average year (average value for the 30-year period from 1971 to 2000), while the red line represents the five-year moving average of the difference from the average year, and the straight line (green) shows the long-term trends of the average difference.

Source: Japan Meteorological Agency. "Climate Change Monitoring Report 2003"

Nevertheless, in March 2001, immediately after the release of the Third Assessment Report, the United States, the world's largest source of carbon dioxide emissions, announced it was withdrawing from the Kyoto Protocol. The reasons given for withdrawal included the lack of obligations on the part of developing countries to reduce emissions, which was called unfair, and the possibility of adverse effects on the U.S. economy. The U.S. government also pointed out the scientific uncertainties in the Kyoto Protocol, and in May 2001 asked the U.S. National Academy of Sciences (NAS) for its opinion on the IPCC report. The NAS responded with the release of a report which agreed in general with the content of the IPCC assessment report, but concluded that clarification at a higher standard of reliability was needed.

The Third Assessment Report won the support of participants at a ministerial-level meeting of the Ninth Conference of the Parties to the Framework Convention on Climate Change (COP9), held in Milan in December 2003, because it provides a clear scientific basis for taking policy action against global warming, and will be utilized as the basis for future international negotiations. The results of this conference appeared to show that policies against global warming cannot make progress without the contribution of science and technology, in the form of global monitoring and change forecasting (Figure 1-1-19).

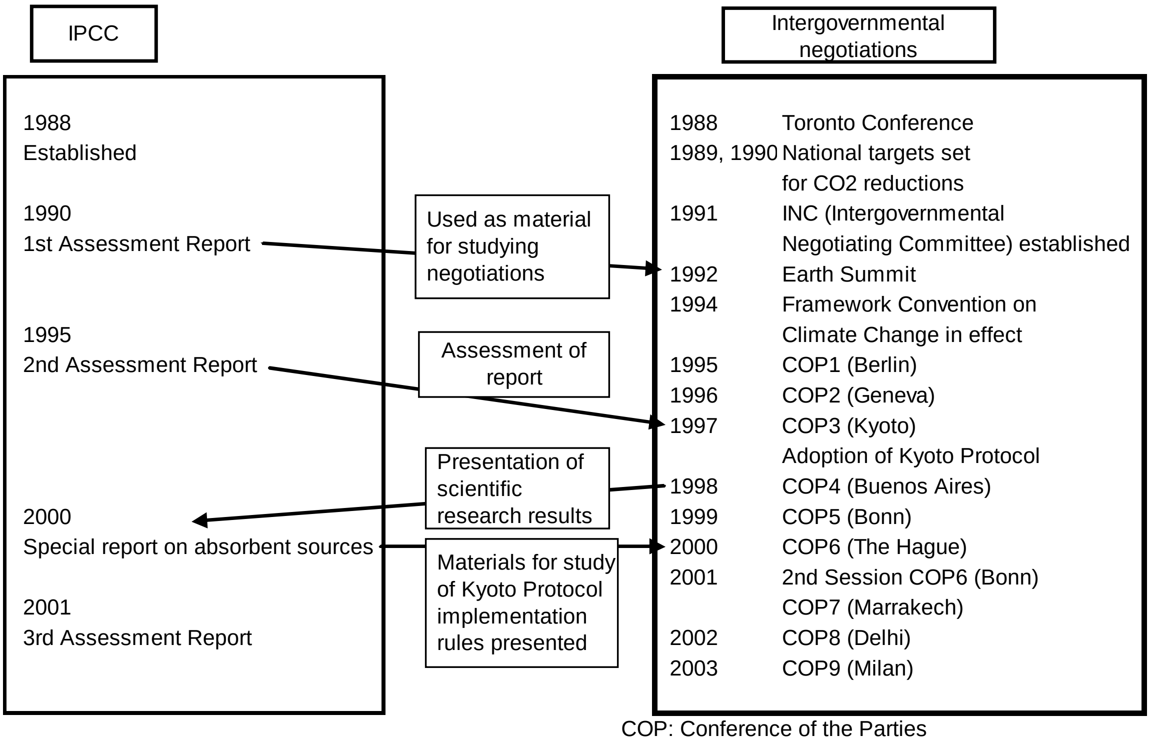


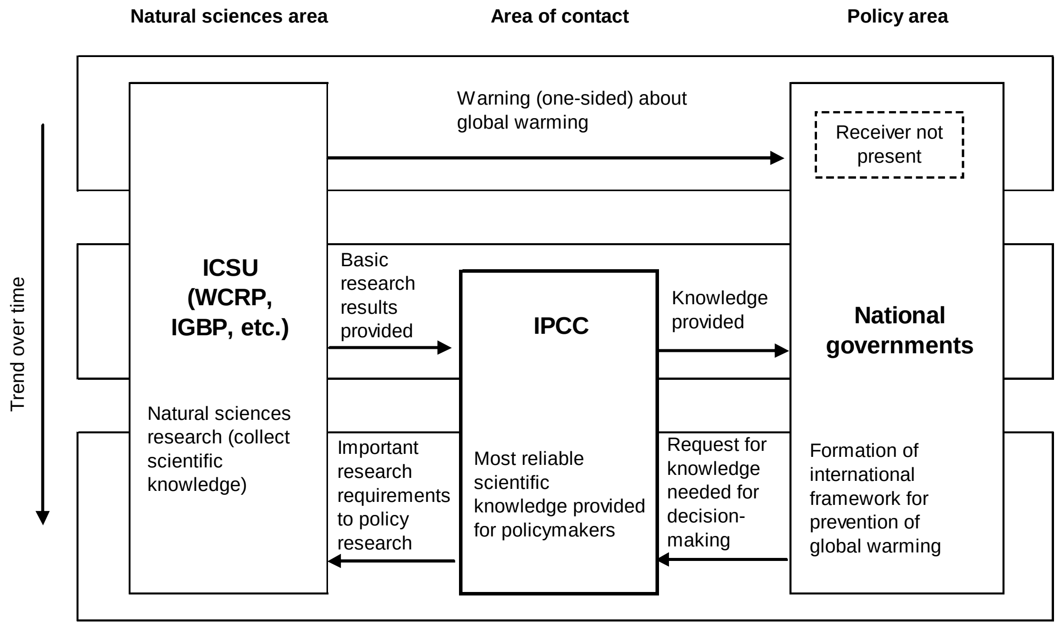
Figure 1-1-19 Relationship between IPCC and inter-governmental negotiations

Source: Prepared by MEXT, based on materials from the Council for Science and Technology Policy (August 2001)

As can be seen, international society is increasingly placing expectations and demands on science and technology toward the resolution of global environmental problems.

At the World Summit on Sustainable Development (Johannesburg Summit), attended by 191 nations around the world in 2002, the participants adopted the Johannesburg Declaration on sustainable development, as well as an Action Plan for the Declaration. The Action Plan incorporates high expectations for science and technology, and states that "improving cooperative structures between scientists in the natural sciences and social sciences, and between scientists and policymakers, will improve policy and decision-making at all levels, including emergency actions at every level," and promises to "continue supporting IPCC and other international scientific assessments in support of decision-making, and to cooperate with them." In addition, to elucidate global climate change and its effects, the Action Plan also "recommends organized monitoring of the Earth's air, land, and sea" and "recommends the development and wide-ranging use of Earth monitoring technology."

Later, adoption of the "G8 Science and Technology Action Plan for Sustainable Development," which includes calls for strengthening international cooperation for Earth monitoring, at the 2003 Summit of Advanced Nations (G8: Evian Summit), shows that science and technology is playing an increasingly important role, and that expectations are rising (Figure 1-1-20).



ICSU: International Council for Science WCRP: World Climate Research Programme
IGBP: International Geosphere-Biosphere Programme

Figure 1-1-20 About the relationship between science and policy

Source: Prepared by MEXT, based on materials from the Council for Science and Technology Policy (August 2001)

The rapid development of Earth monitoring technologies and other sciences and technologies since the start of the 20^{th} century has made it possible to make more precise and more reliable forecasts of future climate change. This accumulation of scientific knowledge has helped persuade national governments to recognize the importance of international efforts for the prevention of global warming, and has resulted in mandates for governments to promote policies toward that end. In other words, science and technology has come to have a major effect on global-scale decision-making in society, or to put it another way, the day has arrived when policymaking cannot proceed without input from science and technology.

1.1.2.2 New Responsibilities for Science and Technology in the 21st Century

The World Conference on Science (Budapest Conference) convened in the Hungarian capital of Budapest in July 1999 under the joint auspices of the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the International Council for Science (ICSU) was an event that marked a global turning point, with scientists re-examining the future of science and technology, and the nature of science.

The background to convening this conference can be described as follows: Where scientific and technological progress over the past several decades brought economic prosperity, it also had a negative side, such as environmental problems, that needed to be newly resolved. In recognition of the fact that the negative problems could not be resolved without the appropriate and timely utilization of science and technology, and that , it was necessary for science society, industry, government, and citizens to meet at a single location, the conference attracted about 1,800 people from around the world, including scientists, technologists, legislators, journalists, bureaucrats, and ordinary citizens, to talk for six days about the nature of science in the 21st century.

The conference adopted the "Declaration on Science and the Use of Scientific Knowledge" and the "Science Agenda – Framework for Action" to state the new responsibilities for the promotion of science in the 21st century.

