Chapter 1 1945-1994: The Era of Science and Technology for Postwar Reconstruction and Economic Recovery

Chapter 1 looks back at the trajectory from the postwar period up to just before the enactment of the Basic Act on Science and Technology, drawing on descriptions in the White Paper on Science and Technology (renamed the "White Paper on Science, Technology and Innovation" from the 2021 edition; hereinafter collectively referred to as the "White Papers" in Part 1).

Since initiatives in science, technology and innovation, as well as social and economic development, have progressed continuously, it is difficult to delineate or name distinct eras. From a broad perspective, however, this White Paper organizes them in its own way, drawing on past White Papers and other sources.

In each section divided by era, background information is first provided to describe the conditions faced by society, the economy, and science and technology at that time, followed by details organized under categories such as the science and technology promotion system, priority fields, and responses to societal challenges. Care has been taken to ensure that the descriptions are as simple and clear as possible, with reference to White Papers published at key milestones, such as at the time of enactment of the Basic Act on Science and Technology and at ten-year intervals thereafter (the 1995, 2005, and 2015 editions).

Section 1 1945-1955: The era of science and technology for postwar reconstruction and economic recovery

During these eleven years, the wartime system was dismantled by the General Headquarters of the Supreme Commander for the Allied Powers (GHQ/SCAP), and a new democratic system was established. This was also a period in which the importance of promoting science and technology was recognized from the perspective of livelihood reconstruction and economic recovery. In particular, to raise the level of science and technology that had fallen behind due to the severance of ties with other countries, emphasis was placed on introducing technology from abroad and promoting exchanges of people with other nations. Furthermore, this was also a period when bans on research in specific fields began to be lifted, triggered by the conclusion of the San Francisco Peace Treaty[1] and the advocacy at the United Nations for the peaceful use of nuclear energy. In 1949, Hideki Yukawa, a professor at Kyoto University (at the time), became the first Japanese person to receive the Nobel Prize in Physics, for research results he had published before the war.

Dismantling of the wartime system by GHQ and the development of a postwar science and technology system

After the war, the Cabinet Technical Research Institute, which had served as the central body for mobilizing technology during the war, was dismantled by GHQ. Research in fields such as nuclear energy and aerospace, including the separation of radioactive isotopes, aircraft, and radar, was prohibited, and cyclotrons, experimental devices for nuclear research, were also destroyed. Furthermore, the RIKEN Foundation, which had contributed to the development of science, technology, and industry in Japan since before the war, was reorganized into The Scientific Research Institute Ltd.

■ Figure 1-1-1/ Second cyclotron sunk on the seabed of Tokyo Bay

Source: RIKEN

1 The Treaty of Peace with Japan (San Francisco Peace Treaty), concluded between Japan and 48 Allied Powers to legally end the state of war resulting from World War II. This marked the end of the Allied occupation, restored Japan's sovereignty, and enabled its return to the international community.

Subsequently, as part of the new postwar system for promoting academic research and advancing science and technology, discussions led by GHQ's Economic and Scientific Section resulted in the establishment, by 1949, of the Science Council of Japan (SCJ) as a special organization under the jurisdiction of the Prime Minister, and the Science and Technology Administrative Council (STAC) within the Prime Minister's Office.

The Science Council of Japan (SCJ) was expected to operate independently from the government and to reflect and integrate science into administration, industry, and people's daily lives. STAC, in close cooperation with the Science Council of Japan, was expected to explore measures for incorporating science and technology in administration.

Science and technology for livelihood reconstruction

With many citizens struggling to secure food, clothing, and shelter, urgent measures were required for livelihood reconstruction through increased food production as well as improvements in public health and sanitation. Food production was increased through yield-oriented crop varieties, fertilizer development, and improved cultivation techniques, and by the late 1950s, food shortages had been resolved. In the area of public health and sanitation, infectious diseases such as typhus, smallpox, and cholera spread explosively. While infection control was pursued through GHQ's vaccine aid, Japan also established domestic production systems for vaccines and DDT[1] and founded the National Institute of Health (now Japan Institute for Health Security). As a result, most infectious diseases had subsided by the 1950s.

Science and technology for economic recovery

Although before the war, Japan's science and technology had reached nearly the same level as that of Western nations, mainly in light industry and military-related industries, by the end of the war, it lagged significantly behind advanced Western nations. Therefore, establishing a self-reliant economic foundation was regarded as an urgent task, and economic recovery was pursued under the priority production system[2]. At that time, the role of science and technology was also emphasized. To actively introduce the science and technology of advanced Western nations and quickly raise the level of Japan's science and technology level to international standards, the Agency for Industrial Science and Technology (now the National Institute of Advanced Industrial Science and Technology) was established as an external bureau of the Ministry of Commerce and Industry. In addition, the enactment of the "Foreign Exchange and Foreign Trade Control Act" (Act No. 228 of 1949) and the "Act on Foreign Capital" (Act No. 163 of 1950) further promoted the introduction of technology. Efforts were also made to promote exports through the enactment of the "Industrial Standardization Law" (now the Industrial Standardization Act) (Act No. 185 of 1949) and by improving quality control through the Japanese Industrial Standards (JIS) marking system. Backed by these factors, as well as the special demand arising from the Korean War, the level of mining and industrial production, which had fallen to only one-fifth of the prewar level in 1946, exceeded the prewar peak by 1950.

