[Column 9]

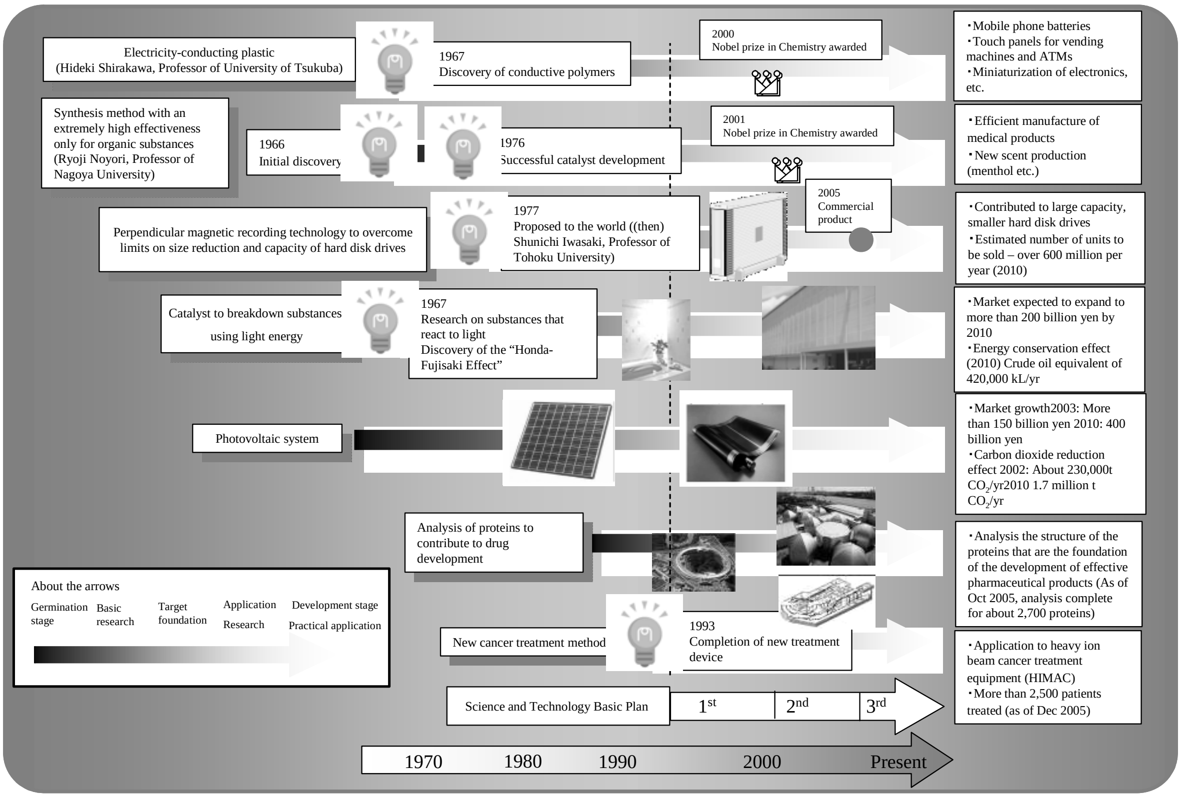
## Japan's Technologies That Have Created Economic and Social Values

To make economic and social values by science and technology, it takes long time R&D with twists and turns from a small seed of basic research at a university. Even when a product is made or when it is put into practical use, it is not always accepted in the market. Let's see examples that were developed into industrialization under such difficult circumstances, and that Japanese technological capacity was shown to the world.

Perpendicular magnetic recording technology is not only used today for computer hard disks, but also is the technology to achieve miniaturization and large capacities of hard disk drives that are used for portable music players and for recording TV programs. It is expected to contribute further to the miniaturization and higher performance of many devices. The Photocatalyst is a catalyst to break down substances using light energy, and its self-cleaning function has already been used for tiles and glasses for construction and side-view mirrors of automobiles. It is expected that its market will expand in the future. Because environmental issues are important today, the photovoltaic system is counted on very much as semi-permanent and clean energy with no waste generation. Japan occupies slightly less than 50% of the entire production in the world and is the world's largest producing country. Including these, typical examples are shown in the figure below.

These examples verify that even a small seed at the beginning can create big economic and social value if the possibility of the technical seed is believed and R&D is continued. You could say that it shows Japan's possibility to develop based on its science and technology.

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




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

Among the research results produced through the variety of competitively-funded research and development, there are likely to be many results that can accelerate development of innovation by being used in a different system at the next level or research and development at public research institutes. However, since there is no system for actively promoting this use of research results, there is the concern that promising results will be left on the shelf. Therefore, in addition to ensuring the systems to support research and development from the basic research stages up through the innovation stages, it is also necessary to build the means to make sure that the research results created by a certain system, university or public research agency can be appropriately utilized by the system at the next stage in order to further advance innovation.

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

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

Since the 1980s the USA has shifted from science and technology policies focused on specific missions, like defense and medicine, to policies to strengthen industrial competitiveness, in order to respond to the economic pursuit from Japan and the EU. Laws have been enacted to promote alliances among industry, academia and government, including the Bayh-Dole Act to allow inventors to own the patents obtained through federally-funded research, and the SBIR Act, which is a program to provide funds to support entrepreneurship.