The preamble to the Declaration states "the sciences should be at the service of humanity as a whole, and at the same time, should contribute to providing everyone with a deeper understanding of nature and society, a better quality of life, and a sustainable and healthy environment for present and future generations."

Furthermore, the Declaration adds "today, whilst unprecedented advances in the sciences are foreseen, there is a need for a vigorous and informed democratic debate on the production and use of scientific knowledge. The scientific community and decision-makers should seek the strengthening of public trust and support for science through such a debate," and then lists four concepts as responsibilities for science in the 21st century, including the already functioning "science for knowledge," as well as the new "science for peace," "science for development," and "science in society, and for society" concepts (Table 1-1-21).

The "Science Agenda – Framework for Action" presents specific actions that governments and the community of scientists should take to fulfill the contents of the Declaration.

Table 1-1-21 Overview of the "Declaration on Science and the Use of Scientific Knowledge"

<Preamble>

The sciences should be at the service of humanity as a whole, and should contribute to providing everyone with a deeper understanding of nature and society, a better quality of life, and a sustainable and healthy environment for present and future generations.

Today, whilst unprecedented advances in the sciences are foreseen, there is a need for a vigorous and informed democratic debate on the production and use of scientific knowledge. The scientific community and decision-makers should seek the strengthening of public trust and support for science through such a debate.

The main text consists of the following four sections:

1. Science for knowledge; knowledge for progress
   - Promoting fundamental and problem-oriented research is essential for achieving endogenous development and progress.
   - The public sector and the private sector should work in close collaboration and in a complementary manner in the financing of scientific research for long-term goals.
2. Science for peace
   - Worldwide cooperation among scientists makes a valuable and constructive contribution to global security and to the development of peaceful interactions between different nations, societies and cultures.
   - The natural and social sciences and technology need to be used as tools to address the root causes and impacts of conflict.
3. Science for development
   - Enhanced support should be provided for building up an adequate and evenly distributed scientific and technological capacity through appropriate education and research programmes as an indispensable foundation for economic, social, cultural, and environmentally sound development.
   - Science education, in the broad sense, without discrimination and encompassing all levels and modalities, is a fundamental prerequisite for democracy and for ensuring sustainable development.
   - The building of scientific capacity should be supported by regional and international cooperation, and progress in science requires various types of cooperation.
   - In each country, national strategies and institutional arrangements and financing systems need to be set up, or the role of sciences in sustainable development enhanced.
   - Measures should be taken to enhance those relationships between the protection of intellectual property rights and the dissemination of scientific knowledge that are mutually supportive.
4. Science in society, science for society
   - The practice of scientific research and the use of knowledge from that research should always aim at the welfare of humankind, including the reduction of poverty, and be respectful of the dignity and rights of human beings, and of the global environment.
   - Each country should establish suitable measures to address the ethics of the practice of science and of the use of scientific knowledge and its applications.
   - All scientists should commit themselves to high ethical standards.
   - Equal access to science is not only a social and ethical requirement, but also essential for realizing the full potential of scientific communities worldwide, and for scientific progress that meets the needs of humankind.

Up through the 20th century, science has progressed based on "science for knowledge," so that while it produced various results and benefits for society, it also produced negative environmental problems. The Declaration is undoubtedly the result of recognition by the community of scientists that they are in danger of losing the trust and support of society if science and technology in the 21st century cannot contribute to the resolution of these negative issues.

At the Johannesburg Summit of 2002, then-chairman Hiroyuki Yoshikawa of the ICSU, who had been invited to represent the community of scientists, clearly stated in a speech that "the science and technology community bears a responsibility to engage with the issue of general and comprehensive sustainable development through education, training, research, and the technological revolution. Scientists and technologists should be responsive to demands for knowledge required by society, the private sector, and government in order to devise solutions and choices regarding sustainable development." Earlier, in 2001, about 90 science academies from around the world joined to establish the InterAcademy Council (IAC), for the purpose of offering scientists' advice for policymaking by the United Nations and other international institutions.

Efforts to implement the specifics of the Budapest Conference Declaration are currently in progress.

In Japan, as well, the Second Science and Technology Basic Plan now in effect positions "building a new relationship between science and technology and society" as its basic philosophy, and developing policies for the establishment of communications between science and technology and society, and for returning scientific and technological results back to society. In addition, consideration of the future of the Science Council of Japan, which represents the community of scientists in Japan, was conducted, and a proposal was completed in July 2003. In line with the Budapest Conference Declaration, the new proposal places emphasis on the council's functions for policy recommendation and for communication with society.

UNESCO and ICSU are currently doing follow-up on the progress since the Budapest Conference Declaration and Science Agenda.

1.1.2.3 Policy Trends in the United States and Europe

(1) Trends in the United States (Proposals for the Direction of Science and Technology Policy after the End of the Cold War)

In the United States, President Bill Clinton in February 1993 announced "Technology for America's Economic Growth – A New Direction to Build Economic Strength," shifting the direction of science and technology policy from military research to civil research in order to strengthen economic competitiveness.

Science and technology policy in the United States following the World War II, while at times shifting emphasis with changes of administration, is said to have been basically shaped by a report issued in 1945 by Vannevar Bush, head of the wartime Office of Scientific Research and Development, entitled "Science: The Endless Frontier" (popularly known as the "Bush Report"). The report listed the sectors of science research activity that should be supported by the federal government, including military research, public health, and medical science, and also argued for an emphasis on basic research, asserting that government support for basic research would be linked to the growth of industry.

Later, in September 1998, the U.S. House of Representatives Committee on Science released a report on U.S. science and technology policy in the 21st century, entitled "Unlocking Our Future: Towards a New National Science Policy," in which a proposal was made to shift to a science and technology policy that focuses on society.

The House of Representatives Committee on Science report revealed a recognition that, with the Cold War between East and West now over, there was a need to shift away from the previous emphasis on strengthening military power to a science and technology policy that aimed for strengthening economic competitiveness, to ensure that the United States would be able to maintain a leading role in the midst of economic globalization. The report listed four main goals for science and technology policy in the future, including national security, health, the economy, and support for decision-making, and revealed what policies the federal government should take to achieve those goals, as well as the responsibilities of the state governments, universities, industry, scientists, etc.

Items meriting particular emphasis included:

- i) Promotion of basic research
- ii) Application of scientific and technological results to new industrial technologies, and to societal and environmental problems
- iii) Improvement of science education, and

emphasis on dialogue between scientists and the people

Regarding the last point, the report particularly focused on the improvement of science and mathematics education for children age 12 and under, and called for increased communication between scientists and technologists and the people, with specific recommendations as follows:

- To build bridges between scientists and journalists, scientists should be required to take courses in journalism and communications before graduation, and journalists should be given the opportunity to take science writing courses
- Researchers and technologists with skills for communicating with ordinary people should be given time to work on communications, in addition to their regular research activities
- Plainly worded summaries of government-funded research results should be prepared for publication, or placed on the Internet, so that a wide range of ordinary citizens can acquire the information

Later, in February 2001, the United States Commission on National Security/21st Century, a bipartisan group of people with legislative experience, announced the "Road Map for National Security: Imperative for Change" report, which featured proposals for U.S. security strategy through 2025.

The report, working from the assumption that the true source of national power and wealth lies in science and technology and in advanced education, and arguing that the United States needs to maintain its leading position in the world, emphasizes the importance of science and technology to U.S. national security, and makes proposals for the federal government to double its outlays for research and development, and to expand science and technology education.

(Federal Government Response to Societal Issues)

After the multiple terrorist attacks of September 2001, expectations rose for the utilization of advanced science and technology in response to the people's security and emergency situations. In this regard, the community of scientists is making proposals to the government. In June 2002, the National Research Council (NRC) issued a report titled "Making the Nation Safer: The Role of Science and Technology in Countering Terrorism." The report featured an announcement of the determination of the U.S. science community to respond to terrorism, showed the direction of anti-terrorism research and development from the short-term and long-term perspectives, and proposed the establishment of a strategic security institution, which culminated in the establishment in January 2003 of the U.S. Department of Homeland Security (DHS). To promote utilization of science and technology, the Homeland Security Advanced Research Projects Agency (HSARPA), was established within the DHS for comprehensive implementation of everything from basic research to development related to homeland security.

Again, in response to the anthrax incident of September 2001, the Public Health Security and Bioterrorism Preparedness and Response Act was passed in June 2002, to position research into bioterrorism countermeasures as an important sector for government research and development, and R&D is now going ahead at the National Institutes of Health (NIH) and elsewhere.

Elsewhere, the National Nanotechnology Initiative (NNI) was established in the year 2000 for the nationwide promotion of research and development into nanotechnology, a sector where competition has become fiercer around the world. It was further bolstered by the passage of the 21st Century Nanotechnology Research and Development Act in December 2003. While progress in research and development for the nanotechnology sector is expected to have a huge impact on both the economy and society through the creation of new industries, it is also recognized that its impact on society must be taken into consideration when applications are made, in much the same way as the bioethics issue has shaped the biotechnology sector. And while research on nanotechnology's impact on society has been pursued since the NNI was launched, the new law mandates that research and development take into consideration ethical, legal, environmental, and other society-related issues.

In the United States, expectations for science and technology tend to rise higher each time a societal issue becomes apparent, and development of responsive policies from the perspective of science and technology being accepted and utilized by society is now in progress in various sectors.

