Introduction

Science and technology has generated new knowledge, such as discoveries of new principles, and has dramatically contributed to the development and progress of people's lives, the economy, and the society. Particularly in Japan, which lacks natural resources, technological innovations served as the key in achieving a remarkable recovery and high economic growth from the postwar devastation bringing material affluence to people's lives. In this process, Japan, which was making efforts to catch up with Europe and the United States, became one of the frontrunners as the world's second-largest economic power, and the time has come for Japan to demonstrate creativity and open the way to the future. Thus, the Japanese government enacted the Science and Technology Basic Law in 1995, and has implemented various measures for promoting science and technology according to the Science and Technology Basic Plan Phase 1 and Phase 2, in order to become an advanced science and technology-oriented nation.

On the other hand, social and public expectations for science and technology became more sophisticated and diverse, and new problems that need to be addressed such as global environmental issues have emerged.

Under such circumstances, international knowledge competition has intensified not only among western developed countries, but also among countries including China and the Republic of Korea. Therefore, Japan needs to further develop its "scientific and technological capabilities."

Dr. Shinichiro Tomonaga, the physicist who was the second Japanese Nobel Prize winner following Dr. Hideki Yukawa, said the following in an article contributed to *Kagaku* (Science) magazine, after referring to the difference in the research environment between Japan and the United States at the time: "It is wonderful that there are many brilliant scholars and ardent, competent young researchers also in Japan. These people have actually made remarkable accomplishments despite various adverse conditions. However, the scientific level of a country is defined not only by the research achievements of existing scholars, but also by taking into consideration everything that underlies and supports such achievements and serves as the foundation for future development. And with that in mind, the scientific level of Japan is far from satisfactory."

As indicated by Dr. Tomonaga, the scientific and technological capabilities of a country are not limited to numerical data, such as the current number of scientific papers, the frequency of their citation, and the number of Nobel Prize winners. Instead, they are considered to be more multi-dimensional, including the diverse research activities among industry, academia, and government, and their achievements/effects, the scientific and technological human resources carrying out these activities, the research infrastructure and the science and technology systems consisting of various elements such as the research environment and R&D funds, and potential that indicate future possibilities.

The Annual Report on Promotion of Science and Technology introduces the trends of a wide array of scientific and technological activities based on a specific theme every year, in Part 1. This year, which is the tenth year from the enactment of the Science and Technology Basic Law, the report regards "scientific and technological capabilities" to collectively cover the present scientific and technological capabilities of Japan and their level on a global scale, the achievements to date, and the future possibilities and potential, and it analyzes and introduces them from various angles and in a comprehensive manner.

In recent years, people's awareness of science and technology has been declining. The assumable reasons are that the latest science and technology are becoming more and more sophisticated and complicated and the fact that people are becoming less aware of science and technology since scientific and technological achievements have come to permeate very deeply among people. Therefore, in order to help readers concretely understand science and technology as well as its achievements, the report discusses them by focusing on the actual case examples, scientists/engineers, and research facilities as much as possible.

1.1 Contributions of Scientific and Technological Progress

Although the scientific and technological progress has made great contributions to society in Japan, we seem to be losing opportunities to realize or become aware of such contributions. Here is an example.

One of the items that have become rapidly diffused in recent years is the mobile phone. After digital services were launched in 1992 and the sale of mobile phones was liberalized, mobile phones quickly spread mainly among young people. Mobile phones used to weigh 750 g in 1987, but phone units that only weigh 230 g were released in 1991. Furthermore, those with a volume of 100 cc and weigh less than 100 g were placed on the market in 1996. With this, the reduction in weight and size seemed to have reached their limits. Nevertheless, mobile phones became even more compact and lightweight, and now there is even a model that weighs less than 70 g. In addition, mobile phones have become multi-functional. They not only serve as a phone, but also as an e-mailer, a camera, a video game machine, and even a music player or an electronic money wallet. Today, many people from children to the elderly would find it difficult to imagine life without a mobile phone.

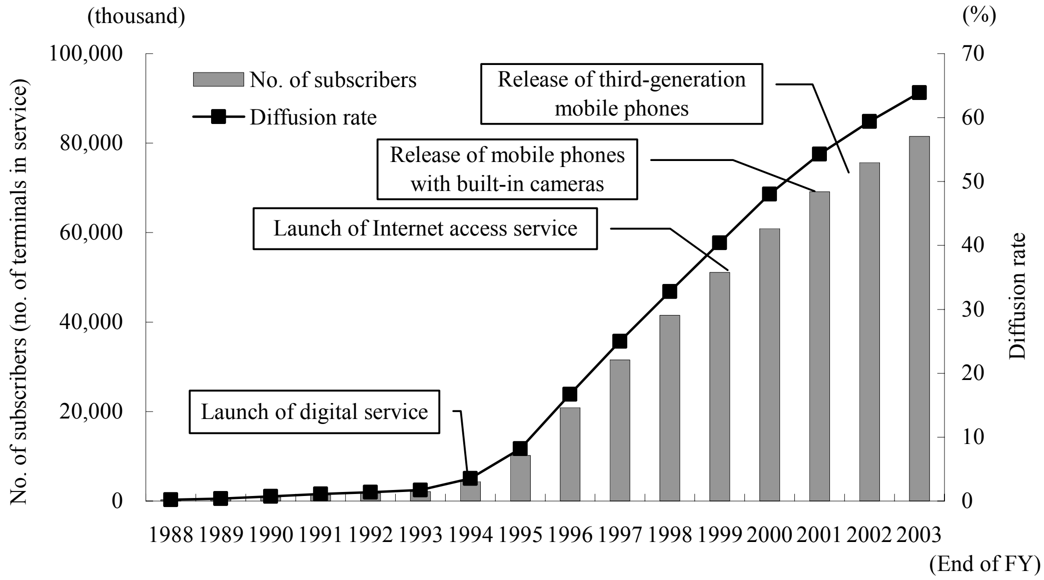


Figure 1-1-1 Number of Mobile Phone Subscribers

Source: Ministry of Internal Affairs and Communications, "Information on Subscribers of Cellular Telephone, Pager and PHS (Personal Handy-Phone System) in Japan," March 1, 2005.

It should be noted that such progress owes greatly to the contributions of Japan's original science and technology.

Today it is taken for granted that mobile phones come with color liquid crystal displays (LCDs), but LCDs for mobile phones were first commercialized in 1985 by a Japanese company.

Since a mobile phone LCD does not emit light by itself, it has a light source behind the LCD.

This is called a backlight. At present, many mobile phones use a light-emitting diode (LED) for the backlight. The white LED used for the backlight was invented at a Japanese university, and the technology seed was put to practical use by a Japanese company for the first time in the world. Japanese companies command the highest share ofthe worldwide LED market.

Meanwhile, the lithium ion battery, which is long-lasting and contributes to making mobile phones lightweight, was also commercialized for the first time in the world by a Japanese company in 1990.

The polymer battery, which is used as a backup battery, uses conductive plastic as the electrode.

Hideki Shirakawa won a Nobel Prize for the discovery of this conductive plastic in 2000.

In a foldable mobile phone, the main body with buttons and the part with the LCD are connected by a flexible substrate, which is flexible in itself. This substrate is made of a paper-like material made from synthetic fiber and an extremely thin beaten-copper. Conventionally, when the synthetic fiber was formed into a paper sheet, the fiber became tangled and could not be spread out uniformly. This problem was resolved by the technique developed through the making of traditional Japanese paper. As for beaten-copper, a Japanese company having the technology of making gold leaf that has been passed down since the Edo period commands a 40% share of the world market of beaten-copper for mobile phones.

Japanese science and technology is also applied to the electronic parts used in mobile phones. Capacitors are indispensable for electronic circuits, and a large number of multilayer chip ceramic capacitors, which are one type of capacitors, are used in mobile phones. They are tens to hundreds of derivative layers in between electrode layers pressed together and fired. The size is 1 mm×0.5 mm, and the height ranges from 1 mm to 2 mm. Japanese companies command 80% of the world market share for these multilayer chip ceramic capacitors, and one of these Japanese companies originates from a manufacturer of Kyoto's Kiyomizu-yaki ceramics.

These are only a few of the science and technology achievements that are used in mobile phones. Accumulation of such scientific and technological progress results in the current lightweight and easy-to-use mobile phones.

Science and technology has generated new knowledge, such as discoveries of new principles, and has dramatically contributed to the development and progress of people's lives, the economy, and the society. Chapter 1 overviews the achievements of the progress of science and technology in the 20th century by referring to the actual examples.

1.1.1 Creation and Use of Knowledge

1.1.1.1 Contributions of Science and Technology

A single mobile phone alone is packed with numerous cutting-edge scientific and technological accomplishments. In this manner, in the modern society, the scientific and technological knowledge and achievements are being used in our daily lives in various forms.

Science and technology has two functions: creating new knowledge such as elucidating unknown phenomena that surround us and discovering new laws and principles; and using the knowledge gained in the real world. Because these two functions interact and are hard to separate, and because scientific and technological achievements have already been permeated throughout our daily lives like the atmosphere itself, we have come to rarely realize them as scientific and technological achievements.
However, science and technology has had various impacts and spillover effects in our daily lives in the process of their development. These impacts and spillover effects are reviewed below.

