Chapter 2

Science and Technology to Create a New Society

Section 1 Science and Technology Response to Demographic Change

1 Science and technology for lifelong health

(1) Building a society favorable to bearing and raising children

According to the 2002 “Japanese National Fertility Survey” reported by National Institute of Population and Social Security Research, married couples felt that the ideal number of children was an average of 2.56, but the actual number of children planned was an average of 2.13. The biggest reason for the planned number of children being lower than the ideal number of children was the burdensome costs of raising and educating children. Among the couples surveyed, 12.7% had no children, and about half of the couples without children were concerned about infertility. Furthermore, more than half of those who were concerned about infertility responded that they had undergone tests and/or treatment for infertility.

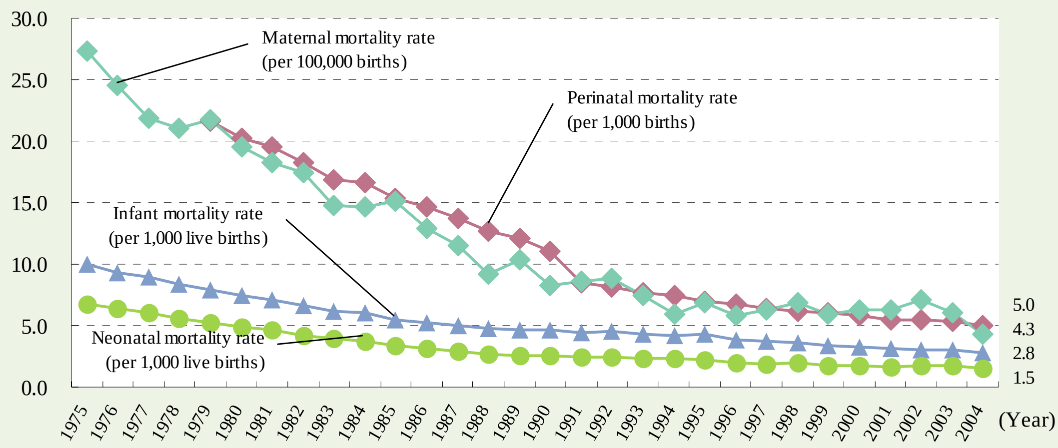
According to research by the Ministry of Health, Labour and Welfare, in FY2002 it was estimated that about 467,000 people had gone through fertility treatment. In 2003, it was reported that about 68,000 people underwent in vitro fertilization and embryo transfer at the 648 facilities registered with the Japan Society of Obstetrics and Gynecology, resulting in the births of about 17,000 children.

(2) Raising healthy children

● **Improving medical technology to help raise healthy children**

In 1904, the neonatal and infant mortality rates in this country were 73.9 and 151.9, respectively (per 1,000 live births). One hundred years later (2004), these rates are 1.5 and 2.8, respectively, a drastic improvement. These improvements are the result of progress in the prevention and treatment of disease, as well as other areas of science and technology. Consequently, pediatric care can focus attention even on diseases that have relatively few patients. There is ongoing development of treatments and research to elucidate the mechanisms of intractable diseases like pediatric cancers, metabolic disorders like endocrinological disease, asthma, and allergic reactions like atopic dermatitis.

Figure 2 ▶ Trends in indicators of mother-child health



Notes: 1. The births for the maternal mortality rate are the number of foetal death (after 12 or more weeks of pregnancy) added to the number of live births.
2. The births for the perinatal mortality rate are the number of foetal death after 22 or more weeks of pregnancy added to the number of live births.

Source: Created by the Ministry of Education, Culture, Sports, Science and Technology using the Vital Statistics of the Ministry of Health, Labour and Welfare

Incorporation of Brain Science Research

Due to the recent advances in brain science, it has become possible to seek biological processes in the mechanisms of human learning and education. Progress in brain function imaging technology, such as functional magnetic resonance imaging (fMRI) has enabled empirical study of the function of the human brain. There is also progress on the identification of genes that contribute to intellectual activities in humans along with advances in molecular biology using model organisms, such as mice. These advancement of studies lead to the rise of research to elucidate genetic and environmental impact on mental ability (Figure 3).

In 2000, Japan was the first in the world to establish an interdisciplinary field that combined brain science and education and subsequently initiated research in this area. The subject goes beyond the boundary between natural science and humanities/social science, integrating many different fields, including brain science, developmental psychology, ethology, linguistics and pedagogy. Research is proceeding using advanced brain function measurements and various information technologies. Through the collaborative efforts of scientists and teachers and other people directly involved in education, the accumulated on-site knowledge and know-how is being systematized based on the empirical evidence.

(3) Healthy aging for the elderly

In an aging society with fewer children, it is very important for the elderly to keep fit and to support themselves for the purpose of increasing the quality of life of the citizens and decreasing the burden on society. From this perspective it is necessary to continue with research and development on the prevention, diagnosis and treatment of diseases including cancer and other lifestyle-related diseases, fractures and dementia that require full-time nursing care.

Figure 3 ▶ Activity in the hippocampus during intellectual learning

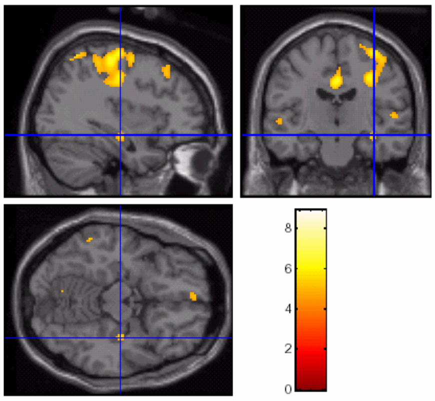


Photo courtesy of the National Institute of Advanced Industrial Science and Technology

One of the first recorded images of the activity in the brain (hippocampus) at the moment of becoming aware of something new (The intersecting blue lines indicate the plane within the brain)

Cancer

In order to further improve the effectiveness of cancer countermeasures and increase the benefits to all citizens, "The Third Term Comprehensive 10-year Strategy for Cancer Control" was established as a strategy starting in FY 2004. Under this strategy, aiming at reducing the mortality rate due to cancer and maintaining the quality of life (QOL) of patients with cancer, in addition to technology development of molecular imaging research, there is also research being done to improve cancer prevention, early diagnosis and treatment methods, including promotion of translational research applied to active prevention, diagnosis and treatment using the results of basic research obtained from research labs, as well as promotion of personalized medical care that is adapted to the characteristics of each individual (Figure 4).