(Expansion and Strengthening of Science Education and Promotion Activities)

In the United States, as was also indicated in the reports issued by the House of Representatives Committee on Science and the United States Commission on National Security/21st Century, expansion of science and technology and education is recognized as being most important for laying the foundation of the nation. On the other hand, public opinion surveys reveal a serious situation in which people are becoming more distant from science and technology and student skills in science and mathematics are deteriorating (Table 1-1-22).

Table 1-1-22 Increased distance from science and technology in the United States

<Public understanding of science and technology>
- News about science attracts little interest from the public.
- The number of people who feel adequately supplied with information about science and technology is relatively small.
- About 70% of Americans do not have a clear understanding of the scientific process.

<Achievement in mathematics and science in primary and middle school education>
- Academic achievement of U.S. students in science and mathematics tends to decline against international norms at higher grade levels.
- The gap in student academic achievement in mathematics between low-income and high-income groups is widening.

Source: U.S. National Science Foundation (NSF). “Science and Engineering Indicators 2002”

In response to this situation, the federal government is placing more emphasis on education policy. Immediately after George W. Bush reached the presidency in January 2001, he announced a comprehensive education reform plan under the name of “No Child Left Behind,” which was followed in 2002 by revisions to the primary and middle school education laws, to mark a series of policies intended to boost academic skill levels.

In mathematics and science education-related areas in particular, the Mathematics and Science Partnership Program was instituted in FY2002, whereby scientists and engineers at research institutions and higher education institutions cooperate with primary and middle school institutions to improve mathematics and science learning in primary and middle school education. The program also seeks to promote greater understanding by building new science halls and museums, or adding to existing ones, and by expanding exhibitions, to boost the people’s literacy regarding science and technology.

(2) Trends in the United Kingdom (Long History of Activities for the Promotion of Scientific Understanding)

The United Kingdom is a country with a long history of science and technology activities, having established a state level academy of science, the Royal Society, way back in the 17th century. Moreover, activities to boost understanding of science and technology in society date back to the 19th century.

In 1799, The Royal Institution of Great Britain was established, followed in 1825 with the commencement of the “Friday Evening Discourse,” a weekly meeting held every Friday evening that was designed to boost understanding of science and technology among ordinary people, and to which the world’s greatest scientists were invited to lecture. This lecture series has continued down to the present day, and in recent years even scientists from Japan have been invited, including a 1997 lecture by Sumio Iijima, famed as the discoverer of carbon nanotubes, and a 2000 lecture by Masao Ito, who is known for brain science research.

In 1831, the British Association for the Advancement of Science was established for the promotion of science and for sharing scientific knowledge. While its activities at first mainly focused on exchanges between researchers, the association's activities today are mainly focused on promoting understanding among people. Every year in spring and fall the association hosts a festival and discussions where researchers come into contact with the people, to promote communication between researchers and the people.

(New Policy Directions Related to Activities for the Promotion of Understanding)

As can be seen, the United Kingdom has for many years been actively engaged in disseminating science and technology among the people. In recent years, however, a number of societal issues regarding science and technology have arisen, including problems related to gene recombinant technology and bioethics, and to Bovine Spongiform Encephalopathy (BSE). These new issues are beginning to shake the people's trust in science and technology, and the people are starting to disassociate themselves from science and technology. According to a public opinion survey conducted in January 2001 by the Wellcome Trust, three out of four respondents expressed perplexity at scientific progress, while two out of three respondents thought that science and technology were being used to promote human life, medical issues, and health.

In regards to this situation, the United Kingdom House of Lords Select Committee on Science and Technology released a report in February 2000 entitled "Science and Society."

The report summarized the problems attendant with promoting increased understanding of science and technology among the people, and listed some necessary policies. The report also indicated the need for two-way communication between researchers and the people, to wipe away the people's lack of trust in science in recent years (Table 1-1-23).

Table 1-1-23 General topics for promoting understanding of science and technology in the United Kingdom House of Lords Select Committee on Science and Technology report, "Science and Society"

○ Five general topics

1. Creation of a new culture of dialogue between scientists and the people is needed.
2. Careful attention to the people's values and attitudes is needed.
3. The people's trust in scientific advice for the government has been shaken, and an urgent response is needed.
4. All institutions offering advice in the science and technology sectors, and engaged in policymaking, need to take more open, transparent approaches.
5. Constructive, mutually cooperative relationships between scientists and the media are needed.

Source: United Kingdom House of Lords Select Committee on Science and Technology. "Science and Society"

The United Kingdom has a concept for focusing on the relationship between science and society, called "Public Engagement in Science and Technology (PEST)." This concept calls for two-way dialogue between scientists and the public for the purpose of deepening mutual understanding among scientists, policymakers and the public.

While the term previously used in the United Kingdom to describe this dialogue was "Public Understanding of Science (PUS)," the original meaning of "public understanding" had tended to become lost as scientists engaged in one-way activity to teach the public about science. In other words, society's strongly hostile reaction to the occurrence of problems in the relationship between scientists and society hinted at a lack of public understanding of science. Development of the PEST concept came about in response to the previous lack of success as things stood, and to the prospect of increasing distrust of science and technology.

In the United Kingdom, promotion of activities under this concept is intended to boost the public's interest in and awareness of science. For example, researchers provided with government research funding are either required or strongly encouraged to engage in activities boosting public understanding of their research results, and their research funds may be allotted for such activities. Furthermore, the Research Councils that distribute the research funds (seven Research Councils have been established for the various academic sectors) provide support activities for researchers so that they can implement the lectures required for communication with the public, and researchers are becoming increasingly aware of the need for mutual understanding with the public.

In a speech made in September 2002, Lord Sainsbury, the Minister for Science, said that "it is not enough for the public to understand science, the scientist also needs to understand the public. Moreover, debate should not be limited to the science itself, but should also include the benefits, risks, and value of science, and its effects on our lives."

As can be seen, there has been a great shift in thinking about science in the United Kingdom, with more aggressive efforts to implement a dialogue between scientists and the public so that the public relationship with science and technology results in two-way communication, toward the goal of building a new relationship between science and technology and society.

(3) Trends in France

In France, a number of societal issues in science and technology have become apparent in recent years, including the bioethical problem and the nuclear power issue, etc., and a public opinion survey conducted in November 2000 revealed that people are growing more distant from science and technology. In response to this situation, the government is actively promoting more understanding of science and technology among the people, and various policies related to science education.

A representative example of a policy for promoting increased understanding of science and technology in France is the "Science Festival." This program, instituted in 1992, uses exchanges between the people and researchers to deepen the people's understanding of researchers and of science and technology, and to help them possess essential knowledge, and its purpose is to ensure that the people can learn enough scientific knowledge to be able to participate in debates about problems arising from scientific and technological progress.

In 2002, more than 2,000 events were held in more than 750 different cities, towns, and villages, with participation from about 5,600 researchers. The events attracted a total of about 1 million people (of whom about 250,000 were students).

Moreover, in response to the people's increased need for scientific and technological information, a program was launched in FY2003 to deepen mutual exchanges and build cooperative relationships between researchers and the journalists who can provide information.

In January 2004, researchers resisting the government's freeze on the science and technology budget and proposal of reductions in lifetime employment posts at public institutions prepared a petition demanding reform from the government. This petition circulated far beyond the confines of researchers and was signed by many ordinary citizens as well as researchers, revealing the people's strong interest in the topic.

The government is moving toward enactment of a Basic Planning Law for Research sometime during 2004, in preparation for policies to boost research and development investment, and to promote research and development, and is at the present time engaged in a people's debate with many of the relevant parties toward the law's adoption.

(4) Trends in Germany

In Germany, the "Science in Dialogue" initiative was launched in 2000, based on recognition of the increasing importance in knowledge-based societies of mutual understanding between science and technology and the people. In this initiative, one science sector is selected each year for dialogue, and activities are conducted throughout the year to increase the people's understanding of science and technology (the theme for 2004 is "technology").

Elsewhere, the "FUTUR" project was launched in 2001 to promote research and development in response to the needs of society. This project is operated in reverse to the conventional method of forecasting the effects of science and technology on society, by instead forecasting future changes in society or new societal demands, and then searching out what kind of science or technology will be required in response. Discussions were not limited to researchers and specialists, but were opened widely to participation from industry, students, and ordinary citizens. In February 2002, the four areas shown below were selected as visions for guiding society, and specific research projects are now in progress:

i) Elucidate the thought function
ii) Open the door to the future learning society
iii) Enjoy energetic lifetime health through prevention
iv) Life in the Internet society: Individuals andsafety

The "FUTUR" dialogue programs are continuing to add additional areas for discussion.

(5) Trends in the European Union (EU)

With the introduction of a common currency in 1999 and the admission of 10 new members in May 2004 to create a 25-nation structure, the European Union (EU) is increasing its presence in the world economy and society. In recent years, the EU has seen increased activity to rebuild relationships between science and technology and society.

(EU Science and Technology Policy in Recent Years)

At the present time, the basic policy for science and technology in the EU is a document titled "Towards a European Research Area (ERA)" that was announced by the European Commission in January 2000. In the same way as the unified market and currency in the economic sphere, the document aims for the establishment of the so-called "single European market" through increased consistency of research activities and policies in the scientific and technological sectors, and formulation of an EU science and technology policy based on the document is currently in progress. The document looks at the problems of science and society in terms of the European dimension.