(**Intellectual**/cultural values of science and technology)

Science is an intellectual activity that started from intellectual curiosity for understanding natural phenomena, originating from the feelings of admiration and inspiration for nature and other things surrounding human beings. Scientific and technological achievements bring us new knowledge. Their accumulation expands the limits of people's activities both in space and time, beyond the conventional concept of values. They can enlarge the possibilities of people's activities and serve as the driving force for society from theviewpoints of culture and civilization.

In medieval times, when people believed the geocentric theory of Claudius Ptolemaeus, Nicolaus Copernicus advocated the heliocentric system (Copernican theory), and the theory came to be established by the efforts of Tycho Brahe, Johannes Kepler, and Galileo Galilei. Later, the idea was inherited by Isaac Newton's law of gravitation and modern astrophysics represented by the Big Bang theory, and has influenced people's views of the universe and the Earth in the various times.

John Dalton demonstrated the existence of atoms, which had been a philosophical concept until then, and this developed to Amedeo Avogadro's molecular hypothesis. In addition, the discovery of atoms was accelerated by Dimitri Mendeleev's periodic law, which had a large impact on the understanding of the composition of matter, i.e. that all matter is made up of a certain number of atoms.

Furthermore, the possible existence of even smaller elementary particles has been indicated. In this manner, our understanding of matter is likely to deepen even further in the future.

Charles Darwin's theory of evolution proposed an idea on the evolution of organisms, while the elucidation of genes, which started with Gregor Johann Mendel's law of heredity, hints at the answer to the mystery of organisms. Yet new views on organisms and senses of ethics are expected to develop in the 21st century, which is being called the "century of life science."

Today, as development of science and technology accelerates, their achievements are expected to influence people's values at an even faster pace and may dramatically change the paradigms of society.

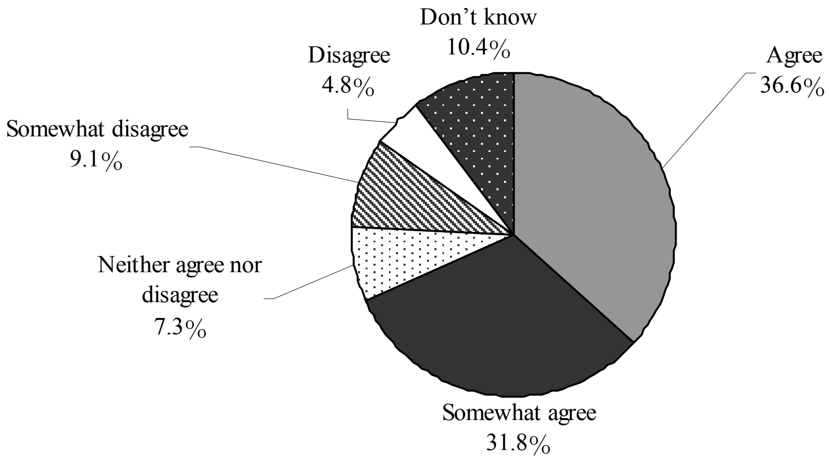


Figure 1-1-2 Scientific Research Is Essential in the Sense That It Brings New Knowledge to Humanity

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

[Column 1]

Albert Einstein: 50th Anniversary of Death, Centenary of Miracle Year

The year 2005 marks the centenary of Albert Einstein's release of his special theory of relativity in 1905. It is also the 50th anniversary of his death. The year 1905 is known as Einstein's "miracle year" because he published a series of important study results in that year.

In June 1905, Einstein released a paper entitled "On a Heuristic Point of View about the Creation and Conversion of Light," in which he denied the then prevailing theory that light was a wave. Einstein instead theorized that light consisted of particles and explained the photoelectric effect, by which metals emit electrons when illuminated by light. The solar cell, developed in the 1950s, is a device that uses the photoelectric effect to generate electricity.

In a dissertation published in July 1905 titled "On the Movement of Small Particles Suspended in Stationary Liquids Required by the Molecular-Kinetic Theory of Heat," Einstein postulated that the erratic movement of particles in fluids, known as "Brownian motion," was caused by molecules' random collisions in a fluid. This mathematic model is now known to be extremely useful in a variety of applications such as predicting the diffusion of fluids and gases and analyzing genetic functions and even stock market trends.

In September 1905, Einstein proposed the special theory of relativity in a dissertation titled "On the Electrodynamics of Moving Bodies" and said the speed of light remained constant, denying the then conventional view that time and space were absolutely constant. The theory of relativity affects actual life as, for example, receivers for global positioning systems adopted in car navigation systems reflect effects of the theory.

In November 1905, Einstein released another paper, named "Does the Inertia of a Body Depend upon its Energy Content?" and said, "The mass of a body is a measure of its energy content." Based on this theory, Einstein came up with the most famous equation in history—$E=mc^2$—in 1907. With this equation, it became apparent that material could be converted into energy, leading to nuclear power generation, which now covers one-third of power output in Japan.

As 2005 is the centenary of the miracle year, the general assembly of the United Nations decided that the U.N. Educational, Scientific and Cultural Organization (UNESCO) should plan activities to commemorate the "International Year of Physics" in cooperation with physical societies and groups throughout the world. In Japan, the Japan Committee for the World Year of Physics, set up jointly by related academic societies, has been undertaking various activities under the chairmanship of Akito Arima.

[Column 2]

Predictions for 20th Century

One may wonder how society will be 100 years from now. While it is impossible for humans to predict the future perfectly, there is no denying that science and technology will greatly affect the future of human beings.

On January 2 and 3, 1901, the Hochi Shimbun newspaper carried 23 "Predictions for the Future." The list is viewed with surprise and deep excitement because a substantial number of them, as mentioned below, have become realities.

Photo telephone	The telephone would have a device to show the image of a caller at the end of the line—the video phone.
Seven-day trip around the world	A trip around the world would take seven days at the end of the 20th century, down from 80 days at the end of the 19th century. People in civilized countries, whether men or women, would travel around the world once or more—an increase in the transfer of people and distribution of goods due to the development of aircraft and other high-speed means of transportation
Freedom from heat and cold	New equipment would be developed to supply air in an appropriate manner so as to adjust heat and cold. African development would be possible as a result—development of the air-conditioner.

- Other predictions that have become realities:

wireless telegraph and telephone; long-distance photography; plants and electricity; human voice reachable over a long distance; the world of electricity; speed of trains; in-town trains; age of automobiles; transport of electricity

- Predictions that have partially become realities

Convenient shopping	Consumers would be able to see remote goods and conclude purchase contracts by photo telephone and immediately receive them sent via underground steel pipe.

Irrigation of Sahara desert; warships and cannons in air; high-speed connection of trains; rise in height of people

- Predictions that have yet to materialize

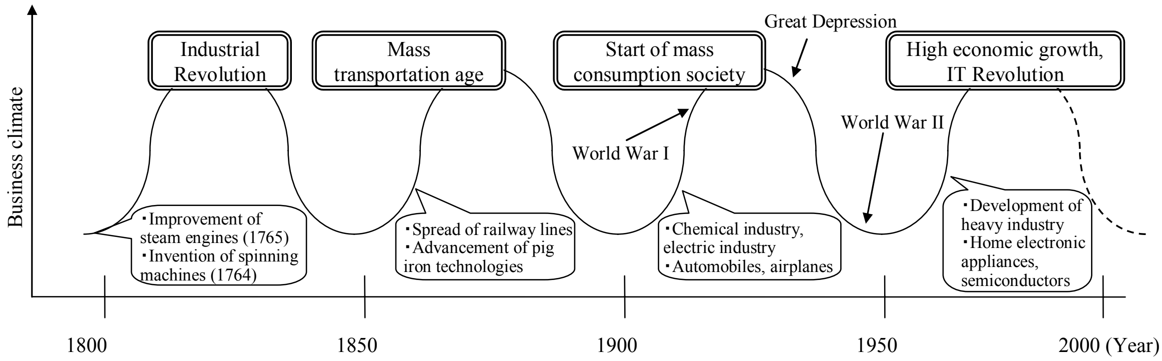
Prevention of typhoons	Advances in meteorological observation technology would make it possible to predict a natural disaster more than a month ahead of its occurrence. In the second half of the 20th century, shipwrecks and other marine perils would be able to be avoided by hitting a typhoon, the most fearful of natural disasters, with cannonballs to convert it into rain. Although earthquakes would be unavoidable, tremor-resistant houses and roads would be built.
Unlimited conversation between humans and animals	Studies on animal languages would advance, prompting elementary schools to have courses in them. Humans thus would be able to freely converse with dogs, cats and monkeys. Most positions of male and female servant would be occupied by dogs, which would run errands for people.

Extinction of wild animals; extinction of mosquitoes and fleas; advances in medical technique; abolishment of kindergartens

(Creating economic values by science and technology)

The rapid progress of science and technology from the end of the 19th century to the beginning of the 20th century gave rise to electrical industries, chemical industries, automobiles, and airplanes, and economic activities expanded due to the emergence of these new industries. After World War II, Japan saw economic development brought about by the diffusion of home electrical appliances and development of the petrochemical industry, followed by economic growth driven by the information and communications technology (ICT) revolution led by the semiconductor industry, which began from around 1985 and lasted until the 1990s.

In either case, creation of new industries based on innovative science and technology brought about significant and long-lasting economic effects. Science and technology has acted as a driving force for economic development through innovation.



In the 1920s, a Russian economist, Nikolai D. Kondratieff (1892-1938), announced a theory that the business climate has a cycle of about 50 to 60 years. He mentioned that this cycle is mainly caused by technological innovation, war, and large-scale development. The graph indicates that a long time is required from occurrence of technological innovations until they produce effects on the market.