Challenges surrounding postwar research and international exchange

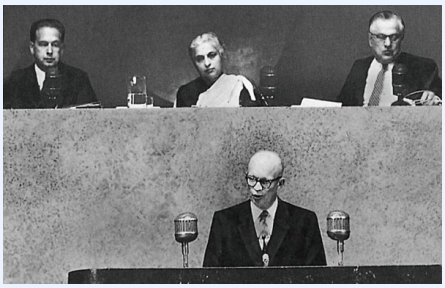
During this period, research funding, equipment, and researchers were generally lacking in both quality and quantity across all research organizations and fields, resulting in subdued activity. In this context, the prompt restoration of international exchanges was regarded as important, to serve as a foundation for the development of Japan's economy as well as its science and technology. Accordingly, following the resumption of voluntary international travel in 1950, many individuals studied in the United States and other countries with government support and under the Fulbright Program[3].

1 Abbreviation of Dichloro Diphenyl Trichloroethane. A strong insecticide used at the time. It was effective in eliminating mosquitoes and lice and in preventing the spread of infectious diseases, but its use has been discontinued in many countries due to concerns raised about its environmental impact.
2 A policy that prioritized allocation of resources to coal and steel production, with the aim of revitalizing other industries through their increased production. It was intended to make efficient use of scarce resources and boost the overall economy.
3 A scholarship program for academic and cultural exchange initiated in the postwar period between Japan and the United States. Funded by the United States, it enabled Japanese students and researchers to study in the United States and brought American experts to Japan.

Lifting of bans on research in specific fields, such as nuclear energy and aerospace

After the Treaty of Peace with Japan came into effect in 1952, peace treaties were concluded with various nations and bans imposed by GHQ on research in fields such as nuclear energy and aerospace were gradually lifted. Along with this, organizations such as the Radio Research Laboratory of the Ministry of Posts and Telecommunications, the National Aerospace Laboratory of Japan, and the Atomic Fuel Corporation were successively established. In the field of nuclear energy, following U.S. President Eisenhower's "Atoms for Peace" speech at the 1953 United Nations General Assembly, momentum grew in Japan for the peaceful use of nuclear energy. This led to the allocation of the nation's first budget for nuclear energy, designated as the Nuclear Energy Research Fund. These developments led to Japan's participation in the First International Conference on the Peaceful Uses of Atomic Energy and in the enactment of the "Atomic Energy Basic Act" (Act No. 186 of 1955). In the field of aerospace, Professor Hideo Itokawa of the University of Tokyo's Institute of Industrial Science conducted a horizontal launch test of a pencil rocket in 1955.

■ Figure 1-1-2/ U.S. President Eisenhower delivering a speech at the United Nations General Assembly



Source: Japan Atomic Energy Relations Organization

■ Figure 1-1-3/ Professor Itokawa holding a pencil rocket

Source: Japan Aerospace Exploration Agency (JAXA)

Developments at universities and other institutions

By 1949, the "Basic Act on Education" (Act No. 25 of 1947), the "School Education Act" (Act No. 26 of 1947), and the "National School Establishment Act" (Act No. 150 of 1949) had been enacted, and a total of 69 universities, including both old-system and new-system universities, had been established. In 1953, to enable joint use by researchers from national, public, and private universities nationwide, the Cosmic Ray Observatory was established at the University of Tokyo, and the Research Institute for Fundamental Physics (now the Yukawa Institute for Theoretical Physics) was established at Kyoto University. In 1951, Japan joined the United Nations Educational, Scientific and Cultural Organization (UNESCO).

Reference: Major global developments

1945 Vannevar Bush presents a report titled "Science, The Endless Frontier"
1947 Invention of the transistor
1950 Establishment of the U.S. National Science Foundation
1953 Watson and Crick announce the DNA double-helix model
1954 United States conducts a hydrogen bomb test at Bikini Atoll
The Soviet Union begins operation of the world's first nuclear power plant

Section 2 1956-1970: The era of science and technology for eliminating technology gaps while promoting high economic growth

This fifteen-year period was an era of unprecedented economic growth, highlighted by milestones such as the launch of the Tokaido Shinkansen, the hosting of the Tokyo Olympic Games, and Japan's emergence as the world's second-largest economy. Daily life became increasingly convenient and prosperous, and the entire nation was brimming with vitality. In addition, science and technology were expected to play a key role in developing the national economy. This was a period that saw the establishment of the Science and Technology Agency, the promotion of independent technology development, the expansion of human resources in science and technology, and the full-scale advancement of large-scale projects such as nuclear power development and space development.