Immediately after the above policy was revealed, a comprehensive strategy for economic and social policy over the next 10 years was established at the EU council meeting held in Lisbon in March 2000 (the Lisbon Strategy). The summit leaders set a goal to establish the world's most competitive knowledge-based economy in the EU within the next 10 years, and recognized the need for building ERA toward realization of that goal. Moreover, they positioned science and technology policy as an important sector within the Lisbon Strategy.

(State of Public Opinion in the EU in Regards to Science and Technology)

A public opinion survey regarding the people's interest in science and technology (Eurobarometer 55.2) was conducted in the EU in 2001, and the results revealed the peoples' complex attitude toward science.

According to results from the survey, people in the EU show a generally positive understanding of science and technology. But while they hold high expectations, they do not believe that science and technology can be a universal cure-all for resolution of all problems. Moreover, interest in science and technology showed a slight drop compared to 1992, revealing that some of the people are becoming more distanced from science and technology.

A little closer look at the 2001 results revealed that more than half of the people in the EU have no interest in science, while more than 60% believe that they are poorly supplied with information about science and technology.

On the other hand, about 80% of respondents expressed belief that science and technology can conquer such diseases as cancer or AIDS, and about 70% thought that science and technology can make their own lives more comfortable.

In addition, with such problems as BSE lurking in the background, about 90% of respondents believe that scientists should be more forthright about providing the people with information about possible risks arising from scientific and technological progress, and should communicate their own knowledge more effectively. Moreover, 70% of respondents thought that politicians should place more trust in the opinions of scientists.

(Development of Policies Related to Science and Technology and Society)

The European Commission, recognizing the necessity for building a new relationship between science and technology and society, announced the "Science and Society Action Plan" in December 2001, toward construction of the ERA. The action plan offered the following three strategic goals:

i) Disseminate a science education culture throughout the EU
ii) Achieve a science and technology policy that is close to the people
iii) Position reliable science at the center of policy proposals

To achieve these strategic goals, 38 action plans have been proposed for joint action by scientists, policymakers, industrialists, and other interested parties in society at the EU level, the member country level, and the regional level (Table 1-1-24).

Table 1-1-24 Overview of "Science and Society Action Plan (2001)"

Strategic Goal No.1 Dissemination of science education culture throughout Europe
(1) Public awareness (10 items)
(2) Science education and careers (8 items)
(3) Dialogue with the people (3 items)
Strategic Goal No.2 Achievement of science and technology policy that is close to the people
(1) Participation of the people and society (2 items)
(2) Achievement of gender equality in science (4 items)
(3) Research and forecasts for society (1 item)
Strategic Goal No.3 Positioning of reliable science at the center of policy proposals
(1) Ethical direction for science and new technologies (6 items)
(2) Risk governance (1 item)
(3) Utilization of specialists (3 plans)

Source: European Commission. "Science and Society Action Plan"

Elsewhere, the Framework Program (FP) launched in 1984 forms the core of EU science and technology policy. FP, a joint research and development program implemented by the European Commission, handles proposals for public bidding projects made by the European Commission for the realization of EU policy, and provides assistance for projects that meet its criteria. The Sixth Framework Program (FP6) is currently in progress, and the FP6 contribution to building the ERA consists of the following three pillars:

i) Merge research activities in the EU (7 priority sectors)
ii) Build the ERA
iii) Strengthen the foundations of the ERA

Within these categories, programs related to science and technology and society include one program in i) above titled "People and Governance in the Knowledge-Based Society," which is a priority sector, and "Science and Society," in ii) above, which is one of four special programs for building the ERA. Here, three sectors (1. Realization of research close to society, 2. Application of responsible research to science and technology, and 3. Stronger role for women in science, and in the dialogue between science and society) have been set as objectives for the development of structural links of actions related to the dialogue between the community of scientists and society.

As can be seen, science and technology policy is positioned as an important sector in the EU and, recognizing that the people's understanding of and participation in science and technology are essential for the promotion of this policy, the EU member states and related institutions are promoting efforts to build new relationships between science and technology and the people.

1.2 How Science and Technology Are for Society

Section 1.1 explained that the key to future progress for mankind lies in the realization of “science and technology for society, and in society.” In Section 1.2, the current state of science and technology, and the issues confronting it, are examined from the viewpoint of “science and technology for society.”

1.2.1 Contributing to Society through Knowledge Creation and Utilization

Scientific and technological activities refers to the elucidation of unknown phenomena, and to the creation of new knowledge through the discovery of new natural laws and principles, and the new knowledge obtained is then utilized in the real society. The essence of how science and technology contributes to society is the creation of new knowledge, and then utilization of that knowledge to boost the prosperity of human lives, and to solve the various issues facing society.

With the shift to a knowledge-based society well underway in the opening years of the 21st century, the creation of new knowledge is an increasingly important aspect of scientific and technological activities, and the role of science in this knowledge creation is important for the realization of “science and technology for society.”

The relationship between science and technology and society, can be described by the example of rain falling on a mountain. Rain that has fallen on a mountain does not immediately wash away downhill. First, it is captured and stored by forests, giving life to trees and other vegetation and creating a verdant landscape. This can be compared to the accumulation of scientific knowledge and the continuing search for truth, obtained through basic research, and perhaps demonstrates that science has intrinsic value in itself. Meanwhile, the rainwater stored in the forest bubbles out from springs and flows downhill in a steadily widening stream. A single stream flow can separate into a large number of sub-flows, and sometimes the flow can go underground into a subterranean network. This situation can be compared to the diversity of research and development that can arise based on scientific knowledge, leading to the planting of various new technological seeds. Eventually, the river reaches farming communities and urban cities, where it is utilized for drinking water and other household purposes, for agricultural or industrial uses, and for various other needs, universally benefiting all aspects of society. This is equivalent to research and development resulting in practical technologies that boost the prosperity of the people’s society and lives, and to the utilization of science and technology in response to various issues facing society. If the forest fails to capture a sufficient amount of the falling rain, society will quickly be faced with drought and people will not be able to live. In the same way, realization of societal progress through science and technology requires a sufficient accumulation of scientific knowledge. In other words, science can be considered to be the foundation strength of society. However, this foundation strength is not something that can be acquired in a single day or night, but instead requires a steady, continuous build-up (Figure 1-2-1).

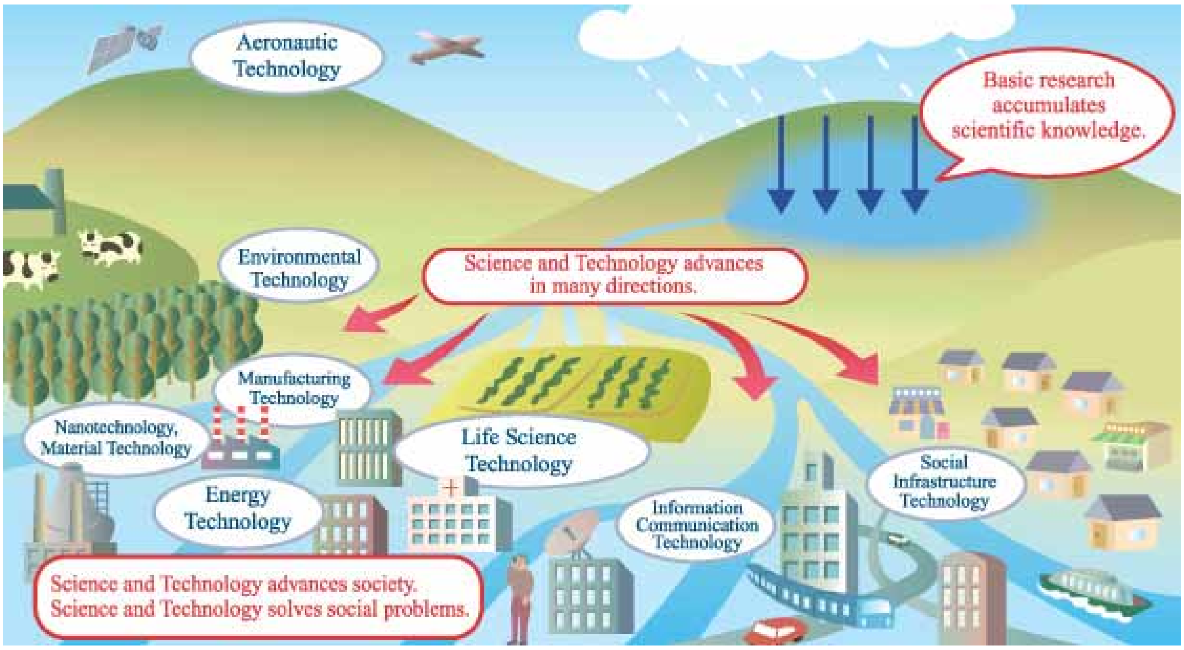


Figure 1-2-1 Relationship between science and technology and society

This section looks at science as the foundation for realizing "science and technology for society," with a focus on the natural sciences.