Figure 1-1-3 Relationship Between Business Cycles and Technological Innovation

Source: Produced by MEXT.

(Achievement of social and public values)

Scientific and technological progress has brought wealth to society mainly in developed countries. Therefore, there are great expectations for science and technology to contribute to further development of the whole of mankind.

On the other hand, as can be seen in global environment issues, the worldwide diffusion of the Internet, the terrorist attacks in the United States in September 2001, and the bioethical and infection issues, the "lights" and "shadows" of scientific and technological development are spreading widely, and are becoming more closely related to social issues, such as economy, diplomacy, security, health and welfare, energy, environment, disaster prevention, and urban problems. For example, environmental problems such as pollution existed in the past, but they were only problems specific to limited areas. However, discovery of ozone holes prompted the whole of mankind to recognize that the global environment is in a critical situation.

Science and technology is a promising means for recognizing and foreseeing problems that face mankind and for identifying their solutions, so it is expected to provide knowledge that can be shared by all mankind

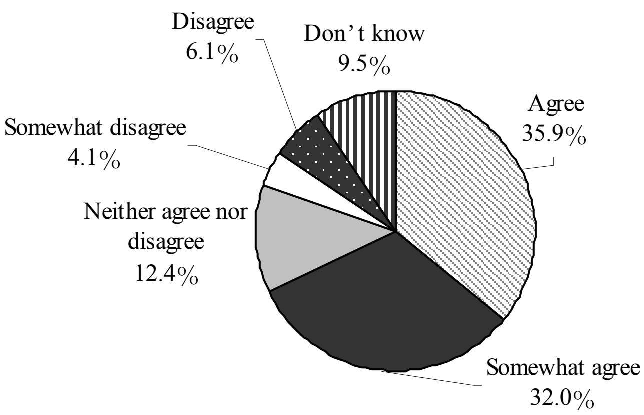


Figure 1-1-4 High Scientific and Technological Standards Are Needed toEnsure Security

Note: Graph shows the responses to the question, "Do you agree with the opinion that 'high scientific and research

standards are essential for ensuring security in your daily life and the general security of the nation?'"
Source: Cabinet Office, "Public Opinion Poll on Science and Technology and Society (February 2004)"

1.1.1.2 Scientific and Technological Progress in the 20th Century

(Turning dreams into reality)

In the 20th century, which is referred to as a "century of science," science and technology made significant contributions to the development of human activity. The desire to make our lives more affluent and convenient (social demand) had supported the remarkable development of science and technology. In developed countries, the science and technology in the 20th century was viewed as something that could turn our dreams into reality.

Science and technology in the 20th century dawned with quantum theory and the theory of relativity. Modern physics rapidly enhanced our understanding on the structure of matter from elementary particles to space. With quantum mechanics, which enabled development of atomic power and semiconductors, mankind acquired great strength.

Genetic research achieved remarkable progress with the finding of the double helix structure of DNA. We were surprised and at the same time fascinated by the mysteries of life to learn that the number of genes of a human was about 22,000, far less than what had been predicted in the past and not so different from that of a fruit fly, which is about 20,000.

In the field of medicine, development and diffusion of preventive, diagnostic, and treatment techniques, including antibiotics, vaccines, and X-ray, enabled treatment of various diseases, and in combination with improved living environment, considerably prolonged the average life expectancy in many countries.

In the middle of the 20th century, mankind looked at the Earth from space and landed on the moon. When people saw the space shuttle flying to and fro in outer space and building a space station under international cooperation, people raised hopes that the era of space exploration would begin and that human activity would come to expand into space.

As electronic equipment such as telephones, televisions, and computers developed and transportation means such as cars and airplanes made progress, people and goods came to move easily around the world, and developed countries acquired materially affluent and convenient lifestyles.

It is not too much to say that changes that mankind has never experienced before were brought about by science and technology over the past 100 years. Science and technology significantly changed modern civilization, contributed to dramatically improving human welfare and convenience in life, and noticeablyexpanded the scope of human activity over the past 100 years.

("Lights" and "shadows")

When the scope of human activity expanded with the development of science and technology in the 20th century, not only "lights," such as affluence and convenience in life, but also "shadows" started to emerge.

The enlarged human activity has come to involve mass production and mass consumption of goods, mass disposal, and heavy energy consumption, and is about to go beyond what the Earth can tolerate. Such concerns as depletion of resources, the global warming issue, and destruction of the natural ecology are casting "shadows" over the basis of survival and sustainable development of mankind.

Meanwhile, in the area of life science, which is expected to have a large impact on people's value judgment, it is necessary to examine concurrently the achievements made through scientific and technological progress, such as genetic engineering and cloning, and the ethical questions involved.

Moreover, there is a risk that scientific and technological development will widen the economic gaps between developed countries and developing countries, and have an influence on the world order.

The 20th century was a century where science and technology became more and more involved with society as they achieved development, and the "shadows" of scientific and technological developpment began to emerge on a global scale.

Table 1-1-5 Development of Science and Technology in the 20th Century

	Inventions and discoveries related to science and technology	Events in society surrounding science and technology
1901	・First Nobel Prize * Shibasaburo Kitasato (Japan) nominated as a Nobel Prize candidate for his research into the tetanus bacillus ・Invention and patenting of a method for manufacture of adrenaline (Japan: Jokichi Takamine) ・Success in wireless transmission across Atlantic Ocean (Italy: Guglielmo Marconi)	
1902	・Discovery of Z-term for latitude variation (Japan: Hisashi Kimura)	
1903	・Proposal of Saturnian model for the atom (Japan: Hantaro Nagaoka) ・First manned flight of powered aircraft (U.S.: Wright brothers)	
1904	・Invention of diode vacuum tube (U.K.: John Fleming)	・Russo-Japanese War
1905	・A "miracle year" for physics; photovoltaic effect; theoretical analysis of Brownian motion; special theory of relativity (Switzerland: Albert Einstein)	
1907	・Invention of triode vacuum tube (U.S.: Lee de Forest)	
1908	・Establishment of ammonia synthesis (Germany) ・Patenting of a method for manufacturing a seasoning mainly composed of monosodium glutamate (Japan: Kikunae Ikeda)	・First sale of Model T Ford (U.S.)
1910	・Discovery of Vitamin B1 (Oryzanin) (Japan: Umetaro Suzuki)	
1911	・Success in cultivation of syphilis pathogen (Japan (Hideyo Noguchi) ・Discovery of atomic nucleus (U.K.: Ernest Rutherford) ・Discovery of superconductivity phenomenon (Netherlands: HK Onnes)	
1913		・Mass production of Ford automobiles (U.S.)
1914		・World War I (until 1918)
1915	・Artificial inducement of cancer tumor (Japan: Katsusaburo Yamagiwa, Koichi Ichikawa) ・General theory of relativity (Germany: Albert Einstein) ・Theory of continental drift (Germany: Alfred Wegener) ・Invention and patenting of Japanese typewriter (Japan: Kyota Sugimoto)	
1917	・Invention of KS steel (Japan: Kotaro Honda)	・Establishment of Institute of Physical and Chemical Research (RIKEN) (Japan)
1920		・World's first radio broadcast (U.S.)
1921	・Discovery of insulin (Canada: Frederick Banting, Charles Best)	
1922	・Proposal of expanding universe model (Russia: Aleksandr Friedmann)	
1925	・Invention of Yagi antenna (Japan: Hidetsugu Yagi)	
1926	・Proposal of wave equation (Austria: Erwin Schrodinger) ・Launch of first liquid-fueled rocket (U.S.: Robert Goddard) ・Success in Braun tube reception of electronic signals (Japan: Kenjiro Takayanagi)	
1927	・Proposal of uncertainty principle (Germany: Werner Heisenberg)	・Japan's first subway opens for operation
1929	・Discovery of penicillin (U.K.: Alexander Fleming) ・Observation of expanding universe (U.S.: Edwin Hubble) ・Invention and patenting of cable phototelegraphic transmission method (Japan: Yasujiro Niwa)	