Since the establishment of the Science and Technology Basic Plan in 1996 there has been significant progress on the preparation of systems to promote industry–academia–government alliances (Figure 1-2-29). In FY2004 the national universities became independent corporations, and took over various responsibilities and authority. This made it possible for each university to implement measures adapted to their own special characteristics, and allows them to hold their own patent rights. In addition, the teaching staff are no longer subject to the restrictions of the public employee system, so each entity now manages salaries and wage levels, as well as policies on outside businesses and employment.

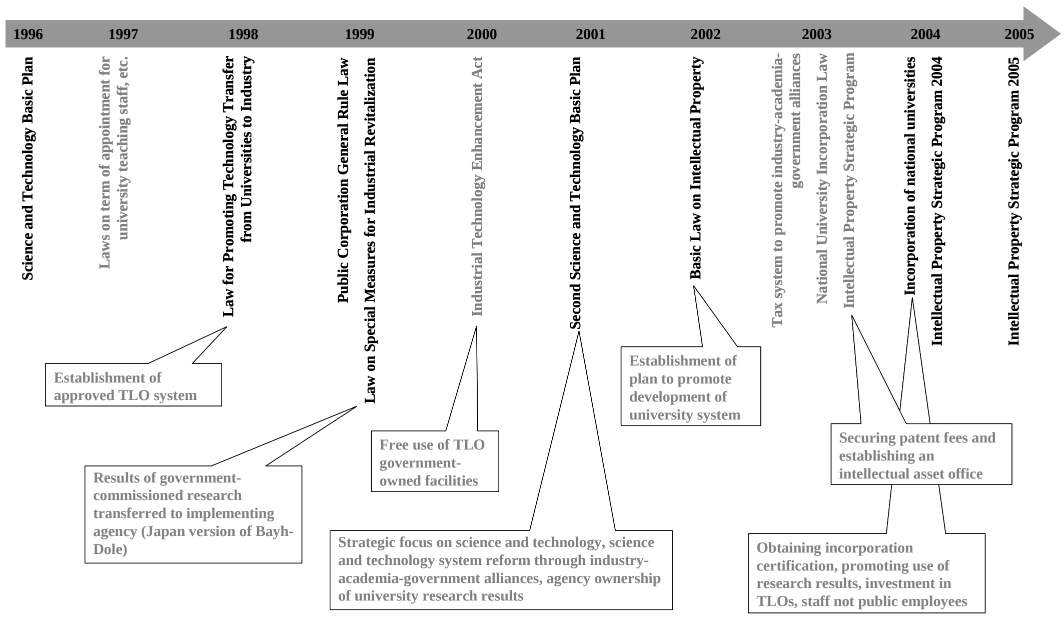
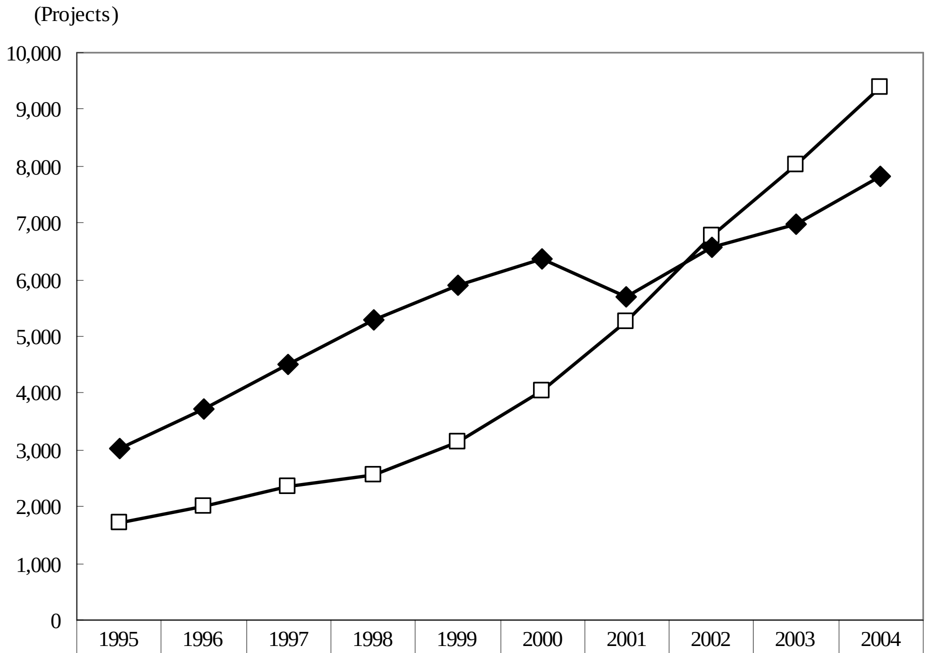



**Figure 1-2-29 Main trends in industry-academia-government alliance measures**

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

At present many universities have established industry–academia–government liaison offices, and specialists in technology, law and finance have been assigned throughout the country as industry–academia–government alliance coordinators in order to increase the return of benefits to society from universities and public research agencies. While grants and endowments from business to universities remain flat, there is an increase in the number of joint-research and commissioned research projects, and a shift from the style of individual collaborations to organizational collaborations, and from non-contractual industry academia-government alliances to contract-based alliances (Figure 1-2-30). This is a change from the past situations of regular collaboration between industry and academia, with no contracts ("working in concert" type industry-academia-government alliances between specific labs and certain businesses) and the use of grant money with no restrictions on allocation of use and annual carry-over. Many of the joint research projects are in the area of life science.