Figure 4 ▶ Hospitals in the near future

Personalized medical care (practical application)

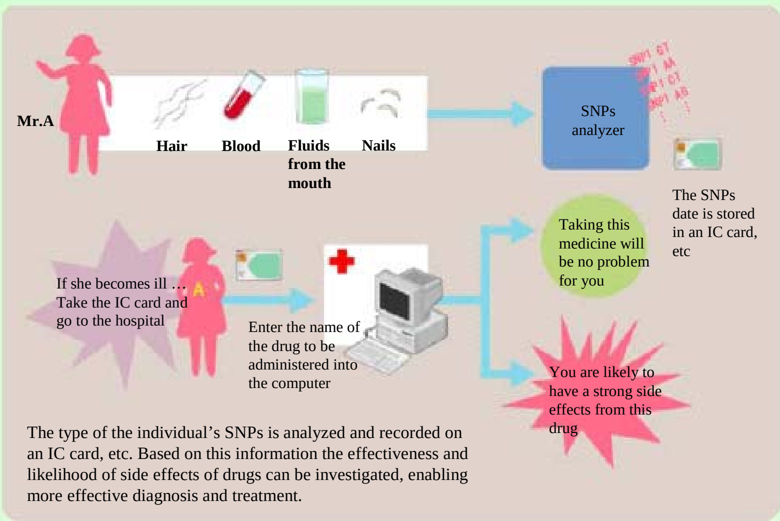
Provide information so that the most effective medications with the minimal side effects will be identified for each individual and to provide treatments that fit the individual

Development of new medicines

Development of ground-breaking new drugs that target the disease genes

Realization of preventive medicine

By knowing in advance susceptibility to certain diseases, daily habits can be modified to prevent the disease

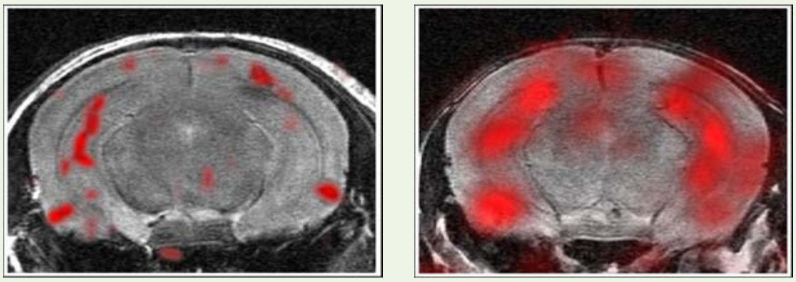


Source: RIKEN

Alzheimer's disease

Alzheimer's disease is a representative disease that causes dementia, afflicting one out of 5 people over the age of 85. There is concern about an increase in the number of patients as the aging of society progresses. In the past, the mechanisms of onset of the disease were not well understood and the treatment was to administer drugs to promote the transmission of information between neurons, rather than trying to prevent the death of neurons. In recent years there have been rapid advances in research on the mechanisms, including the production and breakdown of substances called tau proteins and β−amyloid, which is thought to contribute to neuron damage (Figure 5). Based on the research results, efforts are being made to develop prototype vaccines and drugs to suppress these substances.

Figure 5 ▶ Bioimaging of a mouse with Alzheimer's disease



This is the first successful imaging of β-amyloid using MRI (red portion in the photo) on a living animal. The photo on the left was taken at a younger stage. In comparison, it is clear that the β-amyloid accumulation has advanced in the photo on the right.
Photo courtesy of RIKEN

(4) Contributions to health from fundamental research of biological systems and nanotechnology

Cutting-edge technology – Regenerative medicine

Modern medicine, including advancements in regenerative medicine, is opening the possibilities for the treatment of lifestyle diseases and difficult ailments, like spinal cord injury and cardiac infarction, through the use of cell and tissue transplants.

In addition, development is also promoted on such technologies as strong, readily-accepted artificial bones and ligaments that gradually release substances to promote tissue regeneration through the application of nanotechnology, artificial organs including artificial livers and pancreases that are a fusion of cells and nano-biomaterials, and nano drug delivery systems to deliver medications or genetic material to targeted areas in the body in order to treat difficult diseases or to provide genetic treatment.

Fundamental research

In October 2004, the International Human Genome Sequencing Consortium, composed of research centers in six countries including Japan, announced results of verification and analysis of the precise sequencing of the human genome, including the approximately 22,000 genes that regulate the structure of the proteins that make up the human body.

Progress continues on genome research, including study of the background behind the differences in abilities, such as between humans and chimpanzees and between exceptionally long-lived people and ordinary people; research on how living things develop from fertilized eggs, the kinds of RNA produced at each of the various stages as aging progresses, and how this RNA works; research on the tertiary structure of proteins that fill a variety of functions within the body, as well as making up the body; and research using computers, etc. to understand the actions and interactions of these various components as a complete biological system. There is also continuing development on the basic technology required for the research, including analysis technology.

2 Science and Technology to Improve Social Welfare

Cyborg technology

Even if you lose an arm in an accident, if you think "move arm," the same signals are still transmitted from the brain to the nerves that originally were involved in moving your arm. By reading the electrical signals from those nerves and connecting them to the controller for a robotic arm designed to move in response to those signals, it is possible to create a robotic arm that can be moved like your own arm, simply by thinking, without any other special operations.

Furthermore, there is research being conducted on replicating the sense of touch, so that by attaching touch sensors to an artificial hand, the electrical signals from the sensors can be converted and transmitted through the nervous system. By gaining an understanding of the pattern of the signals that flow throughout the nervous system, it is becoming possible to take signals from external devices and send them as signals that the brain will interpret as signals from an actual sense organ. There is already development being done on artificial eyes and ears using this kind of technology, with more than 60,000 people throughout the world already using this kind of artificial ear.

Wearable Robots (Robot suit HAL (Hybrid Assistive Limb) developed by University of Tsukuba)

Photo courtesy of University of Tsukuba SanLab

Figure 6 ▶ Various types of care-giving robots

Left: Autonomous daily-activity support robot that is equipped with soft skin, sight, hearing, sense of smell and sense of touch, and can perform tasks with a delicate touch.
Photo courtesy of RIKEN
Below: A soothing robot designed to help reduce stress for elderly and limited-mobility patients
Photo courtesy of the National Institute of Advanced Industrial Science and Technology

3 Science and Technology to Enable Diversification of Work Styles

● Aging and Physical and Mental Function

For many years it was believed that the cells of the central nervous system (brain and spinal cord) had no ability to regenerate, and that the numbers declined after a person was born. However, the latest results in brain science reveal that there is a process, called “neurogenesis,” in which new nerve cells are generated even in the brains of adults, and that even with increasing age there is bonding between nerve cells. In addition, it has become clear that human embryonic stem cells [Note] can be differentiated to form nerve cells, so it may be possible in the future for regenerative medicine to be applied for Parkinson’s disease and spinal cord injuries, areas that had lacked fundamental countermeasures.

The region of the brain called the hippocampus fills an important role in memory, etc. and is related to depression in the elderly. It has become clear that stress inhibits neurogenesis and that there is atrophy of the hippocampus seen in patients with chronic depression. Animal tests have shown that anti-depressants promote neurogenesis, indicating the possibility that they may be effective for promoting neurogenesis in cases of depression or Alzheimer’s.

● Development of lifelong learning/vocational skills

In modern society, with the pace of knowledge change increasing, its foundation on information, and in which people are connected by communications technology, it is of increasing importance to continue to learn throughout life and to devise methods of maintaining and improving vocational skills. There is thought to be a growing demand for distance education that provides education programs that meet the needs of many people and can be conducted at times and locations that are convenient for individuals.

[Note] Embryonic stem cell (ES cells): The stem cell stock made from the inner cell mass associated with part of the blastocyst at the initial formation stage of animals. In theory, these have the potential to be differentiated to form any type of tissue, and can be cultivated nearly without limit, so ES cells are receiving a great deal of attention for applications to regenerative medicine.