1.2.1.1 Science's Contribution to Human Civilization

(Societal Significance of Science)

Where technology has developed in close relationship to the convenience and prosperity of human life since before the advent of recorded history, science originated from natural philosophy and was supported by people's intellectual curiosity. The main objective of science has been elucidation of how nature is put together and operates, and it has developed as a separate entity from technology. Of course, while technological progress was backed up by various scientific advances, this does not mean that scientific research was conducted for the purpose of developing new technologies, rather, scientific knowledge was utilized only because it was available. In fact, it was more common for new technologies to be developed in order to pursue scientific research.

After the Industrial Revolution, the separate paths taken by science and technology began to move closer together. Significantly, the concept of linking scientific results to technology for utilization in society became prevalent after around 1850, which is when a chemical industry began to develop based on utilization of knowledge about chemistry, and electrical technologies arose based on knowledge about electromagnetism.

Nevertheless, science has moved away from being the business of the intellectual world, with scientific results now pioneering the frontiers of human activities in terms of both space and time, and expanding the potential of human activities. Science also has become a major influence on people's sense of values, changing the nature of society and becoming the engine driving society's progress from the viewpoint of civilization.

(Scientific Progress Has Changed the Nature of Society, and Its Sense of Values)

While there are probably no end of examples of scientific progress having a major effect on people's sense of values, and changing the nature of society itself, the following is an introduction to just a few of the more famous examples.

The centennial anniversary to one of the most amazing years in history (the “Miracle Year” of 1905) is fast approaching, when Albert Einstein, one of the premier scientists of the 20th century, issued in rapid succession a theory of the photon, a theory of Brownian motion, and the Special Theory of Relativity, all of which served to overthrow the then-prevailing views of physics. Einstein’s Theory of Relativity became the foundations for all later physics, contributing greatly to progress in various fields of science. At the same time, it altered people’s concepts of space and time, and had a huge effect on philosophy and thought.

In the field of astronomy, Nicolaus Copernicus developed a theory, later bolstered and refined by Johannes Kepler and Galileo Galilei, that had a great effect on the development and reform of society, overthrowing Europe’s medieval sense of values and driving it into the modern age. In recent years, however, examples of such society-changing advances have become increasingly common. For example, Edwin Hubble’s discovery in 1929 that the universe was expanding led directly to the Big Bang theory of the origin of the universe (1946) by George Gamow and others. In 1965, Arno Penzias and Robert Wilson detected cosmic background radiation pervading the universe, providing powerful evidence for the Big Bang theory. These discoveries gave people a new “sense of the universe.” Moreover, advances in space development have greatly expanded the space available for possible human activities, and opened up new frontiers for humanity where people can dream. At the same time, images of Earth taken from space have given people all over the world a new “view of the Earth,” vividly revealing its beauty and irreplaceability. Furthermore, the revelation in 1974 by Sherwood Rowland and Mario Molina that chlorofluorocarbon gases were causing depletion of the ozone layer, followed in 1985 by the discovery of an ozone hole, had a huge effect on efforts to protect the global environment.

Alfred Wegener’s theory of continental drift, announced in 1915, is widely accepted around the world today as the plate tectonics theory. At the time of its announcement, however, the mechanism for continental drift was unknown, and the theory attracted few supporters. In the 1950s and later, however, advances in sea floor monitoring advanced the field of geophysics, and in the 1960s Frederick Vine and Drummond Mathews found quantitative evidence of continental drift due to a spreading sea floor. This discovery completely altered people’s “sense of the Earth.”

In the life sciences, meanwhile, as seen by such advances as the Theory of Evolution proposed by Charles Robert Darwin in the 19th century, which greatly changed people’s “sense of nature,” “sense of humanity,” and “sense of society,” there are many examples of discoveries going far beyond the world of science to affect the way people think in many sectors of society. The discovery in 1953 of the double helix structure of the DNA molecule by James Watson and Francis Crick gave birth to an entirely new field of molecular biology. The result has been progressive elucidation of the structure of living things at the molecular level and rapid advances in the life sciences, including the establishment of gene recombinant technology by Stanley Cohen and Herbert Boyer in 1973, the birth of a cloned sheep, Dolly, in 1996, and completion in 2003 of the project to sequence the entire human genome, conducted by the International Human Genome Sequencing Consortium, a collaboration of six countries including Japan, and five other North American and European countries. These recent advances in the life sciences have greatly increased understanding of humans and other living things, extending the frontiers of human activity, particularly in the medical field, and greatly affecting people’s “sense of life” and “sense of ethics.” Furthermore, advances in brain research hint at the possibility of closing in on the human soul, and progress in that area will surely have a large effect on people’s sense of values.

The IT revolution of recent years is the culmination of many developments in computer technology, including the concept of the computing machine proposed by Alan Turing, and the invention of the transistor by William Shockley, John Bardeen, and Walter Brattain, as well as the advent of the Internet and other advances in information and communications technology. The IT revolution, however, does not consist merely of the development of new products or improvement of people’s convenience, but is also greatly changing people’s modes of behavior and lifestyles, through the possibilities it has opened up for the people of the world to use cyberspace for instantaneous exchange of information and opinions. The effects of the IT revolution have changed the nature of society in many dimensions, from the education, medical and welfare, transport, finance, and manufacturing sectors to modes of work and play.

Furthermore, advances in nanotechnology have made possible the elucidation and manipulation of phenomena at the atomic or molecular level, feats that were previously considered impossible, and are now expanding the range of possible human activities. Nanotechnology was launched by a lecture given in 1959 by Richard Feynman, titled "There's Plenty of Room at the Bottom," and its progress has been marked by advances in measurement technology, and supported by such scientific discoveries as the discovery of fullerenes in 1984 by Harold Kroto and others.

Elsewhere, the television has become a major factor shaping our modern society, as the communications medium with the greatest influence. This device, as well, is the culmination of various scientific results over the years, beginning with the invention of wireless communication by Guglielmo Marconi in 1895, the invention of the Braun tube in 1897, the invention of the Yagi-Uda antenna in 1925, and Kenjiro Takayanagi's successful transmission of an electronic image using a Braun tube in 1926.

Table 1-2-2　Footprints of science and technology in the 20th century

Year	Inventions and discoveries related to science and technology	Events in society surrounding science and technology
1901	･First Nobel prize	
	Shibasaburo Kitasato (Japan) was one of the candidates for the prize for his research into the tetanus bacillus	
	･Invention of method for manufacture of adrenaline and procurement of patent (Japan: Jokichi Takamine)	
	･Successful wireless transmission across Atlantic Ocean (Italy: Guglielmo Marconi)	
1902	･Discovery of Z-term for latitude variation (Japan: Hisashi Kimura)	
1903	･Proposal of Saturnian model for the atom (Japan: Hantaro Nagaoka)	
	･First manned flight of powered aircraft (U.S.: Wright brothers)	
1904	･Invention of diode vacuum tube (UK: John Fleming)	･Russo-Japanese War
1905	･Special Theory of Relativity (Switzerland: Albert Einstein)	
1907	･Invention of triode vacuum tube (U.S.: Lee de Forest)	
1908	･Establishment of ammonia synthesis (Germany)	･First sale of Model T Ford (U.S.)
1910	･Discovery of Vitamin B1 (Oryzanin) (Japan: Umetaro Suzuki)	
1911	･Successful cultivation of syphilis pathogen (Japan (Hideyo Noguchi)	
	･Discovery of atomic nucleus (UK: Ernest Rutherford)	
	･Discover of superconductivity phenomenon (Netherlands: HK Onnes)	
1913		･Mass production of Ford automobiles (U.S.)
1914		･World War I (until 1918)
1915	･Artificial inducement of cancer tumor (Japan: Katsusaburo Yamagiwa, Koichi Ichikawa)	
	･General Theory of Relativity (Germany: Albert Einstein)	
	･Theory of continental drift (Germany: Alfred Wegener)	
1917	･Invention of KS steel (Japan: Kotaro Honda)	･Establishment of Institute of Physical and Chemical Research (RIKEN) (Japan)
1920		･World's first radio broadcast (U.S.)
1921	･Discovery of insulin (Canada: Frederick Banting, Charles Best)	
1922	･Proposal of expanding universe model (Russia: Aleksandr Friedmann)	
1925	･Invention of Yagi-Uda antenna (Japan: Hidetsugu Yagi, Shintaro Uda)	
1926	･Proposal of wave equation (Austria: Erwin Schrodinger)	
	･Launch of first liquid-fueled rocket (U.S.: Robert Goddard)	
	･Successful Braun tube reception of electronic signals (Japan: Kenjiro Takayanagi)	
1927	･Proposal of Uncertainty Principle (Germany: Werner Heisenberg)	･Japan's first subway opens for operation
1929	･Discovery of penicillin (UK: Alexander Fleming)	
	･Observation of expanding universe (U.S.: Edwin Hubble)	
1935	･Proposal of mehon theory (Japan: Hideki Yukawa)	
	･Isolation of crystal structure in tobacco mosaic virus (U.S.: Wendell M. Stanley)	
	･Invention of nylon synthetic textile (U.S.: Wallace Carothers)	
1936	･Theoretical computer model (UK: Alan Turing)	
1937	･Development of jet engine (UK: Frank Whittle, Germany: Hans von Ohain)	
1938	･Discovery of uranium fission (Germany: Otto Hahn, Fritz Strassman)	
1939	･Discovery of DDT insecticide (Switzerland: Paul Mueller)	･World War II (until 1945)
		･First flight of jet aircraft (Germany)
1941		･First commercial television broadcasts (U.S.)
1942	･Successful nuclear fission chain reaction (U.S.: Enrico Fermi, et al)	･Manufacture of V-2 rocket (Germany: Werner von Braun)
1944	･Proof of DNA gene structure (U.S.: Oswald Avery)	
	･Discovery of streptomycin (U.S.: Selman Waxman)	
1945		･Manufacture of atomic bomb (U.S.)
		･Bush Report (U.S.: Vannevar Bush)
1946	･Development of ENIAC electronic computer (U.S.: John Mauchly, Presper Eckert)	
	･Big Bang Theory (U.S.: George Gamow)	
	･Development of transistor (U.S.: William Shockley, John Bardeen, Walter Brattain)	
1949	･Hideki Yukawa winner of Nobel Prize for Physics	