Development of science and technology administration and implementation framework

The government recognized the importance of closing the technological gap with the West and developing independent technologies, rather than continuing to rely on "borrowed" technologies from abroad. Accordingly, in 1954, a bill to establish the Science and Technology Agency was introduced in the National Diet as a private member's bill; however, it ultimately lapsed without deliberation. Around the same time, the Japan Business Federation (Keidanren) requested the establishment of a comprehensive administrative body for science and technology. Following these developments, the Science and Technology Agency Establishment Act (Act No. 49 of 1956) was enacted. In the same year, the Science and Technology Agency was formally established within the Prime Minister's Office to promote science and technology, contribute to the development of the national economy, and comprehensively advance science and technology administration. In 1959, the Council for Science and Technology, chaired by the Prime Minister, was established to facilitate coordination with relevant ministries, including the Ministry of Education, which had jurisdiction over universities. Other measures to further strengthen Japan's science and technology promotion and implementation framework included the establishment of the Agriculture, Forestry and Fisheries Research Council under the Ministry of Agriculture and Forestry; the establishment of the Japan Information Center of Science and Technology (now the Japan Science and Technology Agency); the enactment of the Professional Engineer Act (Act No. 124 of 1957); and the reorganization of The Scientific Research Institute Ltd. into RIKEN as a special public corporation. Additionally, there was a boom in the establishment of central research institutes by private companies.

■ Figure 1-1-4/ Establishment of the Science and Technology Agency

Source: Kyodo News

To promote scientific research, the Japan Society for the Promotion of Science (JSPS) was established in 1932 as a non-profit foundation with an endowment from Emperor Showa. After the war, in order to strengthen support for scientific research, individual researchers, and international academic exchanges, JSPS became a special public corporation in 1967, serving as a core institute for the promotion of scientific research.

Income Doubling Plan and the expansion of human resources in science and engineering

Following the Cabinet decision on the so-called Income Doubling Plan, which aimed to double the size of Japan's economy in real terms over ten years beginning from FY1961, the Council for Science and Technology released its first report in 1960, titled "Comprehensive Basic Policy for the Promotion of Science and Technology with a Ten-Year Outlook." The report indicated a direction centered on catching up with the advanced Western nations by substantially expanding human resources in science and technology and strengthening research and

development activities. With regard to securing numbers of scientists, engineers, and skilled technicians in particular, the report pointed out that over the coming decade, Japan would face a shortfall of 170,000 science and engineering graduates and 440,000 skilled technicians graduating from technical high schools. This led the Ministry of Education to formulate a plan to increase the number of science and engineering students at Universities and the overall number of human resources in science and technology, laying the foundation for Japan's high economic growth. As a result of rapid economic growth, by 1968 Japan's GNP[1] ranked second among the free-market economies, behind only the United States. Major milestones during this period include the launch of the Tokaido Shinkansen, the hosting of the Tokyo Olympics, the construction of dedicated expressways, the entry into service of domestically produced YS-11 passenger aircraft, and the hosting of the Japan World Exposition (Expo'70) in Osaka. Moreover, rising incomes, together with declining product prices resulting from technological innovation, led to the widespread adoption of home appliances such as black-and-white televisions, electric refrigerators, and electric washing machines in Japanese households.

Promotion of independent technology development

As the world moved toward liberalization of trade and capital, strengthening the international competitiveness of Japan's industry became a major concern during this period, further heightening the need for independent technology development in the country. On the other hand, scientific and technological development showed a strong trend toward becoming larger in scale, more advanced, and more integrated, necessitating the organization of specialized fields and the allocation of substantial funding based on long-term research and development plans. To address these challenges, the Research Development Corporation of Japan (now the Japan Science and Technology Agency) was established to facilitate the development of important new technologies that were difficult for private companies to pursue independently, by utilizing the research results of universities and national and public research institutes, and by commissioning or coordinating the development of these technologies with companies in an appropriate manner. Additionally, to encourage greater private-sector R&D investment, the government increased its own R&D spending and introduced a tax credit system for experimental research expenses. Through these measures, technological innovation advanced in areas previously dependent on imported foreign technologies, such as electric machinery, nylon, steel, and automobile manufacturing, leading to the development of advanced domestic technologies, including compact automobiles, cathode-ray tube televisions, and textile products. Among the products manufactured using advanced Japanese technology was the transistor radio manufactured by Tokyo Tsushin Kogyo (now Sony Corporation), which utilized Leo Esaki's discovery of the "tunneling effect," a breakthrough for which he was awarded the 1973 Nobel Prize in Physics.

■ Figure 1-1-5/ Reona (Leo) Esaki, recipient of the Nobel Prize in 1973

Source: Leo Esaki

Full-scale launch of nuclear power development and space development

Large-scale projects were promoted and organizational frameworks established, leading to the full-scale launch of nuclear and space development. With respect to nuclear power development, the three laws on nuclear energy were enacted in 1956: the Atomic Energy Basic Act, the "Act for Establishment of the Japan Atomic Energy Commission" (Act No. 188 of 1955), and the "Act for Partial Amendment of the Act on Establishment of the Prime Minister's Office" (Act No. 187 of 1955). These laws set forth basic policy for the research, development, and utilization of nuclear power. Thereafter, the Japan Atomic Energy Commission was established, and a new Atomic Energy