The development of learning and vocational skills using communications technology will support the return to the work force of those who took childcare leave, as well as the re-employment of people who have retired from another job. Furthermore, it is of great importance in an aging society with fewer children, because it is an effective method for older people to further improve their quality of life, pursue study after reaching retirement and work to obtain an academic degree.

Telecommunications systems to support more flexibility in styles of working

About 15% of companies in Japan, and 69% of companies in the USA are using tele-work for employees to work at locations other than the office using telecommunications networks. The importance of tele-work will probably grow as a style of working in an aging society with fewer children, because it allows people to work while also raising children, and reduces the physical burden of commuting to an office.

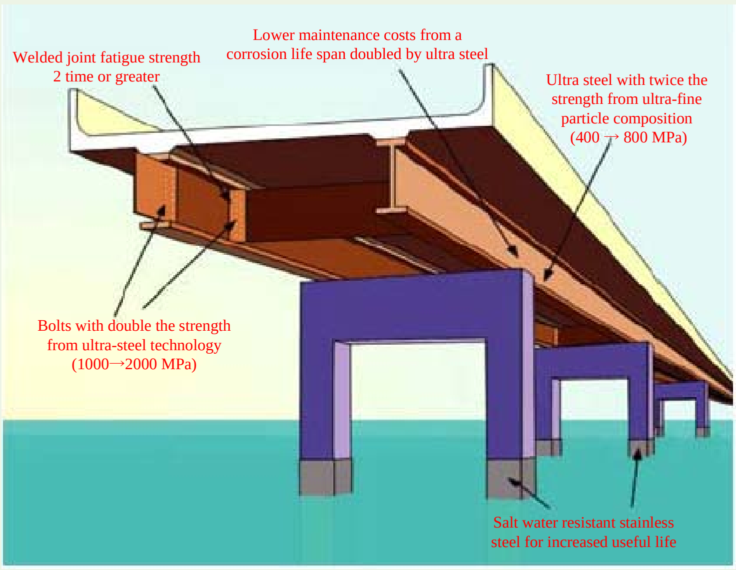
4 Science and Technology to Contribute to the Effective Utilization of Social Capital

New construction materials

Social capital stock, such as the roads, airports and sea ports under the jurisdiction of the Ministry of Land, Infrastructure and Transportation has been steadily accumulating. In the near future a large amount of this stock accumulated during the periods of high growth will begin to require updating or renewal, and it is expected that there will be a large increase in the demand for funding for maintenance, operation and renewal of this social capital stock in the future.

In order to extend the service life of social capital, there is development underway on high-strength materials with a long useful life, having superior recycling characteristics and resistance to weather (Figure 7).

Figure 7 ▶ High-strength, long-life construction materials

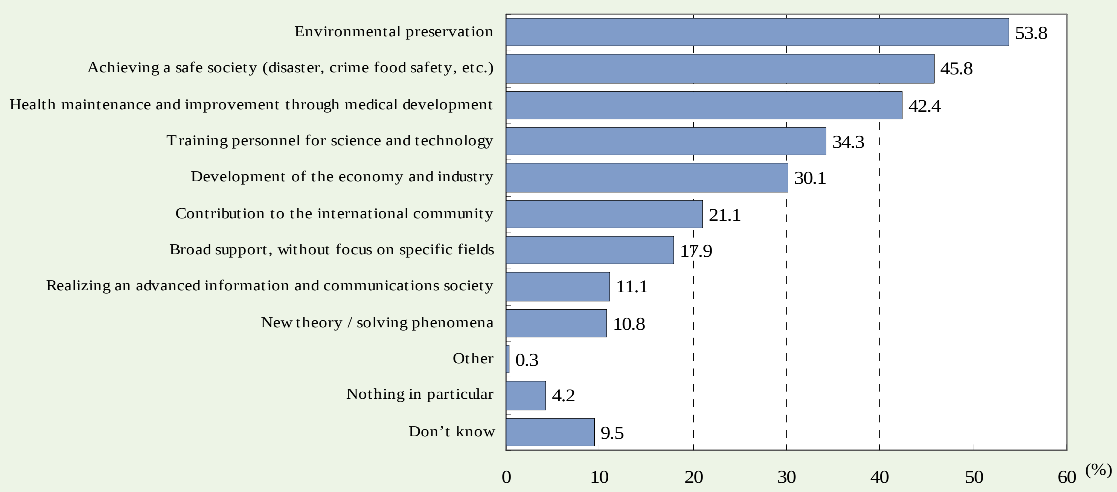


Source: National Institute for Materials Science

5 Science and Technology for Safe and Secure Society and Sustainable Society

In the “Special Public Opinion Poll on Science and Technology” conducted by the Cabinet Office in May 2005, there was the most support for “preservation of the environment” and “achieving a safe society (disaster, crime, food safety, etc.)” as the important focal points for support for science and technology (Figure 8), and nearly 70% of citizens agreed that “a high level of science and technology is required to ensure safety.” It is clear that there are high expectations from the citizens regarding the contributions of science and technology on these problems.

Figure 8 ▶ Points that should be the focus of support for science and technology (multiple answers)



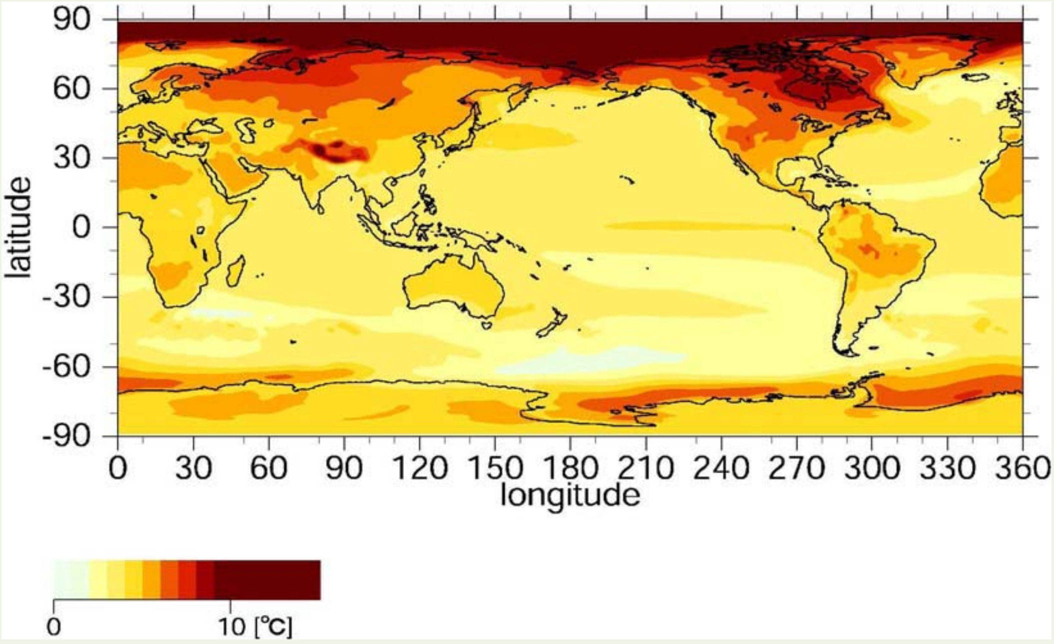
Source: Cabinet Office “Special Public Opinion Poll on Science and Technology” (June 2005)

Global environmental change and large-scale natural disasters

For the Fourth report of the Intergovernmental Panel on Climate Change (IPCC), forecasts were made using Japan’s high-performance supercomputer “Earth Simulator” (Figure 9). The results of the forecast suggest that there is a possibility that rainfall in the Amazon river basin will decrease in the future, and that tropical rainforests will be lost. Abnormal weather indicating the effects of global warming has been seen in various countries in recent years. In Japan also, there have been frequent unusually-high temperatures and record-breaking flooding.