Year	Inventions and discoveries related to science and technology	Events in society surrounding science and technology
1951		· First nuclear power generation (U.S.)
1953	·Elucidation of DNA double helix (U.S.: James Watson, UK: Francis Crick)	
1954	·Discovery of interferon (virus inhibition factor) (Japan: Yasuichi Nagano, Yasuhiko Kojima)	
		·World's first kidney transplant (U.S.)
Circa 1955		·Pollution becomes a societal problem (Japan)
1957		·First criticality in Japanese nuclear reactor
		·Launch of Sputnik artificial satellite (USSR)
1959	·Invention of integrated circuit (IC) (U.S.: Jack Kilby)	
1960	·First successful laser firing (U.S.: Ted Maiman)	
1961		·First manned space flight (USSR: Yuri Gagarin)
1963	·Proposal of theory of sea-floor spreading explains magnetic anomalies (UK: Fred Vine, Drummond Mathews)	
1964	·Proposal of Quark Model (U.S.: Murray Gell-Mann, George Zweig)	·Tokai Shinkansen commences operations (Japan)
1965	·Observation of universe background radiation (U.S.: Arno Penzias, Robert Wilson)	
	·Shinichiro Tomonaga wins Nobel prize for physics	
1966		·Commercially based nuclear power generation (Japan)
1967	·Plate Tectonics Theory (UK: Dan McKenzie, U.S.: Jason Morgan)	·Promulgation of Basic Law for Environmental Pollution Control (Japan)
		·First heart transplant operation (South Africa: Christiaan Barnard)
1969	·Superlattice proposal (Japan: Reona Esaki)	·Apollo 11 lands on the Moon (U.S.)
1970		·Launch of Ohsumi, Japan's first artificial satellite
Circa 1973		·Oil shock (Japan)
1973	·Establishment of gene recombinant technology (U.S.: Stanley Cohen, Herbert Boyer)	
	·Reona Esaki wins Nobel prize for physics	
1974	·Indication that chlorofluorocarbon may be depleting ozone layer (U.S.: Sherwood Rowland, Mario Molina)	
1978		·First in vitro insemination infant born (UK)
1979		·Three Mile Island nuclear power plant accident (U.S.)
1981	·Kenichi Fukui wins Nobel prize for chemistry	·First flight of the Space Shuttle (U.S.)
1983	·Discovery of AIDS virus (France: Luc Montagnier, U.S.: Robert Gallo)	
1984	·Discovery of fullerenes (UK: Harold Kroto, et al)	
circa 1985	·Discovery of the ozone hole (Japan, UK, U.S.)	
1986	·Discovery of high-temperature superconductivity (Switzerland)	·Chernobyl nuclear power plant accident (USSR)
		·Space Station Mir commences operations (USSR)
1987	·Susumu Tonegawa wins Nobel prize for physiology and chemistry	
1989		·End of Cold War
1991	·Discovery of carbon nanotubes (Japan: Sumio Iijima)	·Cellular phone service starts (Japan)
1992		·Earth Summit
circa 1993		·Announcement of Information Superhighway concept (U.S.)
		·Explosive growth of Internet
1994	·Confirmation of top quark (U.S.: Fermi National Accelerator Laboratory)	·Launch of H-II rocket (Japan)
1995		·Great Hanshin-Awaji Earthquake (Japan)
		·Passage of the Science and Technology Basic Law (Japan)
1996	·Birth of Dolly the cloned sheep (UK)	
1997		·Promulgation of Organ Transplant Law (Japan)
1998	·Confirmation of mass in neutrino (Japan: Super Kamiokande)	·Assembly of International Space Station commences (Japan, U.S., EU, Canada, Russia)
1999		·World Conference on Science (Budapest)
		·Japan's first organ transplant from brain-dead donor
		·Criticality accident at uranium processing plant (Japan)
2000	·Hideki Shirakawa wins Nobel prize for chemistry	·Passage of Law concerning Regulation relating to Human Cloning Techniques and Other Similar Techniques (Japan)
2001	·Ryoji Noyori wins Nobel prize for chemistry	
2002	·Masatoshi Koshiba wins Nobel prize for physics	·Johannesburg Summit
	·Koichi Tanaka wins Nobel prize for chemistry	
2003	·Sequencing of human genome completed (Japan, U.S., Europe)	

Source: Prepared by MEXT

[Column 1]

Who are we?

“Where do we come from? What are we? Where are we going?” This is the title of a masterpiece by Paul Gauguin, from the Late Impressionist School. Gauguin used this work as a starting point for a whole series of paintings exploring the theme of "the meaning of mankind's existence."

Scientific knowledge has made great strides in the ensuing 100 years, and the answer to Gauguin’s question is beginning to come clear. Advances in the life sciences, for example, have clarified the history of the evolution of life. Based on such researches, the period since the first appearance of life on Earth to the present day can be treated as equivalent to 365 days (a calendar of evolution), for a graphic portrayal of "where we are now." This result offers one viewpoint for considering the relationship between science and technology and society

Calendar of the Evolution of Life

Birth of the Universe (13.7 billion years ago)	—
Birth of the Earth (4.6 billion years ago)	—
Appearance of life on the Earth (3.8 billion years ago)	January 1
Oxygen appears in the atmosphere (2.0 billion years ago)	July 2
Appearance of eukaryotic life (1.8 billion years ago)	July 22
Appearance of multi-celled life (600 million years ago)	November 4
Appearance of dinosaurs (250 million years ago)	December 8
Appearance of mammals (200 million years ago)	December 12
Appearance of primitive humans (1 million years ago)	December 31, 9:40 p.m.
Appearance of civilization (20,000 years ago)	December 31, 11:58 p.m.
The Industrial Revolution (200 years ago)	December 31, 11:59 p.m., 58.4 sec.
Space Age begins (40 years ago)	0.3 seconds before the end of the year

Source: Prepared by Ministry of Education, Culture, Sports, Science and Technology, based on “*Kagaku o Hagukumu*” (Nurture science) by Reiko Kuroda

(Science Supports Modern Civilization)

One more aspect of the contribution that science has made in the establishment of modern civilization has been the steady spread around the world of scientific thought as science has progressed.

Modern science derived originally from certain sciences in one limited region, Western Europe, where a culture of science developed. Yet while debates may exist regarding specific scientific results, the sciences and scientific thought are today widely accepted in many countries around the world. The history of the worldwide spread of modern science has varied sharply by country and region, and was often fraught with dissension or friction. Today, however, Nobel prizes in the natural sciences are being increasingly awarded to researchers from countries outside the core areas of Western nations, and many people in countries outside of Western Europe have accepted the culture of scientific thought and are contributing to the progress of the world’s science (Figures 1-2-3, 1-2-4). It has often been said that “science knows no borders,” a saying that has never been truer than it is today.

With the spread of modern science, of course, it remains important to maintain the diverse cultures and traditions intrinsic to local areas, and achieving harmony between the two will no doubt be an important issue in the future.

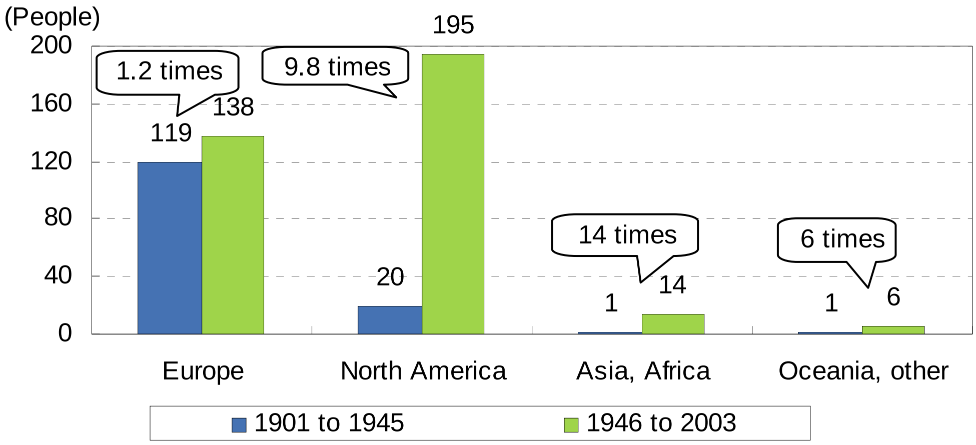


Fig.1-2-3 Trends in Nobel prizewinners (natural sciences) by region

Source: Prepared by MEXT

Table 1-2-4 Nobel prizewinners from Asia (natural sciences)

Sector	Year	Name of prizewinner	Country of origin
Physics prize	1930	C.V. Raman	India
	1949	Hideki Yukawa	Japan
	1957	C.N. Yang, T.D. Lee	China
	1965	Shinichiro Tomonaga	Japan
	1973	Reona Esaki	Japan
	1976	Samuel C.C. Ting	U.S.A. (Note)
	1979	Abdus Salam	Pakistan
	1983	S. Chandrasekhar	India
	1997	Steven Chu	China
	1998	Daniel C. Tsui	China
	2002	Masatoshi Koshiba	Japan
Chemistry prize	1981	Kenichi Fukui	Japan
	1986	Yuan T. Lee	Taiwan
	2000	Hideki Shirakawa	Japan
	2001	Ryoji Noyori	Japan
	2002	Koichi Tanaka	Japan
Physiology or Medicine prize	1968	Har Gobind Khorana	India
	1987	Susumu Tonegawa	Japan

Note: While born in the United States, his parents were Chinese citizens.
Source: Prepared by MEXT

(Promotion of Basic Research from the Viewpoints of Culture and Civilization)

As can be seen from the foregoing, science and technology in modern society is not limited to the technological aspects of a tool for making life more prosperous and convenient. Rather, in its scientific aspect, it forms the foundation for how world's people think and for the nature of society.