1 Gross National Product

Bureau was created within the Prime Minister's Office (later reorganized as an internal bureau of the Science and Technology Agency of the Prime Minister's Office). In 1956, Japan formulated its first "Long-Term Program for Development and Utilization of Nuclear Energy." That same year, the Japan Atomic Energy Research Institute (now the Japan Atomic Energy Agency (JAEA)) was established, followed in 1957 by the Tokai laboratory (now the Nuclear Science Research Institute) within it. In 1963, Japan successfully generated electricity for the first time using the Japan Power Demonstration Reactor (JPDR[1]). That same year, the Japan Nuclear Ship Development Agency (now part of the JAEA) was established to develop the nuclear-powered ship "Mutsu." In 1966, Japan decided to independently develop fast breeder reactors (FBRs[2]) and advanced thermal reactors[3], and in the following year established the Power Reactor and Nuclear Fuel Development Corporation (now part of the JAEA).

With respect to space development, the National Space Activities Council was established in 1960 as an advisory committee to the Prime Minister. In its first report, released in 1962 ("Basic Policy for the Promotion of Space Development"), the National Space Activities Council outlined the principle that "Japan's space development shall be conducted exclusively for peaceful purposes, based on the principles of autonomy, openness, and international cooperation." Consequently, the National Space Development Agency of Japan (now the Japan Aerospace Exploration Agency) was established in 1969. Then, in 1970, Japan successfully launched its first artificial satellite, "Ohsumi."

In addition, the Council for Science and Technology's Second Report in 1959 ("Priority Policies for Science and Technology in FY1960") identified six specific fields to be promoted as specially designated research areas: typhoon disaster prevention, space science and technology, fundamental electrical and electronic engineering, nuclear fusion, marine science and technology, and cancer-related research. By the mid-1960s, a number of advisory councils and research institutes had been established in connection with these areas, including the Council for Marine Science and Technology, the National Cancer Center (now the National Cancer Center Japan), the National Research Center for Disaster Prevention (now the National Research Institute for Earth Science and Disaster Resilience), and the National Institute for Research in Inorganic Materials (now part of the National Institute for Materials Science).

Launch of the White Paper on Science and Technology

In 1958, the government of Japan published its first White Paper on science and technology with the aim of clarifying the status of science and technology in the country and gaining broad public understanding and cooperation for its promotion.

■ Figure 1-1-6/First White Paper on science and technology

Source: MEXT (then the Science and Technology Agency), "1958 White Paper on Science and Technology"

Reference: Major global developments

1956 Japan joins the United Nations

United Kingdom begins commercial operation of the Calder Hall Nuclear Power Station

1957 Soviet Union successfully launches Sputnik 1, the world's first artificial satellite

The IAEA[4] is established

1958 United States establishes NASA[5]

1959 United Kingdom creates a new Ministry of Science

1961 Soviet cosmonaut Yuri Gagarin makes the first manned spaceflight aboard Vostok 1

1 Japan's first power reactor. It was constructed to gain experience in the construction, operation, and maintenance of nuclear power plants, and to understand the characteristics of power reactors through operational testing.
2 Reactors capable of generating more nuclear fuel than they consume while generating power
3 Reactors designed to utilize plutonium, recovered uranium, and other fuels in a flexible and efficient manner
4 International Atomic Energy Agency
5 National Aeronautics and Space Administration

United States establishes the Office of Science and Technology within the Executive Office of the President and launches the Apollo Program

1962 Rachel Carson publishes "Silent Spring"

1967 First human heart transplant is performed in South Africa

1968 UN opens the Treaty on the Non-Proliferation of Nuclear Weapons for signature

1969 Apollo 11 moon landing, led by Commander Neil Armstrong

The U.S. Department of Defense builds ARPAnet[1], the precursor to the modern Internet

1 Advanced Research Projects Agency net. It was the first packet-switched computer network launched by ARPA, an arm of the U.S. Department of Defense for military purposes. Its operation began by connecting four universities and research institutions in the United States.

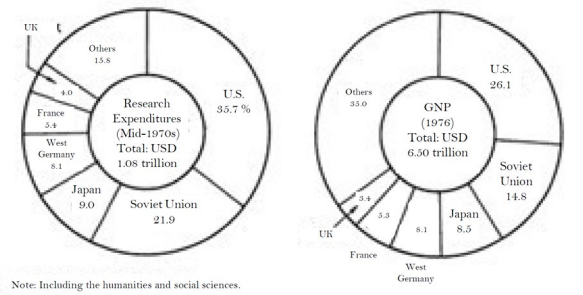
Section 3 1971-1980: The era of science and technology for correcting distortions by economic growth and harmonizing with the global situation

During this decade, priority was placed on science and technology for addressing environmental issues such as pollution[1] resulting from rapid economic growth, as well as for the development and introduction of alternative energy sources in response to the oil crisis[2]. At the same time, against the backdrop of rising technological levels from corporate R&D, Japan's international competitiveness increased in sectors such as automobiles. In addition, the rapid progress of molecular biology led to the initiation of focused promotion of the life sciences during this period. In addition, transportation networks were developed nationwide, the "3Cs" (color television, air conditioners, and cars) spread rapidly, and public awareness began to shift from material affluence to spiritual enrichment.