There is increasing awareness of the importance of building observation systems that link the entire world. As a result, at the 2003 Evian G8 Summit, the First Earth Observation Summit was held at the recommendation of Prime Minister Junichiro Koizumi, and at the Third Summit in 2005, a “Global Earth Observation System of Systems (GEOSS) 10 Year Action Plan” (Figure 10) was approved. Japan is now working to strengthen response to natural disasters, like weather disasters, earthquakes and tsunami, and to construct integrated observation and monitoring systems with satellite, land-based and ocean measurements in order to contribute to global warming countermeasures.

Figure 9 ▶ Geographical distribution of predicted average surface temperature increases

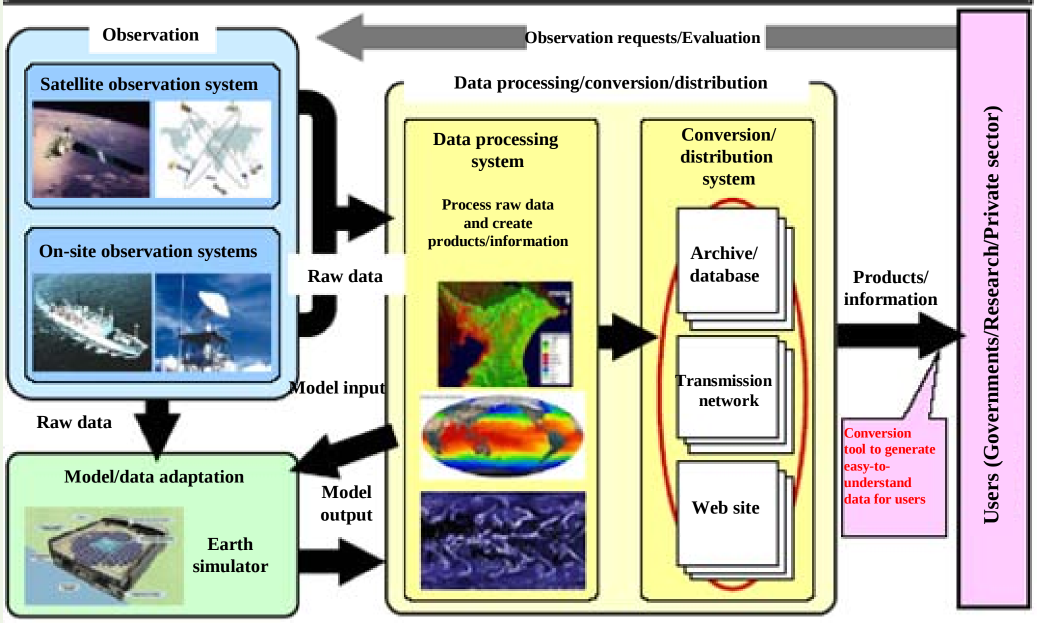


Shows the difference between the average temperature between 1971 through 2000 and the predicted average temperature between 2071-2100 in the future scenario created by the IPCC, assuming the world continues internationalization focused on economic gain

Source: Joint research team of University of Tokyo Center for Climate System Research (CCSR), National Institute for Environmental Studies (NIES), and the Japan Agency for Marine-Earth Science and Technology, Frontier Research Center for Global Change (FRCGC)

Figure 10 ▶ Global Earth Observation System of Systems (GEOSS) construction (10 year action plan)

- Maintain current observation systems, develop new observation systems to supplement the insufficient areas, and build an integrated global observation system with satellite and on-site measurements based on international cooperation.
- Collect the observations from each country and international agency, and achieve efficient, effective global observation
- Make observations to meet the requests of users (9 common benefit areas, including climate change, water cycle, damage from natural disaster)



Source: Ministry of Education, Culture, Sports, Science and Technology

Energy/Resources

There is a limit to the fossil fuel resources, such as the petroleum and natural gas that we currently use, and these are expected to be used up in the not-so-distant future. It is necessary to continue research and development on energy conservation and energy alternatives to fossil fuels, in order to halt global warming and air pollution, to increase Japan's stability and independence instead of relying on imports for most of our energy resources, as well as to contribute internationally through advanced technology.

There are limits to the supplies of the enriched uranium used as the fuel for nuclear power production. Research and development is proceeding on fast breeder reactors and nuclear fuel cycles, to effectively re-use the plutonium that is created at the ordinary nuclear power plants and make it possible to greatly alleviate the restrictions from the uranium resources. In addition, from the perspective of increasing the range of energy options in the future, research and development is continuing on nuclear fusion energy, which has a minimal impact on the environment, and for which there is an abundance of resources.

The results of technical development on solar cells, for example, include improved conversion efficiencies and lower costs for solar cells, and it is expected that Japan will be producing nearly half of all solar cells made in the world.

Serious accidents

To prevent traffic accidents, there is research and development being conducted on systems to grasp road and traffic conditions and the circumstances of the surrounding vehicles through the use of various sensors and detecting devices on roads and in vehicles, in order to improve traffic safety through ITS. In addition, as a countermeasure to single-vehicle accidents, government, industry and academia are working together on the research and development of driver support systems using telecommunications technologies to relay information between vehicle and between the road and vehicles.

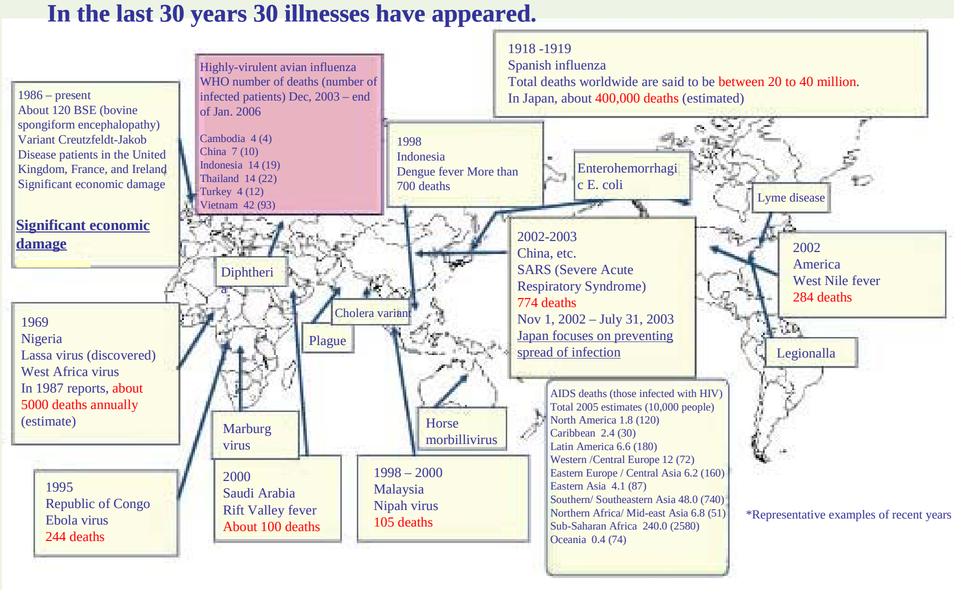
In order to prevent the recurrence of failures and lower the risk of failure in the development of ground-breaking new technology by analyzing past examples of failures, public access to a failure knowledge database has been provided.