In the "Public Opinion Poll on Science and Technology and Society (February 2004)," about 70% of respondents reacted positively to the statement that "scientific research is essential in the sense that it brings new knowledge to humanity," a result that appeared to show that most people in Japan recognize the importance of this scientific aspect of science and technology (Figure 1-2-5).

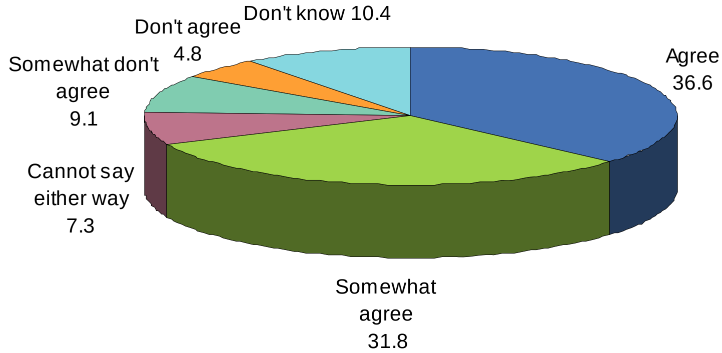


Figure 1-2-5 Scientific research is essential in the sense that it brings new knowledge to Humanity

Note: Response to the question "Do you agree with the opinion that 'scientific research is essential in the sense that it brings new knowledge to humanity'?
Source: Cabinet Office. "Public Opinion Poll on Science and Technology and Society (February 2004)"

In Japan, it is important that basic research for the creation of new scientific knowledge is actively promoted, and emphasis placed on the accumulation and continuation of Japan's knowledge resources, so that the nation can contribute to the advance of international society overall from the viewpoints of culture and civilization.

On the other hand, as was discussed in Section 1.1, it is a fact that various negative effects have appeared in modern society alongside the advances in science, and particularly the natural sciences. It is plain that the natural sciences are not all-powerful. Moreover, the natural sciences alone are probably incapable of explaining the nature of mankind and society. In order to overcome this weak point of the natural sciences, analysis of people's thoughts and behavior, as well as of various social phenomena, is important, as is coordination with thinking in the humanities and social sciences. For the future progress of human civilization, such activity will undoubtedly become increasingly important.

1.2.1.2 Realization of a Prosperous Society through the Utilization of Scientific and Technological Results

(Practical Value of Science)

Scientific results are linked to the development of new products and new technologies, and contribute greatly to economic and medical progress, and to other real social and economic activities. When the question is raised about what science and technology for society really means, one important viewpoint is whether or not scientific results are linked to the development of technologies that can create real, utilizable products and services.

In fact, as shown in Table 1-2-6, the basic research results that were rewarded with the Nobel prize in many cases led, after as many as 10 to 20 years of research and development, to practical application, commercialization, and contribution to economic growth.

Table 1-2-6 Examples of practical applications from Nobel prizewinning results

Practical application	Nobel prize
MRI (Magnetic Resonance Imaging) machine	Felix Bloch, et al (1952 Physics prize) Paul Lauterbur, Peter Mansfield (2003 Physiology or Medicine prize)
Semiconductors (transistors)	William Shockley, John Bardeen, et al (1956 Physics prize)
Insulin	Frederick Sanger (1958 Chemistry prize)
Semiconductors (tunneling effect)	Reona Esaki, et al (1973 Physics prize)
CT (Computerized Tomography) scanner	Alan Cormack, Godfrey Hounsfield, et al (1979 Physiology or Medicine prize)
Monoclonal antibodies	Niels Jerne, Georges Kohler, et al (1984 Physiology or Medicine prize)
Conductive polymers (cell phone screens)	Hideki Shirakawa, et al (2000 Chemistry prize)
Asymmetric synthesis (menthol manufacture)	Ryoji Noyori, et al (2001 Chemistry prize)
Protein analyzer	Koichi Tanaka, et al (2002 Chemistry prize)

Source: Prepared by MEXT

Moreover, science linkage (number of citations of scientific papers per U.S. patent) in major countries in regards to U.S. patents, which are used as an index to show the strength of links between scientific results (scientific papers) and new technologies (patents), is showing a rising trend (Figure 1-2-7). In the past, scientific results obtained through basic research usually followed the so-called linear model, in that it passed through the stages of applied research and commercialization research to reach the product stage. The trend here, however, is an example that appears to show that scientific results are increasingly being converted into products without following the linear model. It would appear that the distance between scientific results and the product stage is becoming narrower.

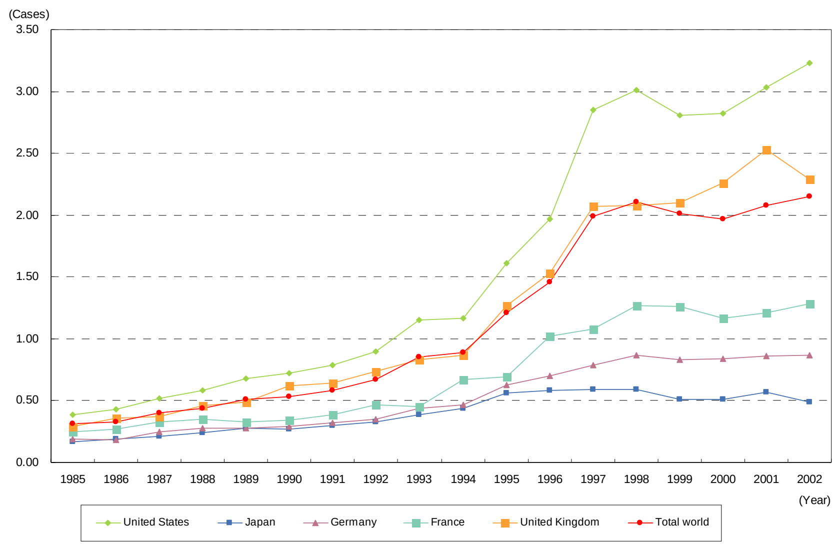


Figure 1–2-7 Trends in science linkage to U.S. patents

Source: Materials by National Institute of Science and Technology Policy

(Japan's Economic Development through the Promotion of Basic Research and Other R&D)

A look at Japan's economy today reveals that, while moderate deflation is continuing, the general outlook is bright, with a continuing recovery in corporate profits and rising investment in plant and equipment. It is important that this bright outlook be linked to firm growth, and revitalization of the economy is one of the most important issues facing Japan.

Economic development in Japan after the Second World War was mainly achieved through the introduction of scientific and technological results from Western nations, the effective conversion of those results into products, and efficient anufacturing.

At present, however, when Japan no longer follows in the footsteps of the Western nations, the nation needs to move beyond the traditional form of follow-up research to obtain the ability to take the lead in the creation of new knowledge ahead of other countries, so as to become one of the world's front-runner nations, and to ensure that Japan can be a survivor in the competition between nations. Moreover, the promotion of basic research for the creation of new knowledge, and of other research and development, is a necessity for Japan's future economic growth. In addition, emphasis is beginning to be placed on the new research and development process, which merges scientific knowledge and technology and then links it to the development of products and solutions to problems. According to the "Public Opinion Poll on Science and Technology and Society (February 2004)," about 70% of respondents agreed with the statement that "development of science and technology is needed to boost international competitiveness" (Figure 1-2-8). While this question was not necessarily restricted to the economic viewpoint in questioning the importance of science and technology for boosting international competitiveness, it does show people's expectations for Japan's scientific and technological strengths at a time when advancing globalization is heightening the competition between nations.

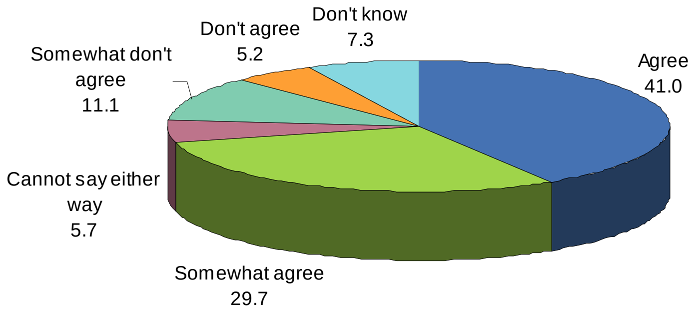


Figure 1-2-8 Development of science and technology is needed to boost international Competitiveness

Note: Response to question "Do you agree with the opinion that 'development of science and technology is needed to boost international competitiveness'?"