	Inventions and discoveries related to science and technology	Events in society surrounding science and technology
1932	・Invention and patenting of MK magnetic steel (Japan: Tokuhichi Mishima)	
1935	・Proposal of mehon theory (Japan: Hideki Yukawa) ・Isolation of crystal structure in tobacco mosaic virus (U.S.: Wendell M. Stanley) ・Invention of nylon synthetic fiber (U.S.: Wallace Carothers)	
1936	・Theoretical computer model (U.K.: Alan Turing)	
1937	・Development of jet engine (U.K.: Frank Whittle, Germany: Hans von Ohain)	
1938	・Discovery of uranium fission (Germany: Otto Hahn, Fritz Strassman)	
1939	・Discovery of DDT insecticide (Switzerland: Paul Mueller)	・World War II (until 1945) ・First flight of jet aircraft (Germany)
1941		・First commercial television broadcasts (U.S.)
1942	・Success in nuclear fission chain reaction (U.S.: Enrico Fermi, et al)	・Manufacture of V-2 rocket (Germany: Werner von Braun)
1944	・Proof of DNA gene structure (U.S.: Oswald Avery) ・Discovery of streptomycin (U.S.: Selman Waxman)	
1945		・Manufacture of atomic bomb (U.S.) ・Bush Report (U.S.: Vannevar Bush)
1946	・Development of ENIAC electronic computer (U.S.: John Mauchly, Presper Eckert) ・Big Bang theory (U.S.: George Gamow) ・Development of transistor (U.S.: William Shockley, John Bardeen, Walter Brattain)	
1949	・Hideki Yukawa wins Nobel Prize for Physics	
1951		・First nuclear power generation (U.S.)
1953	・Elucidation of DNA double helix (U.S.: James Watson, U.K.: Francis Crick)	・Start of color television broadcasting (Japan)
1954	・Discovery of interferon (virus inhibition factor) (Japan: Yasuichi Nagano, Yasuhiko Kojima)	・World's first kidney transplant (U.S.)
1955		・World's first commercialization of transistor radio (Japan)
Around 1955		・Pollution becomes a societal problem (Japan)
1957		・First criticality in Japanese nuclear reactor ・Launch of Sputnik artificial satellite (U.S.S.R.)
1959	・Invention of integrated circuit (IC) (U.S.: Jack Kilby)	
1960	・First success in laser firing (U.S.: Ted Maiman)	
1961		・First manned space flight (U.S.S.R.: Yuri Gagarin)
1963	・Proposal of theory of sea-floor spreading (U.K.: Fred Vine, Drummond Mathews)	
1964	・Proposal of Quark Model (U.S.: Murray Gell-Mann, George Zweig)	・Tokai Shinkansen commences operations (Japan)
1965	・Observation of universe background radiation (U.S.: Arno Penzias, Robert Wilson) ・Shinichiro Tomonaga wins Nobel Prize for Physics	
1966		・Start of commercial nuclear power generation (Japan)
1967	・Plate tectonics theory (U.K.: Dan McKenzie, U.S.: Jason Morgan, et al.)	・Promulgation of Basic Law for Environmental ・First heart transplant operation (South Africa: Christiaan Barnard)
1969	・Proposal of superlattice (Japan: Reona Esaki)	・Apollo 11 lands on the moon (U.S.)
1970		・Japan World Exposition (Osaka) ・Launch of Ohsumi, Japan's first artificial satellite
Around 1973		・Oil shock (Japan)
1973	・Establishment of gene recombinant technology (U.S.: Stanley Cohen, Herbert Boyer) ・Reona Esaki wins Nobel Prize for Physics	・Release of microcomputer in kit form (U.S.)
1974	・Indication that chlorofluorocarbon may be depleting ozone layer (U.S.: Sherwood Rowland, Mario Molina)	
1977		・Release of world's first personal computer (U.S.) ・Release of Japan's first personal computer (Japan)
1978		・First in vitro insemination infant born (U.K.)
1979		・Three Mile Island nuclear power plant accident (U.S.)
1981	・Kenichi Fukui wins Nobel Prize for Chemistry	・First flight of the space shuttle (U.S.)
1982		・Release of world's first CD player (Japan)
1983	・Discovery of AIDS virus (France: Luc Montagnier, U.S.: Robert Gallo)	
1984	・Discovery of fullerenes (U.K.: Harold Kroto, et al)	
Around 1985	・Discovery of the ozone hole (Japan, U.K., U.S.)	
1985		・International Science and Technology Exposition
1986	・Discovery of high-temperature superconductivity (Switzerland)	・Chernobyl nuclear power plant accident (U.S.S.R.) ・Space Station Mir commences operations (U.S.S.R.)
1987	・Susumu Tonegawa wins Nobel Prize for Physiology or Medicine	・Start of mobile phone services (Japan)
1989		・End of Cold War

	Inventions and discoveries related to science and technology	Events in society surrounding science and technology
1991	・Discovery of carbon nanotubes (Japan: Sumio Iijima)	
1992		・Earth Summit
Around 1993		・Announcement of Information Superhighway concept (U.S.) ・Explosive growth of Internet
1994	・Confirmation of top quark (U.S.: Fermi National Accelerator Laboratory)	・Launch of H-II rocket (Japan)
1995		・Great Hanshin Earthquake (Japan) ・Enactment of the Science and Technology Basic Law (Japan)
1996	・Birth of Dolly the cloned sheep (U.K.)	
1997		・Promulgation of Organ Transplant Law (Japan)
1998	・Confirmation of mass in neutrino (Japan: Super Kamiokande)	・Assembly of International Space Station commences (Japan, U.S., EU, Canada, Russia)
1999		・World Conference on Science (Budapest) ・Test observation of Subaru Telescope starts (Japan) ・Japan's first organ transplant from brain-dead donor ・Criticality accident at uranium processing plant (Japan)
2000	・Hideki Shirakawa wins Nobel Prize for Chemistry	・Enactment of Law concerning Regulation relating to Human Cloning Techniques and Other Similar Techniques (Japan)
2001	・Ryoji Noyori wins Nobel Prize for Chemistry	・September 11, 2001 terrorist attacks (U.S.) ・Launch of H-II A rocket (Japan)
2002	・Masatoshi Koshiba wins Nobel Prize for Physics ・Koichi Tanaka wins Nobel Prize for Chemistry	・Johannesburg Summit
2003	・Sequencing of human genome completed (Japan, U.S., Europe)	
2004		・Great Sumatra Earthquake and Indian Ocean Tsunami
2005		・Entry into force of Kyoto Protocol ・2005 World Exposition (Aichi)

Source: Produced by MEXT

1.1.1.3 Relationship between Japan's Modernization and Science and Technology

A large part of Japan's current science and technology originates from those that had been actively imported from Western Europe in order to promptly achieve the "wealth and military strength" and "encouragement of new industries" advocated by the Meiji government. No other country outside those of Western Europe achieved modernization from the second half of the 19th century to the beginning of the 20th century. This rapid modernization owed partly to the fact that favorable social infrastructure had been available. For example, the literacy rate and people's average basic abilities were high and the level of traditional arts and crafts was also high already in the Edo period.

There is an opinion that because Japan made it a national policy to catch up with Western Europe, it adopted science and technology by primarily focusing on their practical use, and consequently failed to sufficiently acquire the scientific spirit. However, it is a fact that science and technology led Japan's modernization to a success in a short period of time. Furthermore, these efforts and achievements of predecessors have been passed down to the present day through human resources development and technological tradition at research institutes, such as universities, and companies, and they support Japan's scientific and technological capabilities.

[Column 3]

Pioneers of Japan's Modern Science and Technology

The history of modern Japanese science and technology got off to a full-fledged start under the leadership of foreign teachers invited by the government of the Meiji era (1868-1912) and Japanese generations that worked to implant modern science and technology in Japan by learning from them or studying abroad. Following their leadership, Japanese researchers began to produce creative world-level study results in the middle of the Meiji era.

While Japan was little known in the European and U.S. science worlds at that time, there were nevertheless Japanese scientists and engineers who made world-class achievements for the first time in Japan. The following three persons are typical of them.

Shibasaburo Kitasato undertook studies on the tetanus bacillus under Robert Koch in Germany and successfully grew the bacillus in pure culture in 1889. He also discovered the toxin and antibody of the tetanus bacillus in 1890, paving the way for immune serum therapy. Based on Kitasato's discovery, the specific treatment of infectious diseases was established. After returning to Japan, Kitasato discovered the Yersinia pestis in 1894. With those achievements, Kitasato became the first Japanese physician known worldwide. In particular, the discovery of immune serum therapy against the tetanus bacillus is highly credited for leading Emil Adolf von Behring to receive the first Noble Prize in Physiology or Medicine for his discovery of immune serum therapy against diphtheria.

Before returning to Japan, Kitasato received invitations from many countries to continue his studies. But he declined all of them and contributed to improvements in medical science in Japan by founding the Institute of Infectious Diseases and the Kitasato Institute. Many of Kitasato's descendents made world-class achievements. Among them were Kiyoshi Shiga, who discovered the shigella bacillus, and Sahachiro Hata, who developed Salvarsan, an agent for the treatment of syphilis.

Jokichi Takamine settled in the United States in 1890 and devised a method of mass-producing and refining the diastase, which has a highly saccharifying capacity, by implanting mould fungi, called koji, on the rhytidome of wheat. He filed with the U.S. government for related patents in 1894 and let a U.S. drug maker release a digestive under the name Takadiastase in 1897. In 1901, Takamine succeeded in isolating the hormone adrenaline in pure crystalline form from bovine glands. While adrenaline is effective in increasing blood pressure and arresting hemorrhage, Takamine was the first in the world to extract the hormone as a purified substance and thus contributed greatly to the subsequent development of neuroscience and endocrinology.

Takamine also worked to promote friendship between Japan and the United States and proposed and contributed to the establishment of the Institute of Physical and Chemical Research, known as RIKEN, in Japan. Both Takadiastase and adrenaline have been widely used throughout the world for more than a century. Making a huge fortune with income from patents on them, Takamine was the first Japanese person to establish a research and development-oriented venture business.

Hantaro Nagaoka was known worldwide as a leading scholar in the field of magnetostriction. He was the first Japanese physicist recognized in the world. As an example of his fame, he was invited to the International Physics Conference in Paris in 1900 to report on his experiments on magnetostriction.

Nagaoka drew international attention in 1903 when he announced the "Saturnian" model of the atom, in which he postulated that electrons revolved around an atomic nucleus. Nagaoka's concept was proved correct in 1911 through experiments conducted by British physicist Ernest Rutherford.