Emerging and reemerging infectious diseases

In the past 30 years, there have been at least 30 emerging infectious diseases (Figure 11). To deal with these diseases it is necessary, first and foremost, to strengthen coordination and information sharing among relevant agencies and specialists both domestically and abroad, and to quickly and accurately identify the pathogen, carriers, and patients exhibiting symptoms. It is also necessary to identify the characteristics of the pathogen, and develop detection methods, and to enhance and fully support the basic and application research on prevention, diagnosis and treatment, including the development of vaccines and wonder drugs.

Figure 11 ▶ Expansion of emerging and reemerging infectious diseases

• **The majority of emerging and reemerging infectious diseases are zoonotic diseases. In the last 30 years 30 illnesses have appeared.**



Source: Created by the Ministry of Education, Culture, Sports, Science and Technology based on basic policy expert survey materials, Council for Science and Technology Policy

Food safety problem

With the progress of the globalization of society and the economy, as well as mass production and wide-spread distribution, if a problem with food safety should ever occur it would have an impact over a broad range (Table 12). For this reason, there is development underway on rapid detection methods for harmful microorganisms and chemical substances, and progress on technology development to trace the production history information using radio frequency identification (RFID) tags, etc., to make it possible to easily verify product indications, provide suitable information, quickly discover the cause, and recall defective foods when a problem occurs.

Table 12 ▶ Reasons for anxiety regarding food safety

	Largest percentage reasons for anxiety and response rate	Percentage of "doubts about scientific evidence"
Contaminants	There are concerns due to some problems that have occurred in the past (32.4%)	6.4%
Pesticides chemicals	Doubts about operator's adherence to the law and sanitation management (36.8%)	7.7%
Livestock antibiotics	Doubts about operator's adherence to the law and sanitation management (44.3%)	10.6%
Harmful microorganisms	Doubts about operator's adherence to the law and sanitation management (34.4%)	32.0%
Genetically modified foods	Doubts about the scientific evidence (44.0%)	44.0%
BSE	There are concerns due to some problems that have occurred in the past (32.0%)	18.1%
Food additives	Inadequate standards and labeling regulations (32.4%)	12.1%
So-called health foods	Doubts about the scientific evidence (29.2%)	29.2%

Source: Created by the Ministry of Education, Culture, Sports, Science and Technology based on the results from the Cabinet Office food safety monitor issue report “Attitudes toward Food Safety” (May 2005)

Terrorism and other crime

In order to deal with terrorism and other crime, there is development on devices to detect substances associated with criminal and terrorist activity, such as illegal drugs, explosives, and biological agents, which are hidden in the mail, without opening the envelope, etc. (Figure 13). There is also development work on portable detectors for biological agents and chemicals, research on the creation of 3-D facial image databases of criminals and automatic matching systems, research on high-speed identification systems for individuals using DNA single nucleotide polymorphisms (SNPs), handwriting analysis, and document forgery detection, and research on detecting areas with a lot of criminal activity using geographic information systems (GIS), and identification of the relationship between area characteristics and the occurrence of crime.

Figure 13 ▶ Devices to detect illegal drugs and hazardous substances without opening the envelope

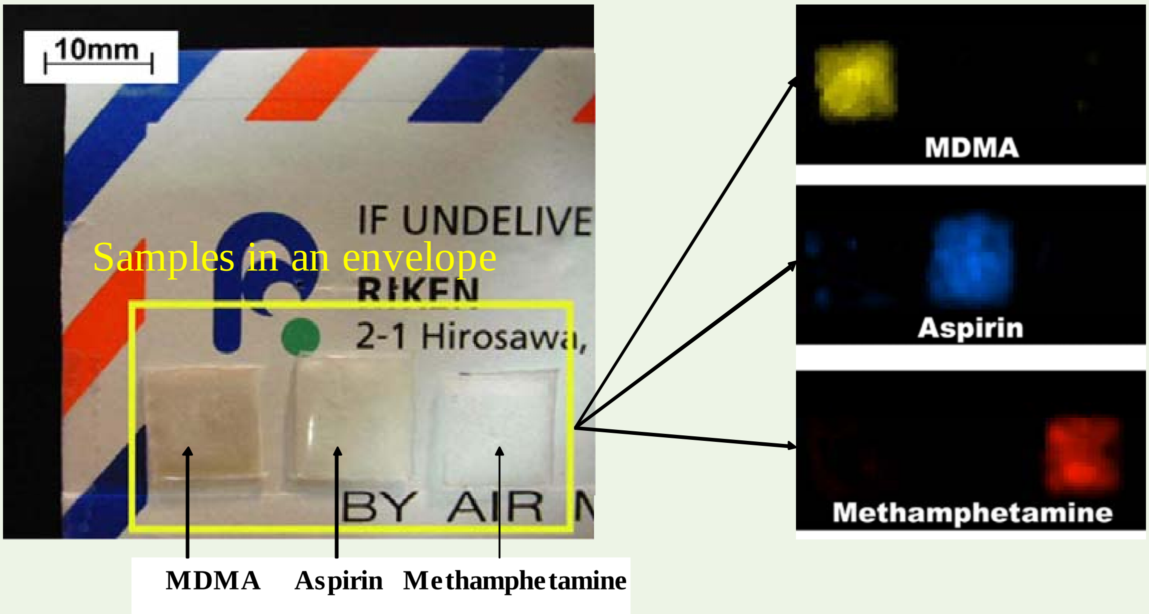


Photo courtesy of RIKEN

Information security problems

The comprehensive research and development needed to ensure the security and reliability of information and communications networks is being implemented, including science and technology to prevent, detect and analyze cyber-crime, verification and cryptographic technology, risk management, communication mechanisms in an emergency, and quantum information communications technology.

Section 2 ■ Science and Technology to Vitalize the Economy

1 Role of Science and Technology in Economic Vitalization

(1) Impact of population reduction/aging society on economic vitality

The population structure in Japan is changing as a result of rapid declines in population and the progression of an aging society with fewer children. It is also expected that the labor force will decrease due to the effect of the baby-boomers reaching an age range characterized by a relatively low labor force participation rate (Figure 14).