Science and Technology Promotion Policies

In 1978, Japan accounted for 10 percent of the world's Gross National Product (GNP). In terms of total research expenditures, Japan ranked third worldwide after the United States and the Soviet Union (Figure 1-1-7). During this period, science and technology policy placed particular emphasis on responding to the worsening environmental problems and the energy crisis. The fifth report of the Council for Science and Technology in 1971 recommended strengthening science and technology to respond to the distortions arising from rapid economic growth, with measures for pollution control, and to promote fields such as the life sciences that would serve as seeds for the next generation of technological innovation. The sixth report of 1977 recommended that it was necessary to strengthen the capacity to respond to drastic changes in the international environment, including the oil crisis, and to develop policies that also took into account the quality of life in areas such as medical care and welfare.

■ Figure 1-1-7/ Research Expenditures and GNP (Mid-1970s)

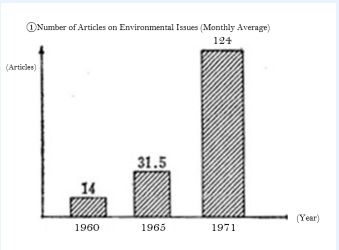


Source: Compiled by the Ministry of Education, Culture, Sports, Science and Technology (then the Science and Technology Agency), based on "Statistical Yearbook," United Nations and "Statistical Abstract of the United States, 100th Edition," U.S. Department of Commerce.

Addressing Pollution Issues

As noted above and shown in Figure 1-1-8, measures to address the increasingly apparent and serious environmental issues, such as pollution and destruction of nature, were regarded as urgent challenges. Following the enactment of The Basic Law for Environmental Pollution Control (Law No. 132 of 1967), the Environment Agency was established, and the National Institute for Environmental Pollution Research (now the National Institute for Environmental Studies) was founded by 1974. Efforts were directed toward strengthening environmental science and technology through research and development for the prevention and control of pollution, as well as enhancing preliminary evaluations at the stage of social application. In addition, during the same period in the United States, the Clean Air Act Amendments (commonly known as the

■ Figure 1-1-8/Trends in the Treatment of Environmental Issues in Newspapers[14]



Source: Ministry of the Environment (then the Environment Agency), 1972 White Paper on the Environment in Figures

1 Obstacles to environmental conservation, such as air pollution, water pollution, soil contamination, noise, vibration, ground subsidence, and offensive odors arising extensively from business and other human activities that cause harm to human health and the living environment. The four major pollution-related diseases, Minamata disease, Niigata Minamata disease (the second Minamata disease), Yokkaichi asthma, and Itai-itai disease, were caused by hazardous substances contained in factory wastewater and emissions.

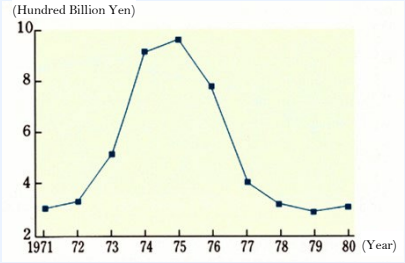
2 Global economic disruption in the 1970s due to the sharp rise in crude oil prices and supply insecurity.

Muskie Act) were enacted with the main objective of reducing emissions of toxic substances in automobile exhaust gas to one-tenth of their previous levels, and the Environmental Protection Agency (EPA) was established. Japan faced serious environmental issues simultaneously with, or even earlier than, the rest of the world. In response, the development of various technologies to reduce environmental burdens, such as emission-control technologies for sulfur oxides (SOx)[1] and nitrogen oxides (NOx)[2], was advanced, along with efforts to address pollution problems through regulatory tightening and other measures.

Response to the Oil Crises

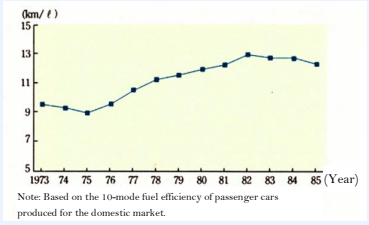
Following the first oil crisis, which was triggered by the Fourth Middle East War in 1973, ensuring a stable energy supply became a major policy issue. In response, the Agency for Natural Resources and Energy was established within the Ministry of International Trade and Industry in the same year. In addition, research and development on renewable energy and energy-saving technologies were actively promoted. In 1974, the "Sunshine Project" was launched to conduct R&D on new energy technologies such as solar and geothermal energy. In 1978, the "Moonlight Project" was initiated for the development of energy conservation technologies[3]. Furthermore, the second oil crisis occurred in 1979, triggered by the Iranian Revolution. In 1980, the Act on the Promotion of Development and Introduction of Alternative Energy (Law No. 71 of 1980) was enacted with the aim of reducing Japan's dependence on oil, and the New Energy Development Organization (now the New Energy and Industrial Technology Development Organization (NEDO)) was established. Industry also actively developed energy-saving technologies, including highly efficient blast furnaces and fuel-efficient engines. These innovations were highly regarded worldwide and also contributed to strengthening the international competitiveness of Japanese industry (see Figures 1-1-9 and 1-1-10).