Japan's modern physics stemmed from Nagoka's wide-ranging studies, which included experimental physics, mathematical physics and geophysics. Assuming such key posts as president of the Osaka Imperial University and of the Japan Academy, Nagaoka made a great deal of contribution to the administration of science and technology in Japan.

As an episode probably seen only among pioneers in any field, Nagaoka, when he was a student at the department of science at the University of Tokyo, wondered whether scientific creativity was inherent in the Japanese and thus took a year off to study the oriental history of science in a bid to find an answer to the question troubling him.

The pictures of the ten great inventors on a poster for “Invention Day”

Sakichi Toyoda (1867-1930) Wooden handloom; Type-G automatic loom
Kokichi Mikimoto (1858-1954) Cultured pearls
Jokichi Takamine (1854-1922) Taka-diastase; adrenaline
Kikunae Ikeda (1864-1936) Sodium glutamate
Umetaro Suzuki (1874-1943) Vitamin B1; vitamin A
Kyota Sugimoto (1882-1972) Japanese typewriter
Kotaro Honda (1870-1954) KS steel; new KS steel
Hidetsugu Yagi (1886-1976) Yagi antenna
Yasujiro Niwa (1893-1975) Phototelegraphic method
Tokushichi Mishima (1893-1975) MK magnetic steel

* The ten inventors were selected by the Japan Patent Office (JPO) in 1985 in commemoration of the 100th anniversary of the industrial property system.

Figure 1-1-6 Ten Great Japanese Inventors

[Column 4]

Comics and Science Fiction Novels That Foster Dreams about Scientific Technologies

Evolution of Robots

There are many people who became completely absorbed in imaginary future worlds by reading comics and science-fiction novels in their childhood. Robots appeared frequently in the future worlds. The word “robots” was coined by Czech science-fiction novelist Karel Capek in 1920. But in Japan, the word became popular by characters such as “Astro Boy” in animations and comics. Moreover, animation and comics have also greatly inspired the progress of the study about robots in Japan.

The future world that Osamu Tezuka described in his “Astro Boy” comics released soon after the end of World War II was supposed to be the world at the beginning of the 21st century, where robots resembling people lived the same lives as people, occasionally exercising much higher abilities than people, and playing an active role in the fight for justice. Undoubtedly, many children at the time dreamed that some day in the future robots like Astro Boy would come into actual existence. Unfortunately, such robots as Astro Boy have not yet materialized because we have not yet developed the science and technology to produce them even though we live in the 21st century. How much has such a dream come true?

You can see the most recent results in the study of robots at the 2005 World Exposition held in Aichi, Japan. Robots that can walk with two legs such as Astro Boy are exhibited, among which there is a biped robot that walks three kilometers per hour. In the Tsukuba Science Expo held twenty years ago, only one biped robot with two legs and a waist was exhibited, and it took ten minutes for it to walk even one step forward. Since then, robots have steadily progressed. In addition to biped robots, many robots that have a wide variety of functions are developed and exhibited at the Aichi Expo.

Some science and technology, which was once described as being part of an imaginary future world where robots such as Astro Boy would flourish, has now materialized, including mobile phones, small-sized computers, large-sized passenger planes, and elevated expressways.

Science and technology will realize our dreams, but at the same time, our imagination and dreams that appear in novels and comics are a driving force for the development of science and technology.

1.1.2 Relevance of Science and Technology in the Transformation and Development of People’s Lives, the Economy, and the Society

After World War II, Japanese people’s lives improved significantly and Japan achieved high economic growth thanks to the contributions of science and technology. This section overviews such influence of science and technology based on data. At the same time, it also introduces applications of science and technology to addressing social problems that have surfaced as “negative” products of scientific and technological progress in recent years.

1.1.2.1 Improvements in People’s Lives

Currently, many scientific and technological achievements are used in our daily lives and are making our lives more convenient. In addition, the concept of distance and time has changed along with the development of science and technology, and dramatically transformed our lifestyles. Furthermore, science and technology also contributes to maintaining and recovering health, which serves as the basis of our daily lives.

(Better convenience)

Scientific and technological achievements that are familiar to us include home electrical appliances. The development and diffusion of various products including fully automatic washing machines, microwave ovens, video tape recorders (VTRs), air con ditioners, and toilet seats with a warm-water bidet function (Figure 1-1-7) have brought convenience to life and made our living environment more pleasant.

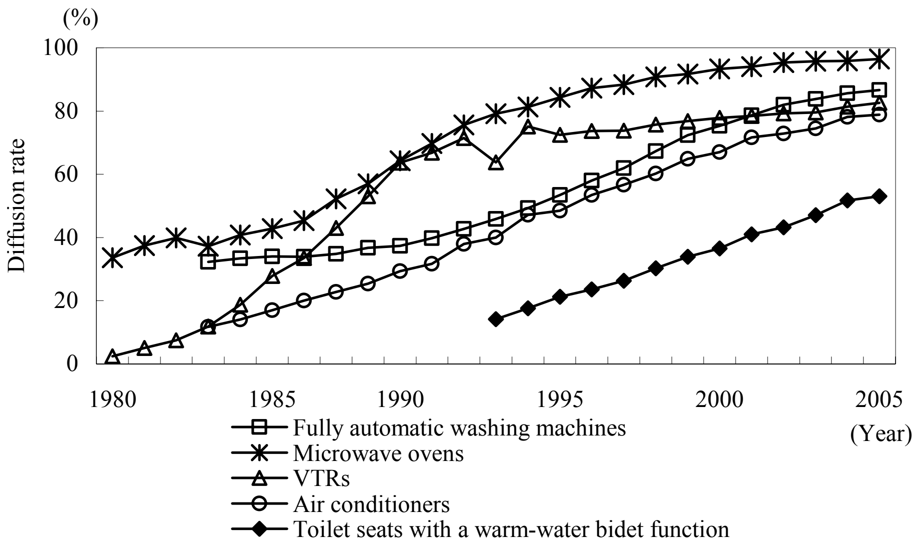


Figure 1-1-7 Diffusion Rate of Home Electrical Appliances

Source: Cabinet Office, “Consumer Confidence Survey”

The frequency of calling or sending e-mail by mobile phones to communicate with other people considerably increased compared to the previous year, indicating that mobile phones have become the central information and communications means in place of postal mail and fixed-line telephones (Figure 1-1-8). Mobile phones made it easier for people to communicate with one another regardless of their locations.

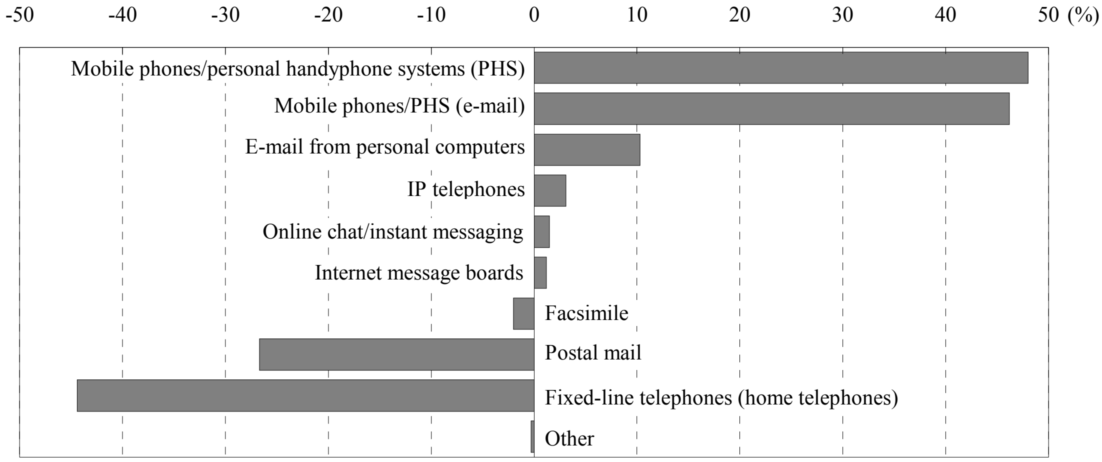


Figure 1-1-8 Changes in Communication Means Compared to Previous Year

Note: Values were derived by deducting the percentage of respondents who answered "less frequently used" from the percentage of respondents who answered "more frequently used."
Source: Ministry of Internal Affairs and Communications (MIC), "Survey on People's Lives in a Ubiquitous Network Society" (March 2004)

(Changes in lifestyles)

In 1956, when the Tokaido Line became fully electrified, it took seven hours and thirty minutes by limited express train from Tokyo to Osaka. However, in 1964, the Tokaido Shinkansen, which boasted a top speed of 210 km per hour—the world's fastest speed at the time—began operation and shortened the time required for traveling from Tokyo to Shin-Osaka to four hours. The emergence of the Shinkansen allowed people to take day trips to areas along the Tokaido Line, and had a considerable impact on people's social lifestyles and economic activities. Since then, many technologies have been applied to the Shinkansen; for example, the axle load was reduced from the original 14 tons to 11 tons through the introduction of aluminum train bodies. As a result, the current Shinkansen achieves a top speed of 270 km per hour, and travels from Tokyo to Shin-Osaka in a mere two hours and thirty minutes (Figure 1-1-9).