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

**Figure 1-2-30 Trends in the Number of Joint Research/Contract Research Projects (National Universities, etc.)**

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

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

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

As an effort to promote industry-academia alliances, the nation is implementing creative seed development projects to conduct research and development for the technology stage with the aim of commercializing unique and creative research results (seeds) from the universities and public research agencies, and an industry-academia collaborative seed innovation project was established in fiscal year 2006 with a new matching grant format.

Even with the adjustment to the foundations of industry-academia-government alliances, as described above, the investment of outside sectors is small in comparison to the USA. The funds invested by companies are mostly used for

company-internal research. In addition, although the amount of research and development funding received by universities from business within Japan is gradually increasing, in fiscal year 2004 Japanese business invested 201.2 billion yen in research and development overseas, but only 83.6 billion yen of research funding was received by universities in Japan from companies, less than half of the amount sent abroad[14] (Figure 1-2-31). In a questionnaire survey conducted in August 2001 by Nippon Keidanren, domestic businesses were asked the reasons for offering funding to universities overseas. The answers included the ability to make flexible contracts with universities that had corporate status, the proposals from the universities based on society demands, and the horizontal cooperation systems for human resources within the universities, such as between administrative groups and instructors in other departments. According to the "FY2001 Survey on Research Activities of Private Businesses" report, the expectations of Japanese business regarding the promotion of research and research content at universities and national institutes were highest for "not just basic research, but also research that considers commercialization." There is a demand for universities to learn and understand the needs of industry, and to actively engage in industry-academia-government alliances.

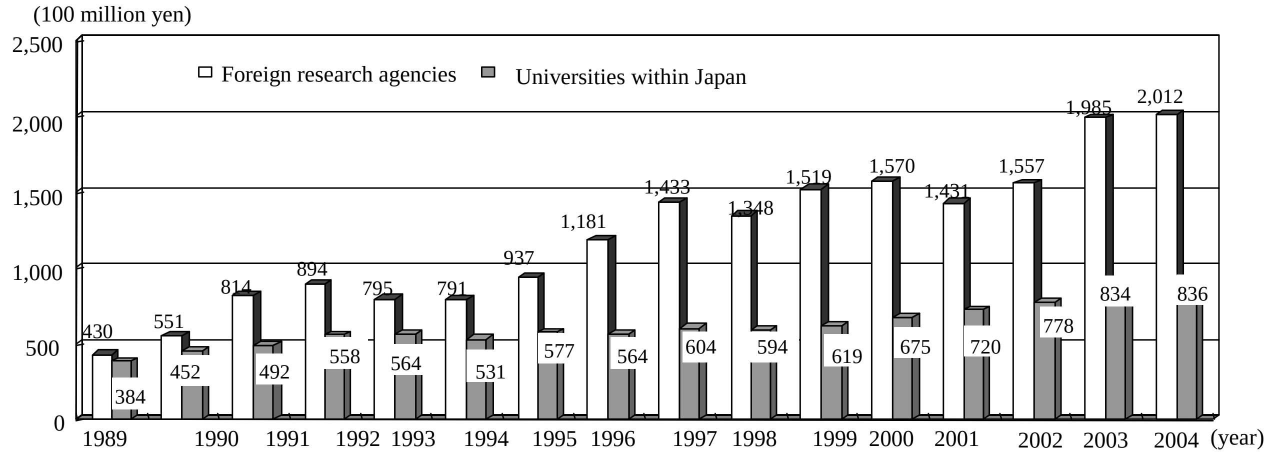



**Figure 1-2-31 Research and development expenditures from industry to domestic and foreign research agencies**

Source: Created by the Ministry of Education, Culture, Sports, Science and Technology from the Ministry of Internal Affairs and Communication Statistics Bureau "S Report on the Survey of Research and Development"

[14] The breakdown of research and development investment from domestic business to overseas is very likely to include funding to subsidiary companies, so further investigation is required.

With the development of industry-academia-government alliances, there is a growing need for regulation/accommodation of the responsibilities and benefits of teaching staff in relationship to the company and their responsibilities of education and research to the university (so-called “conflict of interest,” “conflict of responsibilities”). Nearly half of all the national universities already have some sort of rules regarding conflicts of interest, but it is necessary to continue to encourage the preparation of regulations.