■ Figure 1-1-9/Trends in Private-sector Investment in Pollution Control Equipment



Source: National Institute of Science and Technology Policy, Ministry of Education, Culture, Sports, Science and Technology, (then National Institute of Science and Technology Policy, Science and Technology Agency), Science and Technology Indicators 1994

■ Figure 1-1-10/ Trends in the Fuel Efficiency of Japanese Automobiles



Source: Historical Development of Japan's Science and Technology Policy (1989)

1 Gases that are emitted during the combustion of fuels such as oil and coal. The main example is sulfur dioxide, which is also a cause of acid rain.
2 Gases that are emitted when fuels are burned at high temperatures in automobiles or factories. The main examples are nitric oxide and nitrogen dioxide, which cause photochemical smog and acid rain.
3 Subsequently, the two projects were integrated and evolved into the "New Sunshine Project," which took a longer-term perspective.

Progress in Electronics and Life Sciences

This era also witnessed rapid advances in electronics [1] and information utilization, as well as developments in the life sciences[2]. In the field of electronics, advances in semiconductors, computers, and communication technologies, together with market expansion, drove progress in the control of industrial machinery and household appliances, contributing significantly to strengthening the international competitiveness of Japanese manufacturing. In the field of life sciences, building on the rapid progress of molecular biology, efforts to prioritize this field were initiated. The field was expected to contribute to solving challenges in health care, environmental conservation, agriculture, forestry and fisheries, and the chemical industry.

Response to the Progress of the Era, such as Ocean Development

Amid the global expansion of territorial seas and the establishment of exclusive economic zones, as well as the development of deep-sea resources, interest in ocean development also grew in Japan. In 1971, the Council for Marine Science and Technology was reorganized into the Marine Development Council. In the same year, the Japan Marine Science and Technology Center (now the Japan Agency for Marine-Earth Science and Technology (JAMSTEC)) was established as its implementing body. Through the 1980s, efforts advanced, including the implementation of the SEATOPIA Project, which aimed to establish saturation diving technology, and the development of manned submersibles, including Shinkai 2000 and Shinkai 6500. In addition, prompted by concerns about the potential for a major earthquake in the Tokai region, the Headquarters for Earthquake Prediction Promotion was newly established within the Cabinet in 1976. Under close coordination among relevant ministries and agencies, major initiatives to promote earthquake prediction were pursued with even greater intensity. Other developments during this period included the establishment of the Inter-University Research Institute (now the Inter-University Research Institute Corporation) in 1971. Furthermore, following the enactment of the Tsukuba Science City Construction Act (Law No. 73 of 1970), 43 experimental research institutions from 10 ministries and agencies were relocated by 1980, and Tsukuba Science City was largely completed.

Reference: Major global developments

1972: Physicist Steven Weinberg proposed the concept of "trans-science."

The Club of Rome published The Limits to Growth

The United States enacted the Clean Air Act Amendments (commonly known as the Muskie Act)

1973: Development of recombinant DNA technology (Cohen and Boyer)

1974: Identification of the potential for ozone layer depletion caused by chlorofluorocarbons (Rowland and Molina)

1976: Establishment of the Office of Science and Technology Policy (OSTP) in the United States

1977: Establishment of the U.S. Department of Energy

1978: Birth of the world's first test-tube baby in the United Kingdom

1979: Publication of Japan as Number One by Ezra Vogel

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1 A field of science and technology that controls and applies the movement of electrons. It utilizes electronic components such as semiconductors, enabling a wide range of indispensable systems and devices for our daily lives, including information processing, communications, and control.

2 A field that seeks to elucidate the complex and precise mechanisms of biological phenomena, attracting attention for its potential to contribute significantly to medical and pharmaceutical breakthroughs, solutions to food and environmental issues, improvements in quality of life, and the development of the national economy.

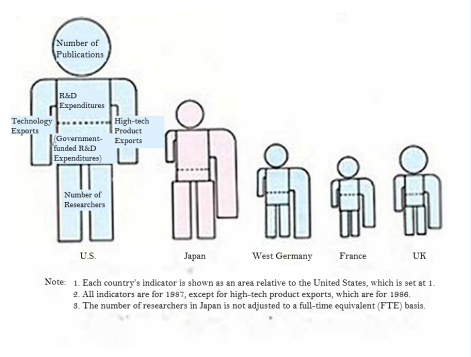
Section 4 1981-1994: The era of the creative application of science and technology against the backdrop of trade friction and a strong yen

These fourteen years constituted a truly tumultuous era, as world affairs underwent major changes such as the end of the Cold War[1], the formation of the European Union (EU), and the rapid economic growth of East Asian countries. At the same time, Japan experienced both the bubble economy and its collapse at home. In the realms of society, the economy, and science and technology, Japan's trade surpluses, supported by the high technological competitiveness of its manufacturing sector and the appreciation of the yen, became a permanent feature and further enhanced its standing in the global economy. At the same time, trade and economic frictions with the United States and other advanced nations deepened, and punitive tariffs[2] were imposed, particularly on advanced technology sectors such as semiconductors, computers, and aerospace. Furthermore, spurred by criticism from advanced countries of Japan's "free-riding on basic research[3]" and the improvement of Japan's scientific and technological standards, efforts to promote creative science and technology with a strong emphasis on basic research were strengthened.