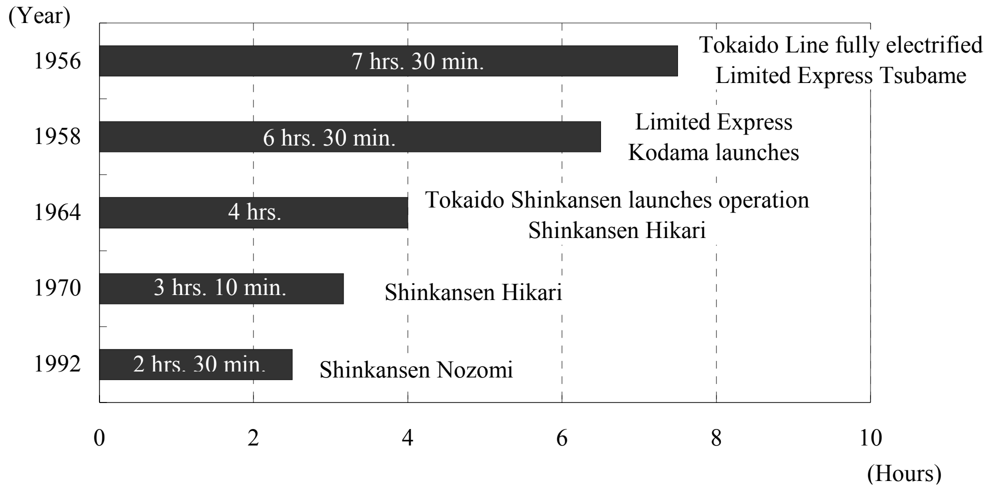


Figure 1-1-9 Travel Time from Tokyo to Shin-Osaka (514.5 km)

Source: Produced by MEXT based on the Website of the Railway Technical Research Institute

Japan's first commercial Internet access service was commenced in 1992. After that, the Internet rapidly spread to people in various segments including companies and general homes, and brought dramatic changes to the methods of information gathering and communication. In schools also, the percentage of public schools connected to the Internet reached 99.8% in fiscal 2003. These schools provide education using information and communications technologies, such as using online information as teaching materials (Figure 1-1-10).

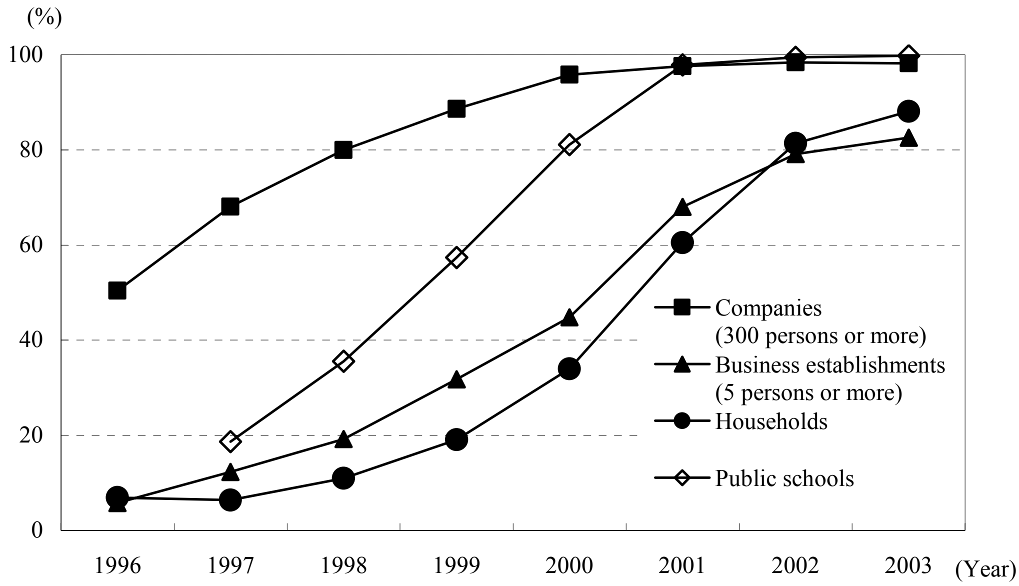


Figure 1-1-10 Internet Diffusion Rates of Households, Companies, Business Establishments, and Public Schools

Notes: Diffusion rate for households indicates the percentage of households where member(s) accesses the Internet via PCs or mobile phones for private purposes "at home/other."
Diffusion rate for companies indicates the percentage of companies where "the entire company"or "part of the offices or divisions" accesses the Internet.
Diffusion rate for business establishments indicates the percentage of business establishments that access the Internet.
Data on the diffusion rate for public schools are only available for 1997 onward.
Source: MIC, "Communications Usage Trend Survey"; MEXT, "Survey Results on Actual Condition of Information Education at Schools"

(Maintenance/recovery of health)

Medical care developed dramatically in the 20th century. Many lives have been saved and life expectancy has been prolonged thanks to the discovery of vaccines and antibiotics, development of various new pharmaceuticals, the progress of medical technologies, the early discovery of diseases through health examinations, and the development of medical equipment used for diagnosis and surgical operations. In particular, Japan has one of the highest longevity rates in the world, and there are signs that the average life expectancy will become even longer in the future (Figure 1-1-11).

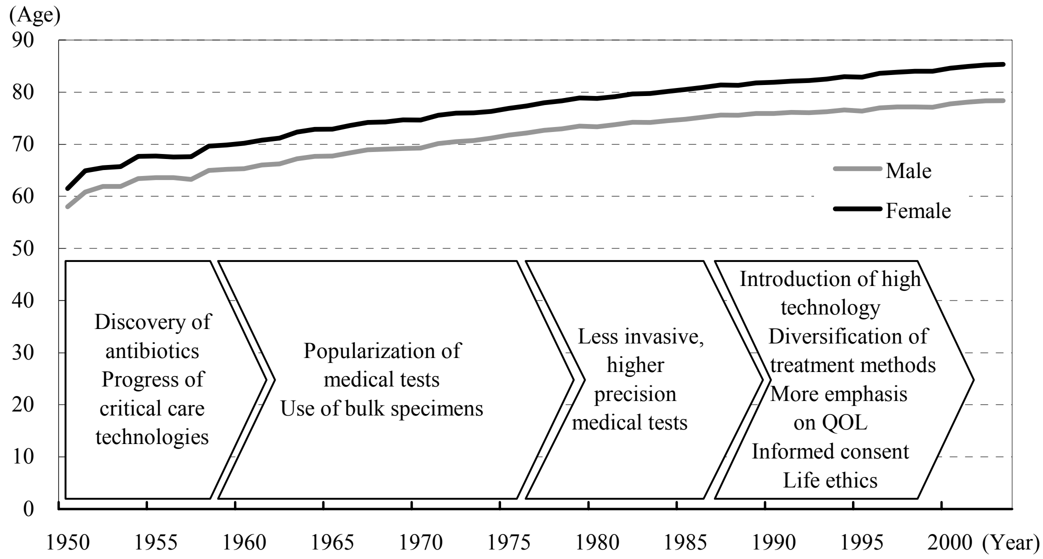


Figure 1-1-11　Development of Medical Technologies and Average Life Expectancy in Japan

Source: Produced by MEXT based on Ministry of Health, Labour and Welfare (MHLW), "Complete Life Tables," "Abridged Life Tables" and Institute of Biomedical Engineering, Tokyo Women's Medical University ed., "21 Seiki Wo Kirihiraku Sentan Iryō" (State-of-the-art medical care for leading the way in the 21st century) (October 1999).

The World Health Organization (WHO) defines, "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity." In the modern society, there is risk of suffering from lifestyle-related diseases such as hyperlipemia, hypertension, diabetes, and obesity due to overeating, insufficient exercise, smoking, and drinking alcohol. In particular, obesity is a risk factor that may trigger yet other lifestyle-related diseases, so easy-to-use body fat scales for home use, drinks that help burn body fat, and fat foods that do not easily form fat deposits were developed in order to control body fat.

1.1.2.2 Economic Development

After World War II, Japan did not merely achieve economic revival, but developed significantly through the subsequent high economic growth. The cause for the economic growth can be indicated by the relationship among three elements: labor, capital, and total factor productivity (TFP). The TFP is said to mainly involve technological progress and improvements in human resources. Looking at the past 30 years, although capital investment largely accounted for the economic development in the first half of the 1970s, the increase in the TFP contributed significantly to the subsequent economic growth, particularly in the second half of the 1980s (Figure 1-1-12). Japan's economic growth has owed greatly to an increase in TFP, that is technological innovations and the like, in addition to quantitative expansion of capital.