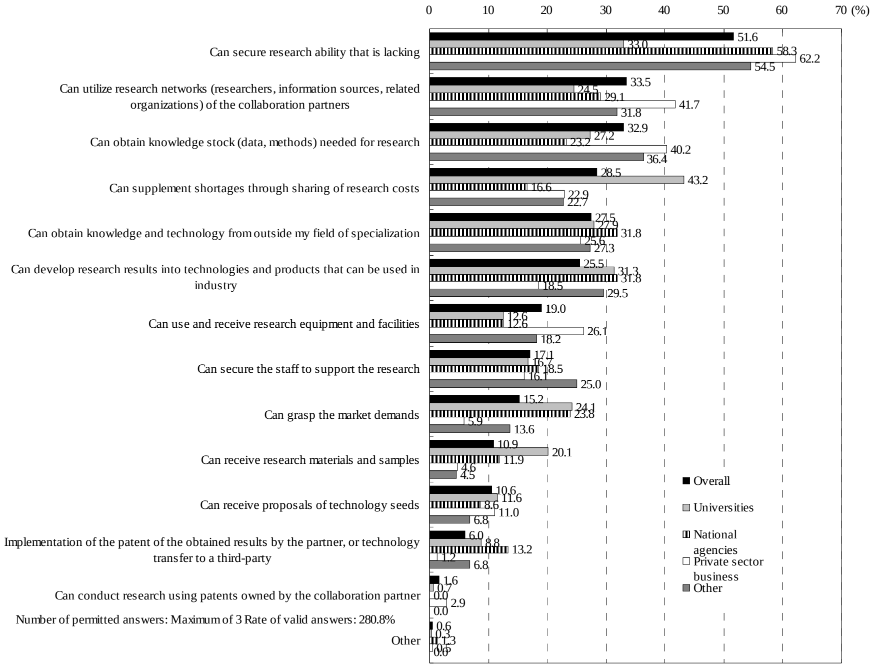
According to the questionnaire survey in the report “2004 Survey of the State of Japan’s Research Activities” although in general the assessment of researchers regarding the effectiveness of industry-academia-government alliance was positive, including “can secure research ability that is lacking,” “can utilize research networks of the collaboration partners,” and “can obtain knowledge stock (data, methods) needed for research,” there were strong calls for “coordinator personnel training/enrichment ” (Figure 1-2-32).

In the results from the questionnaire for the “Current Situation Surrounding Technology Transfers and Future Measures” conducted by the Ministry of Economy, Trade and Industry in June 2005, there is dissatisfaction in the industrial world about the lackadaisical observance of confidentiality requirements by students in the labs, and the handling of company secrets, such as during presentations of new research results at academic conferences. In addition, for collaborative research, although industry generally agrees to arrangements for paying indirect expenses[15] requested by the university, there are problems with payment ambiguities such as amounts, and accounting for how the money is used. For patents jointly owned by a university and a business, since the university cannot utilize the patent itself, they sometimes ask the business for royalty payments to utilize the shared patent (compensation for non-implementation), in order to ensure a source of funding for new research activities and provide financial incentives to inventors. However, paying this kind of compensation can be an obstacle to business, especially in the case of one product that utilizes multiple patents, such as in the electric industry, and there are gaps between the attitudes and awareness of business and universities. In the same survey the universities voiced the opinion that businesses should have an attitude of flexibility and a long- range point of view for negotiations and an integration of the contacts for business.

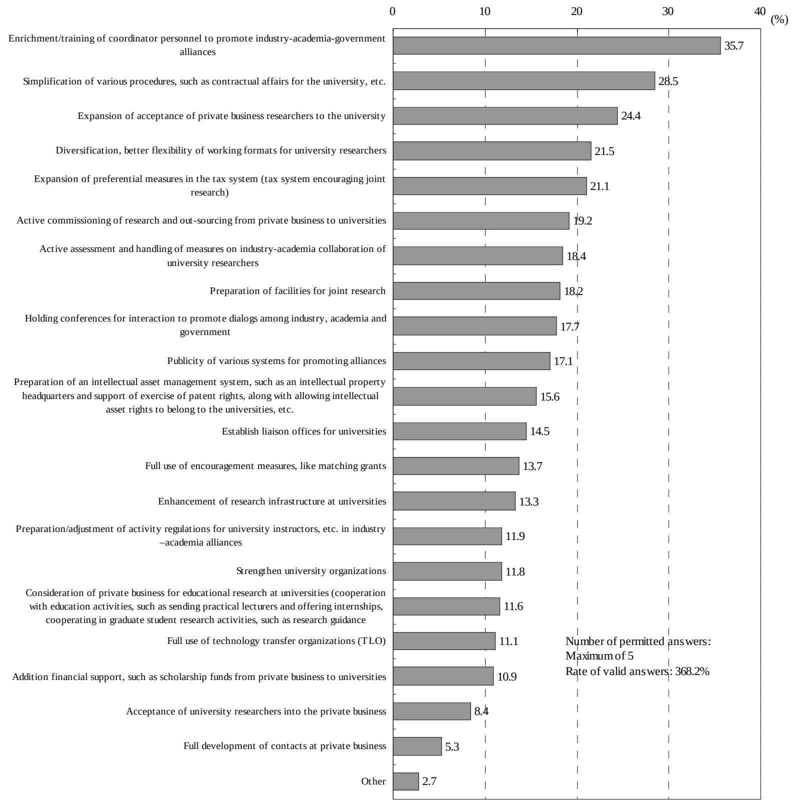
In order to resolve these various problems, the industrial world must consider the unique characteristics of universities and public research agencies, and universities must flexibly adapt to the needs of business. It is necessary to build relationships based on mutual trust, including strict observance of confidentiality without compromiseng the function of broadly releasing research results that should be filled by universities. To achieve this, it is crucial to have personnel who are clear about the situations in the respective areas of industry, academia and government, to exchange researchers among each of these groups, to foster the development of MOT (manager of technology) personnel, and to increase the number of coordinators.