Figure 14 ▶ Labor force trends in Japan in 5 year increments

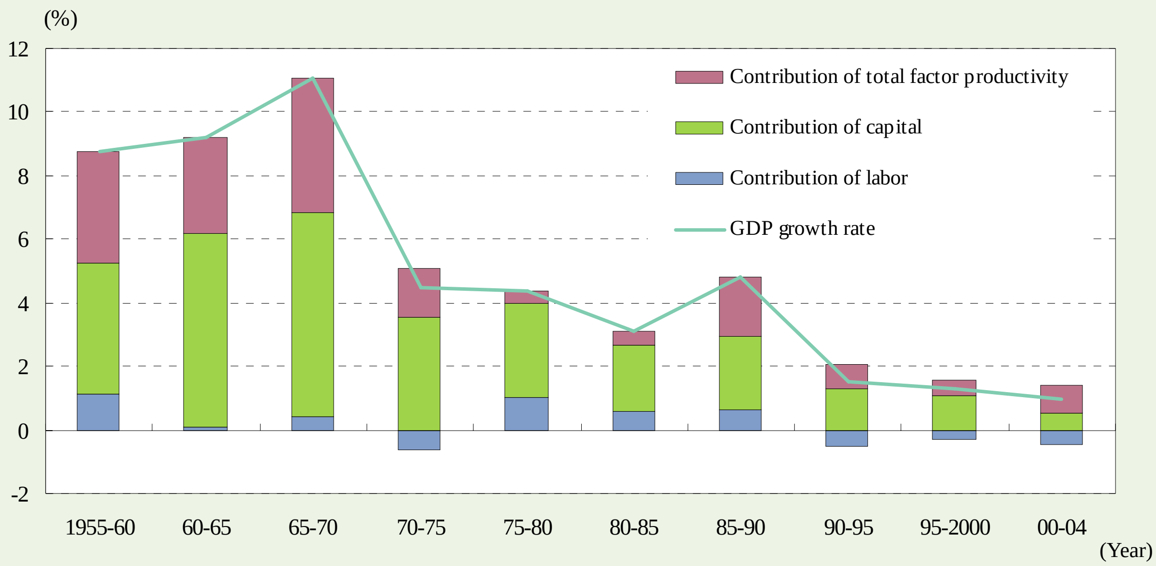
Note 1: For 2010 and after the labor participation rate by age group in 2004 are assumed to calculate estimated values. The future predicted population is based on the intermediate projection.
2: The labor force is the total of working people and unemployed people aged 15 or above.
Source: Created by the Ministry of Education, Culture, Sports, Science and Technology based on the Ministry of Internal Affairs and Communication "Labor Force Survey," "Population Estimates," the National Institute of Population and Social Security Research "Population Statistics of Japan," OECD data, and the Cabinet Office "Report on the Japanese Economy and Public Finance 2005"

With a declining population and an aging society improvements like raising the quality of the labor force and increasing productivity through the innovation that is the wellspring of science and technology, will help overcome the negative impact on the economy. It is also expected that there will be a shift from an economy that depends on "volume" to a new economy based on science and technology.

(2) Innovation and science and technology to improve productivity

Looking at the contributions from labor, capital, and total factor productivity to the GDP growth rate in Japan after World War II shows that increases in capital and in total factor productivity made the greatest contribution (Figure 15). For the increases in GDP growth rate in the late 1980s there was basically no change in the contributions from labor or capital, and the greatest contribution came from total factor productivity.

Figure 15 ▶ Attribution analysis of GDP growth rate



Note: The labor contribution is based on man-hours. The capital stock for years since the 1970s have been by operating ratio.
Source: Ministry of Health, Labour and Welfare "White Paper on the Labour Economy 2005"

In the midst of the progression of the aging of society, it is necessary to increase all-factor productivity in order to maintain and improve economic growth in Japan. Innovation and science and technology improvements are the important elements, and are expected to be even more important in the future.

(3) Trends in various countries on science and technology policies to achieve innovation

Modern Japan and economic societies in other advanced nations are knowledge-based economies and societies, founded on knowledge like the results of science and technology. To maintain and grow these economies it is important to make use of the knowledge base in industrial technology, develop new goods and services, and cycle the knowledge back into society and the daily lives of citizens. For this reason, the development of mechanisms to promote innovation has become an important policy issue for many countries, and a variety of science and technology and innovation policies are being developed (Table 16).

Table 16 ▶ Science and technology policies to promote innovation in various countries

	Japan	USA	EU	United Kingdom
Basic law; Basic plan	Science and Technology Basic Law (1995) Second Science and Technology Basic Plan (FY 2001-2005) Third Science and Technology Basic Plan (FY 2006-2010)	None	Treaty establishing the European Community Framework Programme (FP): Sixth (2002-2006), Seventh (2007-2013) Competitiveness and innovation framework programme (2007-2013)	Science and Innovation Investment Framework (2004-2014)
Priority fields	Four priority fields to be promoted under the Third Science Basic Plan: Life sciences; Information and telecommunications; Environmental sciences; Nanotechnology and materials; and interdisciplinary fields	R&D focus items of related departments and agencies: Homeland security; Network and information technology; Nanotechnology; Natural science; Environment and energy; Life sciences	Sixth FP: Life sciences; Information society technologies; Nanotechnologies and nanosciences; Aeronautics and space; Food quality and safety; Sustainable development; Citizens and governance	E-science; Life science, like genome research; Basic technology (nanotech etc.); Stem cells; Sustainable energy/economy; Agricultural economy and land utilization (use of farming regions, disease control in animals, food safety, etc)
Innovation-related policy/strategy	Third Science and Technology Basic Plan (Ch 3, 2. Creating scientific development and persistent innovation)	President's American Competitiveness Initiative	Competitiveness and innovation framework programme (2007-2013)	Science and Innovation Investment Framework (2004-2014)
Goals/programs of the above innovation policies	(Third Science and Technology Basic Plan) Maintaining the various research fund systems according to the development stage of R&D; Building a sustainable and progressive industry–academia-government collaboration system; Promoting the utilization of new technologies in the public sector; Promoting entrepreneurial activities, R&D ventures; Promoting R&D by private enterprises	Expanding R&D investment by the federal government; Promoting R&D investment by the private sector; Strengthening elementary and lower secondary school education ($380 million for math and science education); Educating/training national labor force; Obtaining talented personnel; Economic policy to promote sustainable growth	Entrepreneurship and Innovation Programme; ICT Policy Support Programme; Intelligent Energy -Europe Programme	Promoting world class research; Sustainable university research; Promoting industry–academia alliances; Increasing R&D investment in industry; Knowledge transfer and innovation; Science, technology and engineering education; Confidence of citizens in science and technology Innovation across agencies; International cooperation
New activity on innovation		Competitiveness Committee "Palmisano Report"; National Academies "Rising Above The Gathering Storm"; House Democratic Party "Innovation Agenda"(bill); Senate "American Innovation and Competitiveness Act" (bill); House "PACE Act" (bill)	A group of experts (headed by former Prime Minister of Finland, Esko Aho) advise on concrete action for innovation (Aho Group Report)	
R&D expenditure (Note)	3.4 trillion yen (0.68%) (FY2004)	10.2 trillion yen (0.81%) (FY2003)	8.8 trillion yen (0.67%) (FY2003)	1.2 trillion yen (0.59%) (FY2003)