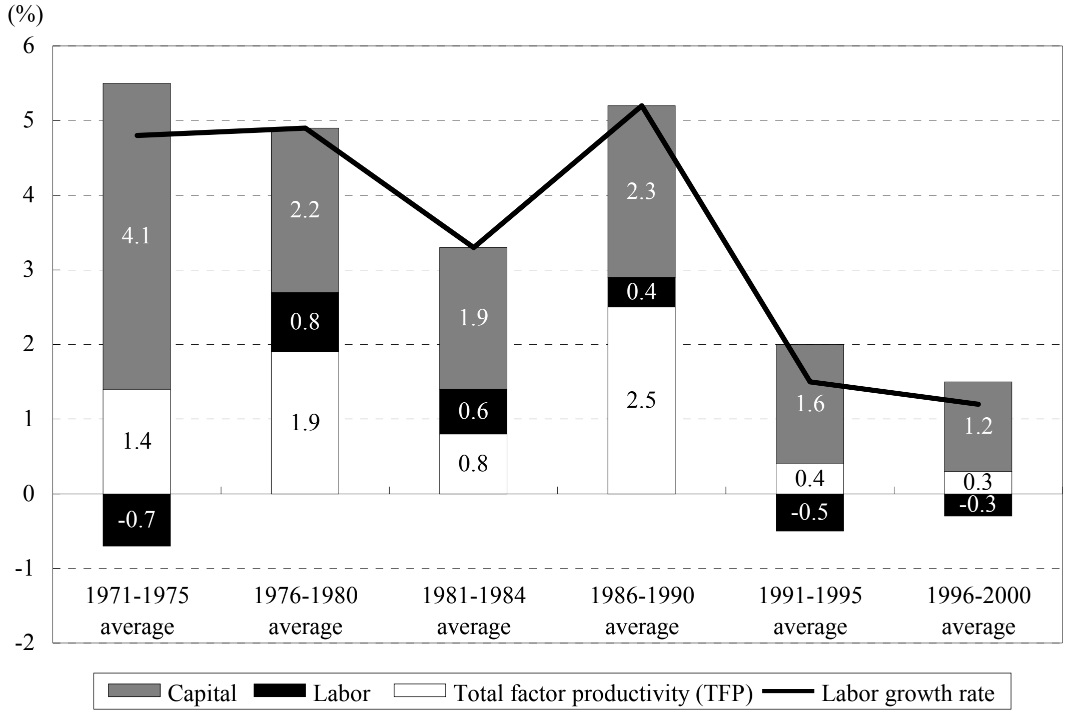


Figure 1-1-12 Contributions of Technological Innovations to Economic Development

Notes: 1. TFP increase rate = (real growth rate of value-added production) - (capital share x capital stock growth rate) - (labor share x labor input growth rate)
2. The simple averages of production growth and contributions of the respective elements to the production growth were obtained for each period.
The data for 1985 was deleted because there would be a gap based on the market entry of Nippon Telegraph and Telephone Corporation (NTT).
3. The average values from 1996 through 2000 were obtained by MEXT in accordance with the estimation method indicated in "Economic Survey of Japan FY 1997."
Source: Economic Planning Agency, "Economic Survey of Japan FY 1997."

1.1.2.3 Addressing Social Issues

As seen in the environmental problems and bioethical issues, science and technology also serves as a cause of threat to the survival of mankind and a cause of concern for people. Effective use of science and technology is also expected for building a safe and secure society, such as addressing such "shadows" of scientific and technological development, taking measures to alleviate damage from natural disasters, and preventing terrorism.

(Environmental problems)

Global warming caused by greenhouse gases such as CO_2 has become a major problem. About 20% of Japan's CO_2 emissions are attributable to the transportation sector, of which 90% are emitted from cars. In order to reduce CO_2 emissions, the fuel efficiency of gasoline-fueled cars was improved by about 18% from 1997 to 2002 (Figure 1-1-13) through various kinds of technological development, such as making the engines and the power transmission systems more efficient, reducing the weight of the vehicle, and reducing the air resistance. In addition, hybrid cars, which efficiently combine the power of the engine and other power such as electricity, were developed, and cars that boast about twice the mileage of gasoline-fueled cars appeared. In this manner, efforts are being made to reduce the environmental loads by saving resources through improvement of fuel consumption, by curbing CO_2 emissions, and by cleaning emissions.

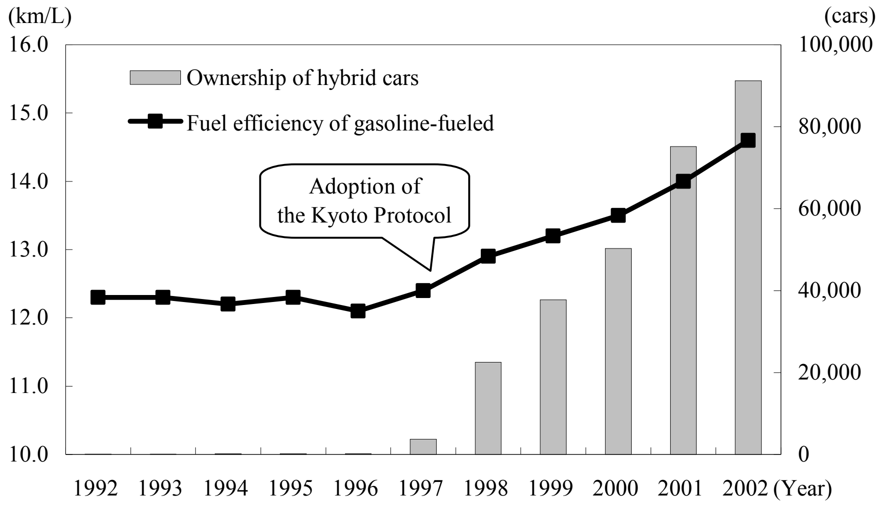


Figure 1-1-13 Fuel Efficiency of Gasoline-Fueled Cars and Ownership of Hybrid Cars

Sources: Ministry of Land, Infrastructure and Transport, "List of Automobile Fuel Efficiency" (March 2005); Japan Automobile Research Institute.

In Japan, energy consumption at home has been increasing. Therefore, new technologies have been introduced to many home electrical appliances to reduce their energy use. For example, when comparing an electric refrigerator, which uses a lot of energy, in 1981 and 2001, the average rated volume nearly doubled over the 20 years, but the annual power consumption per 1 liter of volume has been drastically cut to less than one-third due to technological innovations including a significant improvement in insulation efficiency and use of an inverter-controlled compressor (Figure 1-1-14).

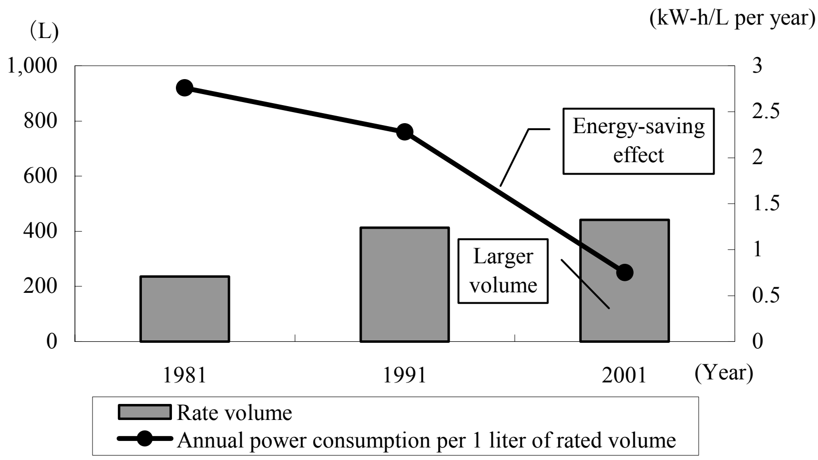


Figure 1-1-14 Energy-Saving Performance of Refrigerator-Freezers

Source: Surveyed by the Japan Electrical Manufacturers' Association (JEMA)

As an entire nation, Japan maintains the lowest level of primary energy consumption per GDP among the major developed countries (Figure 1-1-15). This suggests that Japan, which has scarce energy resources and depends largely on imports, is achieving high productivity based on technologies for using energy efficiently.

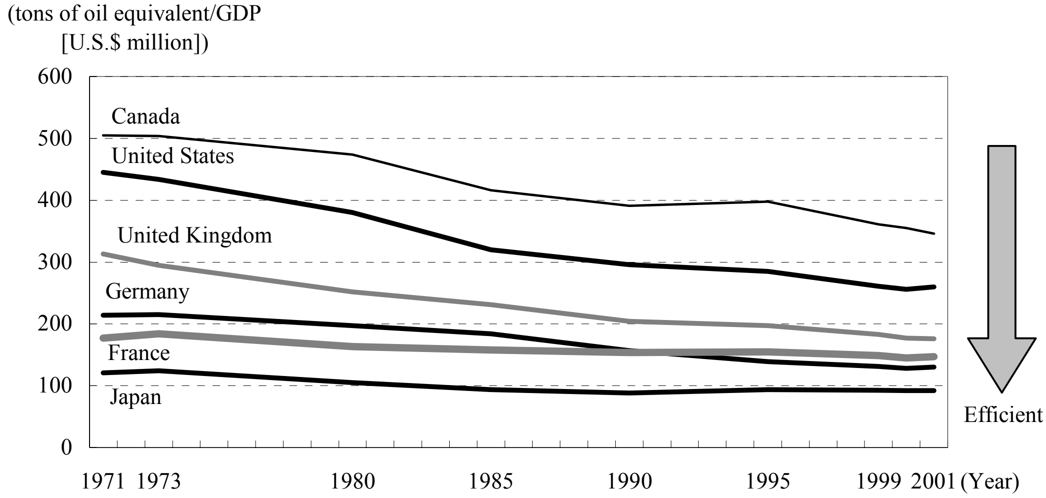


Figure 1-1-15 Primary Energy Consumption per GDP

Source: OECD, "Energy Balances of OECD Countries"

(Science and technology for safety and security)

People have come to face various risks and threats as social systems became more and more sophisticated and complicated. According to a questionnaire survey implemented by the Study Group on Science and Technology Policy for a Safe and Secure Society, more than 75% of the respondents answered that they "feel concern" or "feel slight concern" about crimes, traffic accidents, and air/water pollutions (Figure 1-1-16). Science and technology is also expected to contribute toward eliminating such concerns and achieving safe and secure living and society.