Advancement of creative science and technology

From the early 1980s, led by the United States, Japan faced criticism of "free-riding on basic research," which argued that its large exports of high-tech and industrial products were based on the results of basic research conducted by other countries. In contrast, its expenditures on basic research and the number of publications were insufficient compared with advanced nations such as the United States, Germany, and France(Figure 1-1-11). This also became a major issue in the 1988 amendment of the Agreement between the Government of Japan and the Government of the United States of America on Cooperation in Research and Development in Science and Technology.

■ Figure 1-1-11/ Overview of R&D expenditures, number of researchers, technology exports, high-tech product exports, and number of publications in major countries



Source: Prepared in 1990 by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) (then the Science and Technology Agency), based on OECD statistics and national statistics

In response to such criticism, Japan designated 1981 as the "First Year of Japan as a Science and Technology Nation," and thereafter moved to vigorously promote its fundamental and pioneering research. Specifically, in 1981, Japan established research support mechanisms, notably the "Science and Technology Promotion Coordination Fund[4]" and the "Exploratory Research for Advanced Technology (ERATO) Program[5]." The latter program produced groundbreaking research that laid the foundations for AI and quantum computing technologies, and it became a model for many subsequent initiatives to support advanced research. In the late 1980s, Japan also established researcher training programs, including the "Research

1 A political, economic, and military confrontation between the Western bloc led by the United States and the Eastern bloc led by the Soviet Union, characterized by the absence of direct armed conflict.
2 A U.S. trade measure imposing tariffs higher than the normal rate on certain Japanese imports, as retaliation for practices deemed unfair. This was intended to reduce the price competitiveness of Japanese products and curb imports from Japan.
3 Criticism that Japan's economic growth was achieved by capitalizing on the results of basic research conducted by other advanced nations. Japan was said to focus on product development while making relatively little contribution to basic research.
4 Competitive funding to promote science and technology in Japan by enabling the strategic advancement of research and development across ministerial boundaries. The fund played a flexible and focused role in supporting research aimed at solving important issues and pioneering new fields. The program has since been restructured.
5 A program implemented by the Japan Science and Technology Agency to promote research projects aimed at generating globally leading, innovative science and technology. Led by outstanding research leaders, it focused on advancing original and high-risk research, with the aim of contributing to the development of future science and technology and the creation of new industries. At present, reflecting contemporary needs, the Creative Science and Technology Promotion System has been developmentally dissolved, and ERATO has been reorganized under the Strategic Creative Research Promotion Program.

Fellowship for Young Scientists" by the Japan Society for the "Research Fellowship for Young Scientists in Science and Technology" by the Promotion of Science and the Science and Technology Agency. Simultaneously, in 1986, Japan enacted the Act for Facilitating Government Research Exchange (Act No. 57 of 1986) to promote active collaboration between researchers in the public and private sectors. Recognizing the need to develop a large-scale, cutting-edge research infrastructure that could not be possessed by a single institution, planning for the large synchrotron radiation facility SPring-8 began in 1988. This facility began operation for shared use under the Act for the Promotion of Public Utilization of the Specific Synchrotron Radiation Facility (Act No. 78 of 1994), which led to the subsequent development of large-scale shared facilities such as supercomputers. In the late 1980s, the establishment of central research laboratories again became a boom in the private sector, particularly among large corporations. Furthermore, in 1983, to strengthen the functions of the Science and Technology Council, a Policy Committee was established under it. In 1988, the National Institute of Science and Technology Policy (currently part of MEXT as the National Institute of Science and Technology Policy) was established within the Science and Technology Agency. Additionally, in 1985, with a view to further developing the completed Tsukuba Science City, the International Science and Technology Exposition (Tsukuba Expo) with the theme "Dwellings and Surroundings – Science and Technology for Man at Home" was held in Ibaraki Prefecture.

■ Figure. 1-1-12/Opening of the Tsukuba EXPO '85 (1985)

Source: Tsukuba City

Formulation of the General Guidelines for Science and Technology Policy

In 1986, the Cabinet approved the "General Guidelines for Science and Technology Policy," which paved the way for the subsequent Basic Plan. Based on the 11th Report of the Science and Technology Council in 1984, the outline ("Comprehensive Basic Policy for the Promotion of Science and Technology in Response to New Situational Changes and from a Long-Term Perspective"), set three priority R&D areas: advancing basic and pioneering science and technology, promoting science and technology for economic revitalization, and promoting science and technology to enhance society and quality of life.

The subsequent 1992 General Guidelines for Science and Technology Policy incorporated initiatives, including the early doubling of government investment in research and development.