[15] Facilities expenses, etc. for test equipment besides the direct research expenses.

**(Reasons for effectiveness of industry-academia-government alliances)**




**(What is needed for industry-academia-government alliances)**




## Figure 1-2-32 Opinions of researchers involved in industry-academia-government alliances

Source: Ministry of Education, Culture, Sports, Science and Technology “Survey of the State of Japan's Research Activities” report (2004)

[Column 10]

## Successful Industry-University-Government Joint Research (The 4th Award for persons of merit in Industry-Academia-Government Collaboration by the Conference on the Promotion of Industry-Academia-Government Collaboration in June 2005)

- Research on ubiquitous computing technology (The Prime Minister's Award)

The TRON Project started for the purpose of building a ubiquitous network society to help people's lives by installing TRON, which is a basic OS made in Japan, in various equipments used in people's daily lives and using network connections. "ITRON," designed for the TRON Project, is suitable for reducing the size of the OS and has been adopted in many industrial products including household appliances, audio-visual equipments, office machines, and automobiles. However, due to the development of computer technology and sophistication of functions with it, the importance of design recently shifted to the efficiency of development, and to cope with it, the environment for real time system development including hardware architecture with high portability has become necessary. For this purpose, the OS was standardized to make the enhancement of functions easier. This is the T-Kernel, which is the result of basic research of computer science at a university, and its platform is T-Engine. By using T-Kernel, it has become possible to cope with small systems to high-level large-scale systems, and many kinds of products that have the T-Kernel as an installed OS are used around the world. At present, many demonstration experiments are promoted towards a ubiquitous network society with electronic tags and mobile terminals as the result of research in distribution, stock management, food traceability, management on medication, tour guides, and others.

- Research on the Healsio water oven (Chairman of Nippon Keidanren (Japan Business Federation) Award)

The industrial need to seek products to satisfy people's desires for health, due to the decreasing and aging population, and the environmental purification technology which was basic research of a university were combined together and the water oven as a kitchen appliance was commercialized. Based on the knowledge of generation and characteristics of superheated steam of which research was promoted as the method to extract, analyze, and measure endocrine-disrupting chemicals in a university, the conventional large superheated steam generator was shrunk to the size for family use, and eight times as the temperature of a conventional microwave with constant voltage was realized. Thus, a system to efficiently use superheated steam was developed jointly by industry-university collaboration. This product created a new realm of cooking that is "to bake by water," and is said to have the effects of fat/salt reduction and of preventing decomposition of antioxidants such as vitamin C and CoQ10 by low-oxygen cooking.

- Development and commercialization of the "cryo-TEM (cryogenic transmission electron microscope)" and structural analysis of membrane protein (Minister of State for Science and Technology Policy Award)

An electron microscope enables you to observe an object at atomic level by using short electron rays of which the wavelength is much shorter than visible wavelengths. It illuminates high-energy electron rays on the object to observe and therefore destroys weak-bond molecules or crystals, so that there are several restrictions when selecting the object to observe. The cryo-TEM (cryogenic transmission electron microscope), jointly developed by a university and a company, uses the phenomenon where damage to a molecule or crystal by electron rays is extremely small below -270 degrees C. It was successful in enabling the observation of the structure of liquid and organic matters that were vulnerable to electron rays, which could not be observed by conventional electron microscopes.

In addition, the decomposition capability was improved up to the world’s highest level by developing a rapid quenching method to prevent degeneration of membrane protein samples caused by dryness under ultra low temperature, an energy filter to prevent noise caused by the electron scattered from the ice of the water around the protein, and an automatic sample exchange device that enables great improvement of operability. As a result, it has become possible to analyze the structure of membrane protein in human cells, which was difficult to observe in the past but is very important as a target of medicine. All six types of membrane protein that have been analyzed so far were analyzed by cryo-TEM, and a great ripple effect in the drug discovery industry is expected.