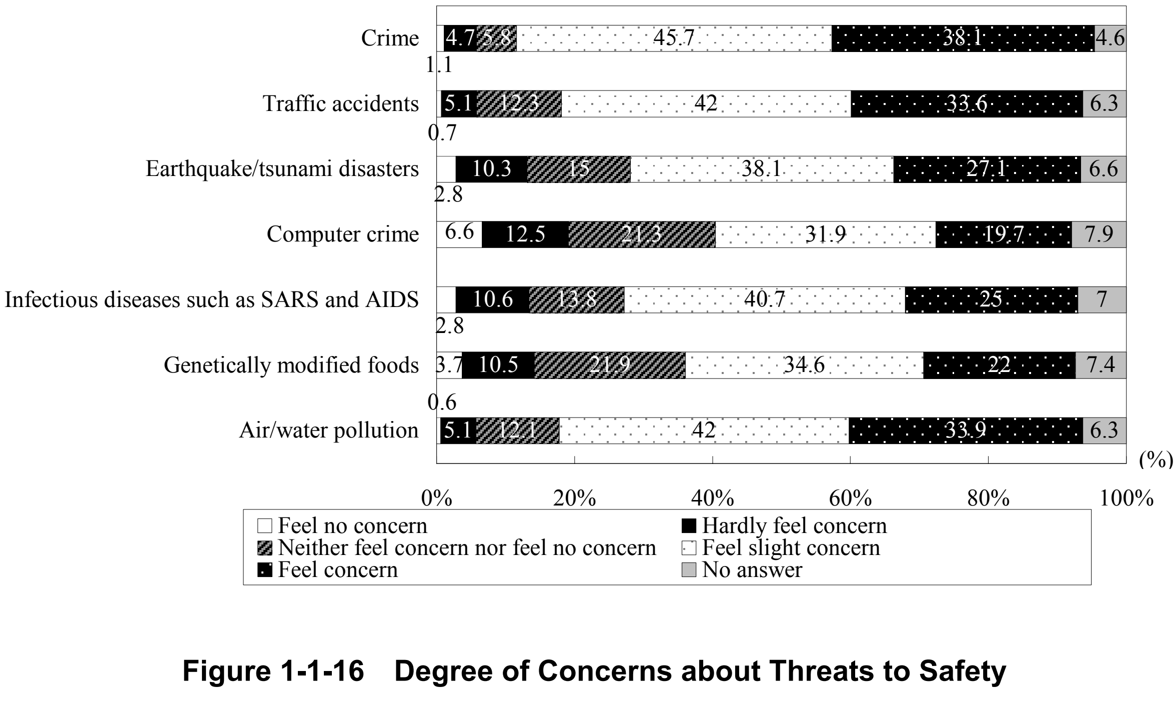


Figure 1-1-16 Degree of Concerns about Threats to Safety

Note: Values are the result of a questionnaire survey conducted on 3,600 citizens by postal mail (no. of valid responses: 1,476).
Source: Extracted from the results of a questionnaire survey conducted by the Study Group on Science and Technology Policy for a Safe and Secure Society (February 2004).

[Column 5]

Key Words for Future Science and Technology
Considerate to the Planet and Comfortable for Human Beings:
Love the Planet

The main task for all members of the earth in the 21st century is to seek the establishment of sustainable symbiosis of all lives on the planet from the perspective of the whole world. A new challenge has already begun regarding how science and technology can contribute to solving problems emerging on a global scale that human beings are expected to face in the future.

With "Nature's Wisdom" as the main theme, the 2005 World Exposition (Abridged name: Expo 2005 Aichi; Nickname: "Love the Earth") is held with the participation of many countries and multinational organizations. As a comprehensive and international exposition, this Expo is being held in Japan for the first time in 35 years, since the Osaka Expo in 1970, and it is also the first world exposition of the 21st century.

State-of-the art science and technology is displayed to show how science and technology is used to make the recycling-oriented society and to put it into practice for the purpose of the establishment of sustainable development of the society, which is a major issue of the 21st century.

The "Bio Lung" is built at the center of the exposition site. It is a green-painted wall, 150 meters long and 15 meters high, covered with flowers and plants. This facility functions as the lung of the site, reducing the environmental burden by inhaling carbon dioxide and exhaling oxygen by taking advantage of the power of plants, and to improve the living environments in the surrounding area by lowering the temperature during the summer time.

At the food courts, where visitors can enjoy foods from all over the world, environmentally friendly biomass tableware made of recyclable organic materials (biomass) such as plants are used. They are decomposed to water and carbon dioxide by microorganisms in the ground after being dumped, which helps effectively reduce waste and create a post-petroleum society.

Visitors can also experience a next-generation environmentally conscious transport system for moving around inside the site.

As for electricity supply, atomic energy generated at the Mihama Nuclear Power Plant was used for Osaka Expo. But in the case of the Aichi Expo, "New Energy Power Plants" such as photovoltaic power plants and fuel cell power plants located in several places within the site are planned to supply sufficient electricity to meet the expected demand of 2,200KW of electricity of the Japan Pavilion and others in the Nagakute area.

In February 2005, just before the opening of the Aichi Expo, the Kyoto Protocol finally went into effect, eight years after the adoption of the treaty.

It is unclear how the weather will change in the future because of the impact of various environmental problems. But in the past, serious changes in the weather that could destroy human life have occurred many times. Modern civilization has finally taken the first step to seriously considering how to tackle environmental problems and resultant changes in the weather.

The Japan Pavilion Nagakute The Japan Pavilion Nagakute (left) is covered by a bamboo basket. It is 90 meters long, 70 meters wide and 19 meters high. At the Japan Pavilion Nagakute, the steel sheet roof is used for taking advantage of the effectiveness of heat radiation caused by the super hydrophilic photocatalytic property, which is an achievement of Japan's original basic research. Water flows down from the upper side of the roof, evaporates on the surface, and deprives heat from the roof (i.e., the heat of vaporization), which is an achievement of Japan's original basic research. Water flows down from the upper side of the roof, evaporates on the surface, and deprives heat from the roof (i.e., the heat of vaporization), which cools the roof and then lowers the temperature inside the pavilion. This reduces the air-conditioning load. Waste water disposed within the pavilion is zoned and reused for this purpose. Moreover, active oxygen is created on the roof because of ultraviolet rays, which decompose organic matter on the roof. And, as decomposed materials are washed away by rain, the roof remains clean.

[Column 6]

Ten Years after the Great Hanshin Earthquake

Fatalities numbering 11,000, total disaster victims coming to 7 million, among which 4.6 million live in evacuation houses, and a total amount of economic damage of 112 trillion yen, the equivalent of the national budget for one year and three months (of which direct damage is 67 trillion yen)—these are the estimated damage figures if an earthquake of the same magnitude as the Great Hanshin earthquake (magnitude 7.3) hit the Tokyo metropolitan area at present. (These figures are quoted from the materials of the Earthquake Measure Experts Research Committee about Inland Earthquakes in Metropolitan Areas, by the Central Disaster Prevention Council. Estimation is made based on the assumption that the earthquake source is in the northern part of Tokyo Bay.)

In the early morning of January 17, 1995, the “Southern Hyogo earthquake” struck, with a magnitude of 7.3 and a source at the Nojima Fault. This earthquake is the first big inland earthquake that has hit a major city of an advanced nation in modern history. The earthquake was later renamed the Great Hanshin earthquake.

The Great Hanshin earthquake caused the greatest human and physical damage in the postwar period. The number of the people killed or missing came to 6,436, a total of 250,000 houses were destroyed, and the direct economic damage reached ten trillion yen. In addition to building damage, the transportation network such as the Hanshin Superhighway, Japan Railways lines, private railways and harbors, and the lifeline network including the water, electricity and gas systems suffered destructive damage, which revealed the vulnerability of the functions and social infrastructure of modern cities.

After the earthquake, the Office to Promote the Research and Study of Earthquake was established, and full-scale joint efforts by the government, private companies and academia were launched to work out measures to prevent and reduce disasters. The Japan Meteorological Agency, universities, the National Research Institute for Earth Science and Disaster Prevention, the Building Research Institute, and private companies and others are engaged in efforts to establish the network of earthquake observation, to explore the mechanism of earthquake occurrence by using simulation models, to develop seismic isolation and damping technologies for buildings and other structures, and to develop robots for disaster relief.

Moreover, on the tenth anniversary of the Great Hanshin earthquake in January 2005, a real size three-dimensional full-scale earthquake destruction testing facility called “E-Defense,” the largest of its kind in the world, was constructed at a site next to the Miki Earthquake Disaster Memorial Park in Miki City, Hyogo. This facility is equipped with the world’s largest shaking table, which is 15 meters long and 20 meters wide, and can recreate an earthquake of the same size as the Great Hanshin earthquake. It also has shakers, fourteen of which can move structures vertically and ten of which can move them horizontally. The testing facility can explore how a building is destroyed, how much a building is destroyed and why a building is destroyed, by shaking the building with a weight of 1,200 tons at maximum from three directions and eventually destroying it. By increasing the strength of buildings, human casualties would become more serious when buildings collapse, because people would be buried under the bricks. Researchers have been striving to develop construction design methods to minimize human casualties, by allowing a building to be partially destroyed under strong vibrations.

Natural disasters cannot be prevented even if modern technologies are applied. But science and technology are expected to play an important role in minimizing disaster damage, securing the safety of people who suffer disasters and rescuing disaster victims as quickly as possible. In this field, Japan is expected to make an intellectual contribution.