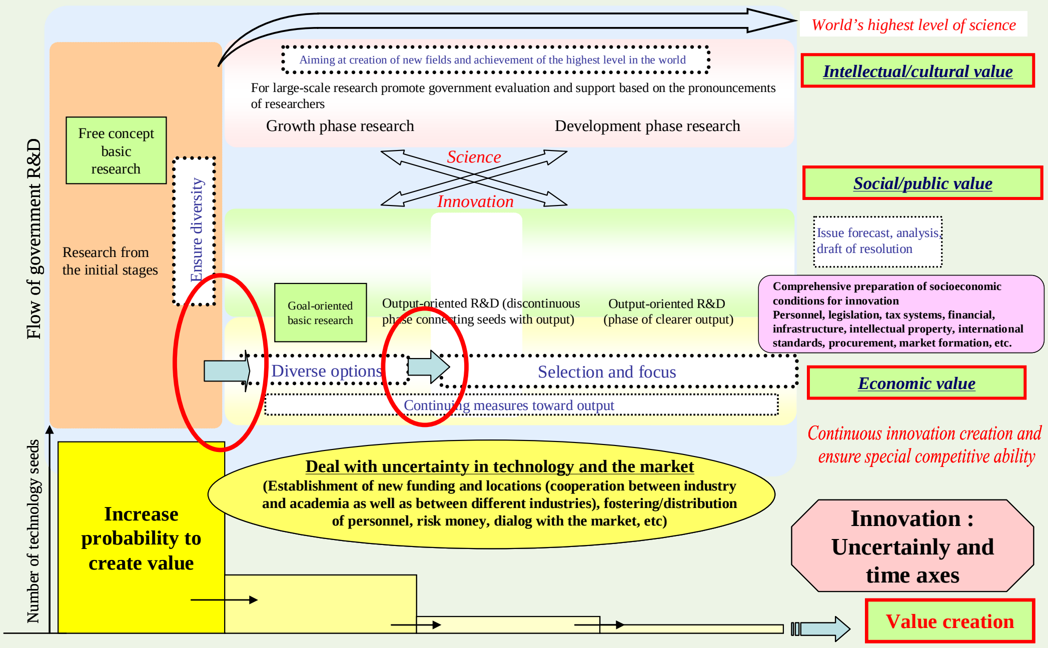
	Germany	France	China	Korea
Basic law; Basic plan	None	Long Range Plan for Research (2006-)	National Guidelines for Medium- and Long-Term Plans for Science and Technology Development (2006-2020) Eleventh Five-Year Plan (2006-2010)	Science and Technology Basic Law (2001) The Long-Term Vision for Science and Technology Competitiveness by 2025 (1999) Science and Technology Basic Plan (2002)
Priority fields	Life science; New technology; Sustainable development	Strengthening ability on defining strategic directions and priority topics; Building an integrated, transparent system for research assessment; Promoting research cooperation; Providing attractive science careers; Supporting industry-academia cooperation and industrial R&D; Enhancing the French research system and integrating French research with European research	Focus areas in the National Guidelines for Medium- and Long-Term Plans for Science and Technology Development: Energy; Water and mineral resources; Environment; Agriculture; Manufacturing; Transportation industry; Information industry and service industry; Population and health; Urbanization and urban development; Public safety; National defense	6 technology fields in the Science and Technology Basic Plan (2002-2006): IT (information technology); Biotechnology; Nanotechnology; Space and aviation Environment and energy; Culture technology
Innovation-related policy/strategy	Innovation Policy–More dynamic for competitive jobs (BMBF 2002) Agenda 2010 (2004) Pact for Research and Innovation (2005)	Innovation Research Law (1999) Innovation Support Policy (2002)	Summary of National Guidelines for Medium- and Long-Term Plans for Science and Technology Development: Feb 2002 announcement. Independent creativity (independent innovation); 863 Plan: R&D program to develop high-tech industry technologies. Continuing since 1986; Torch Program: Preparation of high-tech development zones for internationalization, industrialization and commercialization of science and technology results. Continuing from 1988	Roh Moo-hyun administration (2003-) advocating “establishment of a science and technology-oriented society” as one of its national policy targets; Establishing a strategy to promote the next-generation growth effort in 2003 to build a science and technology-oriented society aiming to achieve sustainable economic growth through the development of core technology and new industrial innovation and by becoming the world's No.2 nation based on science and technology; Establishment of an innovation bureau (2004)
Goals/programs of the above innovation policies	(Innovation Policy) Innovation & society/employment Open markets; Human resources; Business based on new technologies; Local and international innovation network; (Pact for research and innovation) Improving research competitiveness; Strengthening cooperation between agencies; Educating young people; Promoting bold research approaches; Increasing joint financial assistance to research institutes by federal and state governments	(Innovation support policy) Government support for business R&D; Improving business access to funding assistance; Improving existing funding assistance systems and establishing new systems; Employment support for young people in research fields; Enhancing priority research areas	Following target until 2020: Raising R&D investment to 2.5% or more of GDP (2.0% or more by 2010); Science and Technology contribution rate: 60% or more; Reliance on foreign technology: 30% or less; Number of citations of Chinese scientific papers/patents: Be top 5 in the world	Defining a 10 Future Growth Industry as a strategy to promote next generation growth activities while aiming to build a science and technology-oriented society
New activity on innovation		Established Industrial Innovation Agency (2005)		
R&D expenditure (Note)	2.2 trillion yen (0.78%) (FY2003)	1.8 trillion yen (0.89%) (FY2003)	0.6 trillion yen (0.63%) (FY2003)	0.4 trillion yen (0.63%) (FY2003)

Note: Government-financed R&D expenditures and the percentage of GDP include the portion from the local governments. The government-financed R&D expenditures are calculated using the IMF rates for the national currency.
For the EU, values are based on total research funding for the 25 member states.
Source: Created by the Japan Science and Technology Agency Center for Research and Development Strategy from data for various countries

2 Measures Connecting Science and Technology with Innovation

As countries adopt innovation policies and global competition becomes more intense, it is important to develop new technology and to continue to effectively connect the superior research results to innovation, while also promoting and ensuring diversity in basic research, such as by universities and public research institutions which are the sources of innovation, in order to maintain and develop Japan's economic growth. Therefore, there is a need for government, industry and academia to work together to establish innovation systems that are best suited to our country.

Figure 17 ▶ Development of science and creation of continuous innovation



Source: Created by the Economic and Social Research Institute, Cabinet Office based on the White Paper on Science and Technology 2005

(1) Promotion of basic research at universities, which are the wellspring of innovation

Universities are a source of "knowledge", and are a treasure trove of the seeds that give rise to innovation. In FY2004 the national universities and inter-university research institutes became independent organizations. As a result, there is a demand for each university to make use of their independence and autonomy to develop their own individuality and characteristics to vitalize research based on the free ideas of researchers, work in coordination with industry and the government, and make a contribution to the local area.

● Prioritization of research funds

Promote vitalization of research activities through focused distribution of funds, such as establishment of a public recruitment research project system within universities using funds under the discretion of their president, and selective distribution of the budget among departments.