### ●Creating, protecting and utilizing intellectual property

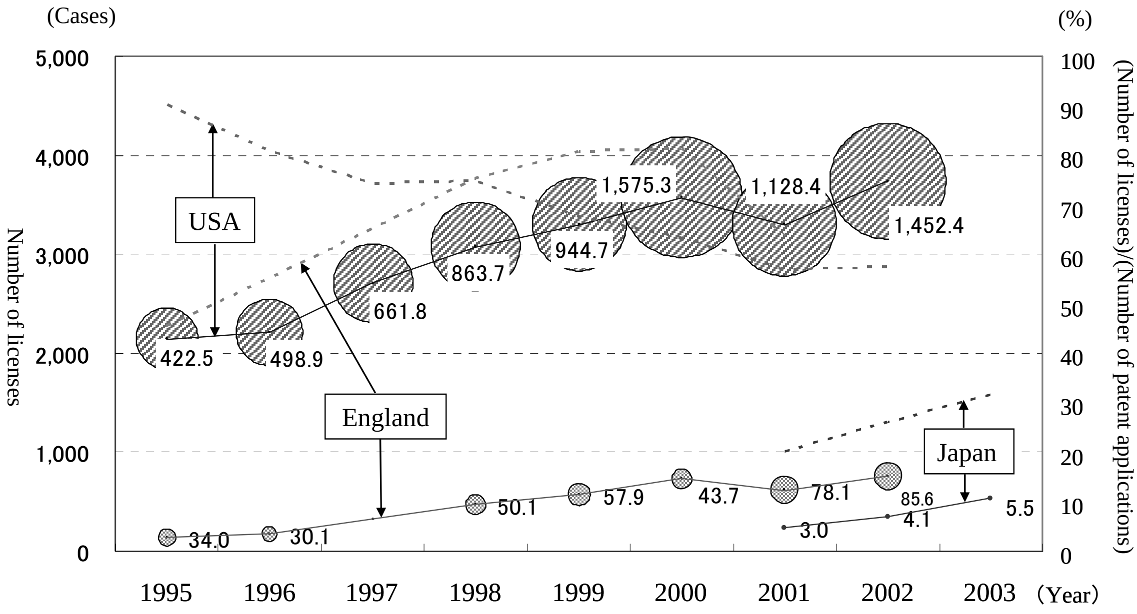
In order to boost innovation, it is essential to stimulate the intellectual creative activity cycle and ensure that the resulting intellectual property is properly protected and utilized.

Intellectual property is expected to fill two roles. One is to motivate research and development. If there is no protection of intellectual property rights, and other companies can use the developed knowledge without prior consent, it will decrease the incentives to invest in research and development. The second role is to encourage the public release of research and development. Patent rights are intellectual property rights that require publication as a condition of the protection, so by strengthening this, it is possible to avoid having research become a business secret and prevent redundant investment by other companies. On the other hand, excessive protection hinders technological innovation, so it is necessary to seek an appropriate protection balance.

### (1) Transferring the research results from universities to society

With regard to the handling of inventions at national universities, in principle, since the Science Council decision in 1977, ownership is vested to the individual. However, without promotion of transfer and use of intellectual assets to industry, the intellectual assets tended to remain on a shelf, so there has been a shift to management of intellectual property, like patents, by the organization (principle of organizational ownership). With the implementation of the University Intellectual Property Centers Program in FY2003, there has been progress on the establishment of intellectual property headquarters at universities. In addition, as a result of the incorporation of the national universities in FY2004 each university took over the rights and responsibilities related to intellectual property, and have developed systems to utilize intellectual property according to their own judgment. As a result, universities became able to make use of the intellectual property according to their own judgment. At present, it has also become possible for national university corporations to accept stock as compensation for permission to use their intellectual property.

As a result of the measures described above, there has been an increase in the number of patent applications and cases of licensing by universities, but in comparison to the USA, the royalty revenues are low, and the rate of increase in royalty revenues is low compared to that in the number of patent license agreements by universities. However, it is true that it took a long time after the Bayh-Dole Act was enacted until economic benefits, like royalty revenues, were generated by the university research results in the USA. Considering too, that a long time is required from investment in research until product commercialization for fields like life sciences, it is likely that the lack of significant results in Japan so far are to be expected. In fact, the United Kingdom started the establishment of TLO at universities in the late 1980s, about 5 to 10 years behind the USA, and has not yet achieved royalty revenues on par with those in the USA (Figure 1-2-33). For technology transfers, the fundamental accumulation is important, and to invigorate future technology transfers it is necessary for universities to promote means to properly secure within the organization the funds for intellectual property activities, such as fees for patent applications. For this the government must increase support for competitive research and development to encourage a return of the research results born at universities back to society, and to appropriately support the costs of foreign patent applications, from the perspective of Japan’s international competitiveness.




| | Japan | USA | England |
|---|---|---|---|
| Royalty revenue (100 million yen) | ○ | ⊘ | ◍ |
| Number of licenses | — | — | — |
| (Number of licenses)/(Number of patent applications) | ••• | ••• | ••• |

**Figure 1-2-33 International comparison of trends in the results of technology transfers from universities**

Source: Created by the National Institute of Science and Technology Policy

## (2) Promoting intellectual property activities

With regard to intellectual property activities, patent applications are still mainly filed for improvement patents rather than basic patents, for defensive reasons, so there is a high percentage of unutilized patents, about 60%. It is important to utilize outstanding R&D results that become the source of global competitiveness by effectively obtaining the rights, particularly as basic patents in Japan and abroad. For businesses it is important to shift from a quantity-based patent strategy to a quality-based strategy, and work on obtaining high-quality basic patents. For universities, it is important to actively obtain the appropriate rights for their intellectual property, regardless of whether it is within Japan or abroad. It is also necessary for the country to support the strategic measures of the universities, etc. It would also be desirable to prepare patent information search systems, like the Intellectual Property Digital Library (IPDL), for using existing patent information, so that it is possible to obtain high-quality research results.