Addressing international relations concerning science and technology, and participation in large-scale international projects

With globalization advancing further in the field of science and technology, large-scale international collaborative projects began to be launched, in addition to ongoing researcher exchanges and joint research activities. Japan participated in the International Space Station (ISS[1]) program, initiated by a call from U.S. President Ronald Reagan, and the ITER[2] project, launched following U.S.–Soviet summit discussions in 1985 and 1988, respectively. In addition, the Human Frontier Science Program (HFSP)[3], proposed by Prime Minister Yasuhiro

■ Figure. 1-1-13/Venice Summit at the time of the HFSP proposal

Source: Ministry of Foreign Affairs website

1 International Space Station
2 International Thermonuclear Experimental Reactor
3 Human Frontier Science Program: An international research grant program supporting innovative global collaborations among scientists and providing young researchers with international research opportunities.

Nakasone at the 1987 Venice Summit to promote basic research on the elucidation of biological functions through international cooperation, was initiated in 1990.

Cancer Control and Addressing global environmental challenges

Cancer, which has been the leading cause of death in Japan since 1981, was a major health concern, and advances in molecular biology at the time led to rapid progress in elucidating the mechanisms of carcinogenesis. Against this backdrop, the "Comprehensive 10-Year Strategy for Cancer Control" (1984–1993) was formulated in 1983 and has been revised approximately every decade since, setting key research priorities such as elucidating the genetic and viral causes of carcinogenesis, developing new diagnostic and therapeutic methods, clarifying tumor promotion and its control, and regulating immune responses. As a result, milestones were achieved, including the world's first clinical application of a heavy-ion cancer therapy device, the discovery of several cancer-related genes, and the identification of the Japanese-type hepatitis C virus, all of which greatly contributed to the later development of therapeutic drugs based on the elucidation of the molecular mechanisms of cancer initiation and progression.

With growing global concern over issues such as ozone depletion, global warming, acid rain, and desertification, the Intergovernmental Panel on Climate Change (IPCC) was established in 1988. Subsequently, at the 1992 "United Nations Conference on Environment and Development" (UNCED[1], Earth Summit) in Brazil, the "Rio Declaration on Environment and Development" was adopted, setting forth principles for the actions of nations and individuals toward the 21st century. In Japan, the "Basic Act on the Environment" (Act No. 91 of 1993) was enacted, and the following year, in 1994, the Basic Environment Plan based on this Act was formulated, thereby advancing environmental research, monitoring and observation, and the promotion of suitable technologies.

Blossoming of Japan's domestic technological development in fields such as nuclear power and space

Since the 1960s, Japan has been striving to develop its own technologies in the fields of nuclear power, space, and marine science, and the results of these domestically developed technologies began to emerge one after another. In the field of nuclear development, milestones included the first criticality of the nuclear-powered ship Mutsu in the mid-1970s, the establishment of the Nuclear Safety Commission in response to radiation leaks from the vessel, and the first criticality of the experimental fast reactor Jōyō and the prototype advanced thermal reactor Fugen. Subsequently, in 1991, the Mutsu undertook an experimental voyage, and in 1994, the prototype fast breeder reactor Monju achieved initial criticality.

In space development, Japan succeeded for the first time in 1994 with the launch of the H-II Launch Vehicle No. 7, employing domestically developed technology in all stages. The H-II Launch Vehicle later launched the Himawari-5 weather satellite and the Space Flyer Unit (SFU[2]) into orbit. In 1992, Mamoru Mohri became Japan's first astronaut to fly aboard the Space Shuttle.

■ Figure1-1-14/Launch of the H-II Launch Vehicle

Source: Japan Aerospace Exploration Agency (JAXA)

In ocean development, the manned submersibles "Shinkai 2000" and "Shinkai 6500" were completed in 1981 and 1989, respectively, each reaching its designated target depth. Additionally, in 1991, Sumio Iijima, then a researcher at NEC Corporation, discovered carbon nanotubes, which are lightweight and extremely strong, with high elasticity and electrical conductivity (which were later mass-produced for the first time in the world by Zeon Corporation).

1 Intergovernmental Panel on Climate Change
2 Space Flyer Unit

Reference: Major global developments

1984 U.S. President Reagan announced the International Space Station (ISS) program

1985 The United States released the Young Report

Windows (Microsoft) was released in the U.S.

Circa 1985 Discovery of the ozone hole

1986 Chernobyl nuclear power plant accident in the Soviet Union

Space Shuttle Challenger disaster in the United States

1988 Commencement of the joint design activities for the International Thermonuclear Experimental Reactor (ITER) involving the U.S., European Community, Soviet Union, and Japan

Establishment of the Intergovernmental Panel on Climate Change (IPCC)

1989 End of the Cold War

1990 United States launched the Human Genome Project (completed in 2003)

Commercial use of the Internet began in the United States; Japan followed in 1993

1992 At the United Nations Earth Summit, the Rio Declaration on Environment and Development and Agenda 21 were adopted

1993 Establishment of the European Union (EU)

The Convention on Biological Diversity (CBD) came into effect

Column 1-1 Features from the Postwar Period to the Pre-Enactment of the Basic Act on Science and Technology, as Seen through Word Cloud Analysis of White Papers

* Omitted to avoid potential inconsistencies with the content of the Japanese version of the white paper that may arise from translation into English.