Flexible reorganization

Take advantage of the ability to flexibly reorganize that comes from incorporation, and develop systems that enable research to be conducted effectively and flexibly.

Development of international research centers

Develop research systems and organizations to improve and fully utilize the inter-agency function throughout the country, and promote creative, cutting-edge research as an international center of research.

(2) Enhancing systems for creating innovation

Maintaining the various systems according to the development stage of R&D

The various research and development funding systems to support the development of science and creation of innovation must be properly prepared to handle the special characteristics and development stages of research. Expanding competitive funds(Note) will gradually improve the level of research and contribute to the development of a robust foundation for the creation of knowledge in Japan. In the future it will be necessary for the new scientific knowledge and technological concepts to be utilized in the economy and society in a visible manner, from the perspective of further strengthening the foundation of knowledge creation and to return the results to society.

Furthermore, in addition to ensuring the systems to support research and development from the basic research stages up through the innovation stages, it is also necessary to build the means to make sure that the research results created by a certain system, university or public research agency can be appropriately utilized by the system at the next stage in order to further advance innovation.

Building a sustainable and progressive industry, academia and government collaboration system

It is important that universities seeking to create new knowledge and theories, business seeking to develop products and services and the government join forces on research and development to foster innovation.

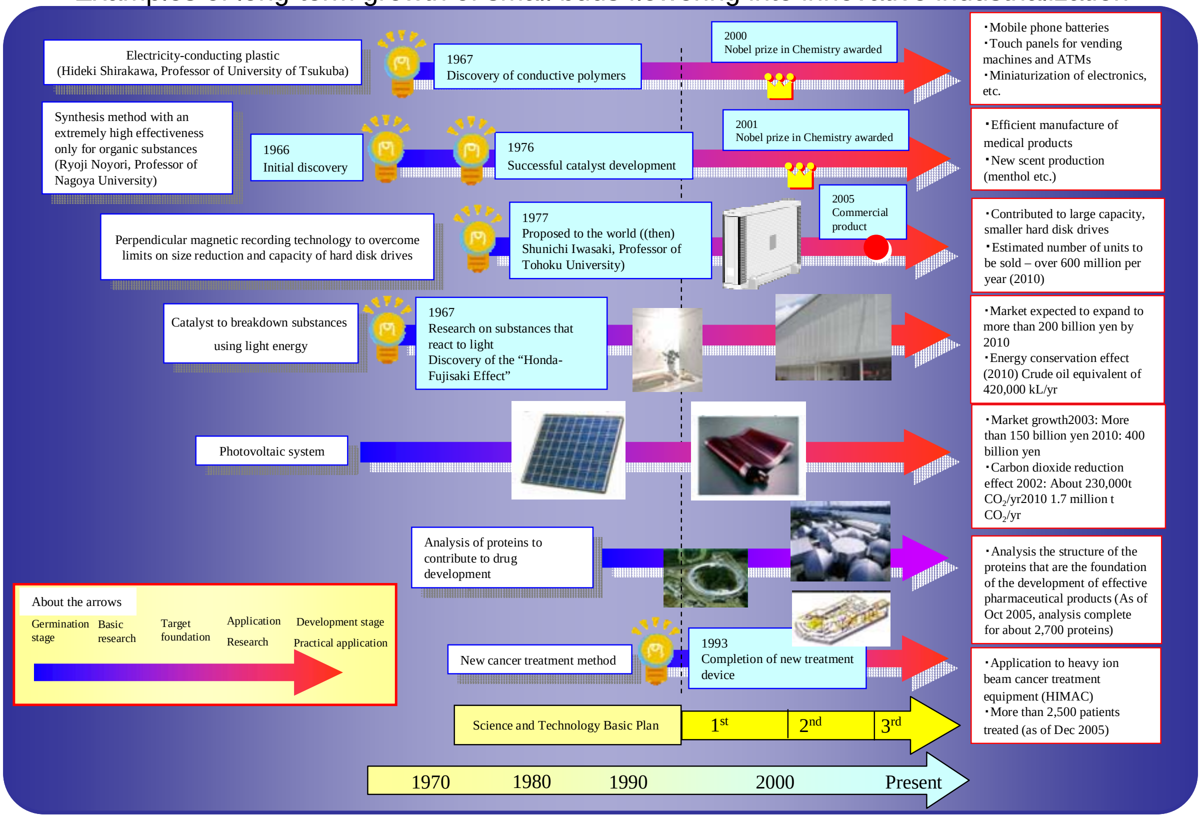
Since the establishment of the Science and Technology Basic Plan in 1996 there has been significant progress on the preparation of systems to promote industry–academia–government alliances. In FY2004 the national universities became independent corporations, and took over various responsibilities and authority. This made it possible for each university to implement measures adapted to their own special characteristics, and allows them to hold their own patent rights.

At present many universities have established industry–academia–government liaison offices, and specialists in technology, law and finance have been assigned throughout the country as industry–academia–government alliance coordinators in order to increase the return of benefits to society from universities and public research agencies. While grants and endowments from business to universities remain flat, there is an increase in the number of joint-research and

(Note) A form of research and development funds for which a call is made for a wide range of research and development topics and proposals. Several people, including specialists evaluate the topics and proposals from the scientific and technological perspective and select the topics that should be studied; and the research and development funding is distributed to the researchers.

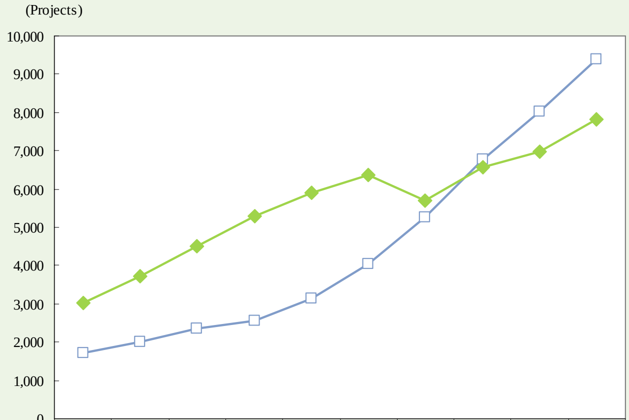
commissioned research projects, and a shift from the style of individual collaborations to organizational collaborations, and from non-contractual industry-academia-government alliances to contract-based alliances (Figure 18).

Examples of long-term growth of small buds flowering into innovative industrialization



Source: Created by the Ministry of Education Culture, Sports, Science and Technology from Cabinet Office Science and Technology Policy materials

Figure 18 ▶ Trends in the Number of Joint Research/Contract Research Projects (National Universities, etc.)



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Number of joint research projects	1,704	2,001	2,362	2,568	3,129	4,029	5,264	6,767	8,023	9,378
Number of contract research projects	3,027	3,714	4,499	5,288	5,898	6,368	5,701	6,584	6,986	7,827

Notes: 1. In FY2004 the number of joint research projects at private universities was 938, at public universities 412, and at all universities 10,728.

2. In FY2004 the number of contract research projects at private universities was 6,240, at public universities 1,169, and at all universities 15,236. The project total for contract research does not include clinical trials, commissioned testing or histological surveys.

Source: Prepared by the Ministry of Education Culture, Sports, Science and Technology