With regard to the problems of compensation for employee inventions, due in part to a great deal of conflict in recent years, Article 35 of the Patent Law was revised and entered into force in April 2005. Under the amended employee invention system, independent agreements on the appropriate compensation between the employer and the employee will be respected as long as they are reasonable.

### ●Promoting entrepreneurial activities of R&D ventures

Research and development-based venture businesses, such as university start-ups, quickly return ground-breaking research results from universities to society, and play an important role as a driving force of innovation. In recent years universities are not just generating the seeds that are the source of knowledge, but are also actively setting up university start-ups to develop new goods and services utilizing their own research results. The number of university-based venture companies in Japan is increasing. A noticeable increase has been seen particularly since 2000, when it became possible for professors at national universities to simultaneously hold positions in private sector businesses, with the cumulative total companies established exceeding 1,000 in 2005 (Figure 1-2-34).

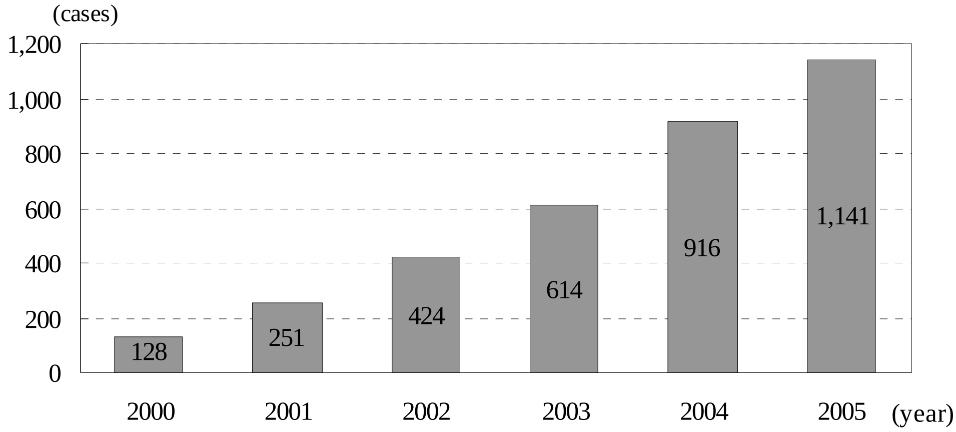



**Figure 1-2-34 Cumulative total of university-based start-ups**

Note: Survey subjects: National, municipal and private universities, technical colleges, and inter-university research institutes throughout the country (786 sites), as well as government research facilities (47 sites)
Source: Ministry of Education, Culture, Sports, Science and Technology "2005 University-Based Venture Start-up Survey"

In the future, in addition to continuing the preparation of the environment for entrepreneurial activity, it is necessary to enhance comprehensive support measures, covering technology, funding, human resources, and creation of demand. In particular, it is important to continue supporting creation of university-based start-up companies and to support for the growth and development of the created venture.

### ●Building regional innovation systems and creating vital regions

According to Professor Michael Porter of Stanford University, a "cluster" is an innovative group of inter-related businesses and agencies associated with a particular industrial field in close geographical proximity, linked by similarities and complementary functions. Various western nations are already making strategic use of clusters, emphasizing the effective use of resources and the regional autonomy. Well known examples include, Silicon Valley in the USA, Cambridge in the United Kingdom, Sophia Antipolis in France and Zhongguancun in China (Table 1-2-35).

## Table 1-2-35 Table of world clusters

| Country | Region | Main field | Economic scale (area, population) | Main universities/ research institutes | Main companies/ start-ups | Development |
|---|---|---|---|---|---|---|
| USA | Silicon Valley | IT | 50 km north to south, 15 km east to west<br>Population 2.3 million (Santa Clara county)*1 | Stanford University (slightly farther, UC Berkeley, UCSF)<br>Extremely large number of VC | About 5,000 high-tech companies (manufacturing: about 1,500, R&D/service: about 2,000)*3, HP, Intel, Oracle, Sun Microsystems, etc. | Science Park established in the 1950s, Spin-off from Fairchild Co., 1980s major global corporations establish labs |
| | Austin (Texas) | IT | Working population 100,000 (mainly high-tech companies)*2 | Texas University Austin | Number of high-tech-related companies, like Dell: about 1,750 *2 | 1980s: government semiconductor research project, Many IT venture companies appear through the activities of Mr. Kosmicki |
| | Boston metropolitan area | Medical equipment, Bio-tech | Population along Rte 128, about 700,000 (City of Boston + Town of Cambridge)*4 | MIT, Harvard, Boston College, etc.<br>Major hospitals, such as Massachusetts General | Bio-related companies: about 250 (18% of entire USA)*3, of these 65 are venture companies<br>Medical device companies: 100, Biogen, Genzyme | From the 70s through the 80s researchers from Harvard and MIT started a series of bio-tech start-ups |
| | Research Triangle Park (North Carolina) | Pharmaceutical bio-tech | 3 cities of Raleigh, Durham, Chapel Hill (30 km east to west, 20 km north to south)<br>Working population about 40,000 *2 | North Carolina State, Duke, North Carolina National Environmental Science Research Lab, Research Triangle Institute, etc. | Base of research in the USA for GlaxoSmithKline<br>Bio venture: about 140 companies *1, 65 companies are bio-research related services | The state built a research park in the 60s, and started a government recruiting project<br>In the 90s, an increase in spin-off start-ups from GSK, State promotes bio-ventures |
| Great Britain | Cambridge | Bio-tech | Radius of 50 km centered on Cambridge<br>Working population over 32,000 *5 | Cambridge University, Cambridge Science Park<br>St John's Innovation Park | High-tech companies: 1,250, of these about 150 are bio-related companies *5 | Series of spin-offs from Cambridge University in the 1980s, In the 1990s, spin-offs from the 80s spin-offs |
| | Northeast England | Nano- technology | Population 2.6 million (about 13,000 jobs created by new high-tech-related business) | 5 universities, including Durham, Newcastle, Northumbria, COE project | | 1999, Northeast England Development Co. established, COE progress in 5 fields, such as nano-technology through collaboration of the 5 universities |