Source: Cabinet Office. "Public Opinion Poll on Science and Technology and Society (February 2004)"

(Nurturing Creative Human Resources)

While research expenses and the development of research equipment, facilities, and other aspects of the research environment are important for the promotion of research and development, the most basic requirement is the nurturing of researchers with creative skills.

However, creative skills cannot be learned from others, but rather can only be obtained through hit-and-miss experimentation. In research and development, and particularly in basic research, researchers must be of a character suited to challenging creative topics on their own initiative, and be able to nurture research human resources with creative skills. Promotion of basic research is therefore important from the point of view of human resource development, as well.

(Importance of Cooperation between Industry, Academia, and Government)

Firmly linking new knowledge born from basic research and other R&D to practical applications is also important.

A look at the science linkage of major countries to U.S. patents, shown in Figure 1-2-7, reveals a major gap between Japan on the one side, and the United States and United Kingdom on the other, and a lower rank than France or Germany, as well, leaving the impression that the results of basic research in Japan are not being adequately linked to technology. In order for the results of basic research and other R&D obtained at universities and other public research institutions to be firmly linked to technology and practical applications, efforts to promote cooperation between industry, academia, and government need to be continued. In addition, new knowledge created through basic research and other R&D needs to be given suitable protection, while at the same time positioned so that society can make maximum utilization of it. A firm response to protection of intellectual property is also important.

(Transmission and Development of Japan's Own Technologies and Skills)

As mentioned above, Japan's economic development after the Second World War was mainly achieved through the introduction of scientific and technological results from Western nations, the effective conversion of those results into products, and efficient manufacturing. Japan's traditional strengths lay mainly in effective and efficient conversion to products, and in the improvement of production processes.

Even with the importance for Japan of gaining an ability in the future of taking the lead to create new knowledge ahead of other countries, these traditional strengths should continue to have significance from the standpoint of effectively and efficiently converting the new knowledge created in Japan into practical applications.

It is said that the elements peculiar to Japan serving to support the effective and efficient conversion of products, and the improvement of production processes – the well-springs of Japan's competitiveness – have included the corporate human resource training programs built on the concept of lifetime employment, corporate knowledge transmission through flexible reassignment of employees, and superior product, making technologies that center mainly on small and medium-sized enterprises.

In particular, the superior product making technologies rely heavily on individual skills, such as individual manual technologies and skills of local technicians in the manufacture of lathes and metal molds, and the accumulation of technical and skilled knowledge for the discovery of and response to problems and response to change.

Once lost, the skills of these superior technologists are extremely difficult to restore and, as the foundation supporting Japan's competitiveness, it is important that these technologies and skills be transmitted onward, and that the associated human resources be firmly maintained and nurtured.

A variety of technologies and skills were being created and developed in various locales around Japan even before the age of modernization that began in the Meiji era (1868 to 1912). As evidenced by such examples as *kumihimo* braiding technology, which formed the basis for the development of high-performance textile strengthening compounds, a large number of traditional technologies and skills are being linked to state-of-the-art technologies and stimulating new development. In addition, the development of nano-level structural analysis technologies has resulted in elucidation of the material qualities of Japanese swords, which approach in quality super-steel materials that remain impossible to mass-produce using modern manufacturing technologies. Elucidation of traditional sword manufacturing methods could well open the way toward realization of that mass production.

It is imperative that the superior traditional technologies and skills intrinsic to Japan be re-evaluated and re-utilized for the modern world.

[Column 2]

Science and Technology in the Edo Period

Japan was developing its own distinctive science and technology even before the advent of modernization. In the Edo Period, in particular, the various domains competed with each other in industry and academics, and science and technology rooted in certain regions spread thereafter throughout the country. The rapidity with which Japan achieved modernization in the Meiji Period and later can be traced to the existence of this scientific and technological foundation.

At present, the National Science Museum, with financial backing from the Grants-in-Aid for Scientific Research Program administered by the Ministry of Education, Culture, Sports, Science and Technology, is leading a research project, "Making Things in the Edo Period" (Note 1) to examine what scientific and technological traditions of the Edo Period should be passed on to future generations. This research project is performing surveys and research into creative cultural objects all over Japan manufactured during the Edo Period, such as the "Bow-Shooting Boy" and "Never-Ending Lamp," both found in the Toyota Collection (Note 2), and the "*Netsuke* Jumping Frog," and then intends to present to society in easy-to-understand language the scientific and technological traditions and culture of Japan.

Moreover, in cooperation with the "Making Things in the Edo Period" project, the Toyota Foundation is implementing a research assistance program based on the theme of "Rediscovery of Modernization and Living: Finding Our Local History." This assistance program targets museum art specialists, teachers, university students, housewives, and other residents in local areas, to assist their cooperation with research specialists participating in the "Making Things in the Edo Period" project, and to help ensure that research results are not limited to circulation among research specialists, but are shared widely among the local people.

For example, the "Making Things in the Edo Period" project is engaged in surveys and research focusing on the works of Ikkansai Kunitomo (Note 3), an Edo Period scientist. Alongside that effort, however, the "Rediscovery of Modernization and Living" program is backing an amateur research group restoration of the Kunitomo's reflecting telescope (the "Ikkansai Experimental Laboratory") and schoolchildren using that telescope to observe sunspots (the "Ikkansai *Terakoya* Children's School"). These research links resulted in an international symposium held in the local community of Nagahama-shi, Shiga prefecture in November 2003, through cooperation with the "Making Things in the Edo Period" project, the local board of education, and amateur research groups, to successfully bring research results and reports to a wider audience.

Elsewhere, Japan's gold, silver, and copper mining operations of the Edo Period, which were some of the most productive in the world, are also being surveyed and researched. For example, the Iwami-Ginzan Silver Mine Ruin is being re-examined with an eye toward eventual registration as a world heritage site, with research results returned to the local area in the form of symposiums with local groups for re-evaluation of the mine as an "industrial heritage" object.

Through such efforts, the traditional science and technology in local areas is being re-evaluated, and raising expectations that the process will lay the foundation toward regeneration of the local economy.

These efforts are promoting surveys and research into the cultural objects of the Edo Period from various vantage points, ranging from scientific and technological aspects to anthropological and sociological aspects, an interdisciplinary approach that is of particular importance. In fact, the "Making Things in the Edo Period" project encompasses more than 400 research participants nationwide, coming from both the scientific and cultural sectors.

Furthermore, these efforts represent a step forward from previous museum and science hall activities, in that the museums and science halls are now actively utilizing the actual objects and materials in their possession in ways that anybody can understand, to build an exchange of scientific and technological research between research specialists and ordinary people, and the museums and science halls are assuming a new role that can serve as a model for promoting the culture of science and technology at the level of the people.

Notes: 1. "Making Things in Edo"
The popular name for the project. The official name is "Surveys and Research Regarding Systematization of Materials at the Dawn of Japan's Scientific and Technological Age." The project was launched in 2001 and is planned to continue for five years.

2. Toyota Collection
A collection of documents and materials regarding the progress of Japan's science and technology purchased by Toyota Motor Corporation in 1999 to prevent their dispersal and contribute to their survey and research, and deposited with the National Science Museum in 2001. The collection centers mainly on items from the mid- to late-Edo Period, sorted into such categories as mechanical puppetry, astronomy and measurement, medical, and living, and numbers more than 1,300 items.

3. Ikkansai Kunitomo
Lived from 1778 to 1840. Expert in gunnery and iron forging in Omi-no-kuni (modern Shiga prefecture). Known for his manufacture of "wind cannons" (air guns) and "divine mirrors" (haunted mirrors), he also made a "telescope mirror" (reflecting telescope) and used it to observe the Moon and sunspots on the Sun.

1.2.2 New Policy Developments Related to Science and Technology for Society

This section examines the development of new policies related to science and technology for society, using the three themes of “scientific and technological progress related to safety and security,” “revival of local areas using science and technology,” and “intra-sector efforts,” to discuss current conditions and topics.

1.2.2.1 Scientific and Technological Progress Related to Safety and Security

(Increased Factors Threatening Safety and Security)

The multiple terror attacks of September 11, 2001 killed several thousand victims in an instant, an attack unparalleled in international society. Again, on March 11, 2004, an explosion on a commuter train in Madrid, Spain left more than 200 dead and more than 1,700 injured. This incident acutely brought home to people in Japan and elsewhere the extent of the threat that terrorism raises.

Turning to Japan, this is a nation that was often beset by natural disasters. As a result of the implementation of disaster prevention policies, losses due to natural disasters have been declining in recent years. Nevertheless, the Great Hanshin-Awaji Earthquake of January 17, 1995 left more than 6,000 people dead, a larger number of disaster victims than the total numbers recorded in any single year since the end of World War II.

In the area of security, a total of 2,853,739 criminal incidents were recorded in FY2002, marking the seventh straight year that a postwar record was registered. Moreover, the arrest and incarceration rate fell to an all-time low, graphically demonstrating a rapid deterioration in security, and the people’s insecurity is increasing (Figure 1-2-9).