*1 2003, *2 1999, *3 1997, *4 2004, *5 1998

| Country | Region | Main field | Economic scale (area, population) | Main universities/ research institutes | Main companies/ start-ups | Development |
|---|---|---|---|---|---|---|
| Germany | Area around Munich (especially Martinsried) | Pharmaceutical bio-tech | Population of Munich about 1.3 million<br>About 20% of the workers in bio-tech in Germany are here. Particular concentration of bio-venture in the suburb of Martinsried (10 km from city center) | Technical University of Munich,<br>Ludwig-Maximillian University<br>Max Planck Institute of Neurobiology, National Environment/Health research center<br>Big role played by BioM Co. About 20 VC companies | About 100 bio-related companies, such as Heisse, and Ingenium 31 bio-venture companies like MediGene *1 | Based on the results of the Max Planck Institute, in 1996 a cluster policy “BioRegio” to promote bio-industry development in Germany |
| Finland | Oulu | IT, bio-medical | Population about 1.24 million *2, More that 7,500 people work at companies in Technopolis *2 | University of Oulu, National technology research center (VTT)<br>Technopolis company | More than 500 high-tech companies in Technopolis, Nokia-related businesses | In 1980 the head of VTT proposed concept of Oulu promotion through a science park, based on this, incubation activities by Technopolis |
| France | Sophia Antipolis | Information –related, environment /life science, etc | About 24 square km<br>Employees 22,000 | National science lab, Nice University science lab, Paris School of Mines graduate school | Number of companies: about 1,100, including IBM, Air France, France Telecom | Concept in the 1960s. National project decided in ’72. Today’s form is from venture companies of the 80s and 90s |
| Korea | Taedok special research zone | High-tech | Working population: about 17,000<br>Students: about 30,000<br>Area: about 5 km2<br>Population of Daejeon about 1.3 million | 59 research agencies<br>25 private research labs, 30 government- affiliated research labs, 4 higher-education facilities, 7 government agencies *3 | Since 1995, 300 technology-based venture companies born, 130 companies within the incubation facilities at the university | Concept born in ’71, since the Asian currency crisis in ’97, spin-offs are active |
| China | Zhongguancun (Northwest part of Beijing) | High-tech | 340 square km area of northwest Beijing<br>More than 360,000 people working at companies *1 | 30 universities, more than 200 national research institutes | 10,000 companies. Growth at a pace of 2,000 companies per year *3 | ’88 government decision to establish a high-tech industrial development zone,<br>in ’99, Beijing defines a Science Park Zone. |

*1 2002, *2 2003, *3 2004
Source: Ministry of Economy, Trade and Industry, “materials by the Institute of Industrial Cluster (May 2005)”

[Column 11]

## Efforts in the Clusters of the U.S.

### Silicon Valley

Silicon Valley is the common name for the high-tech industry area spreading on the south to the west side of San Francisco Bay. At first, the name Silicon Valley was used in a column by a journalist in 1971 who named the area after silicon, which is the basic material of semiconductors of the semiconductor industry, that was concentrated in the area at the time. It is said that the history started from Hewlett-Packard Co. established in 1939 by the support of Fred Terman, Professor of Stanford University. At first, it was a rural zone where only Stanford University and several high-tech companies were located, and apple orchards were spreading that became the origin of the company name of Apple Computer. In 1951, Stanford Research Park was established to compete with the universities on the east coast, and industry concentration has been promoted since then. Though it is a high-tech industry area, the main technological field and major companies of Silicon Valley grown after World War II have not been consistent. It has the characteristics of changing its main industry in almost every decade, namely military products from the 50s to 60s, semiconductors from the 60s to 70s, personal computers from the latter half of the 70s to the 80s, and the Internet from the latter half of the 80s to the 90s. Venture companies, such as Netscape Communications Corporation established in 1994, have been growing rapidly, and the area is leading the high-tech-related industries in the world to today.

Austin

In the Texas state capital of Austin, Dr. George Kozmetsky, who was invited to the city in 1966 as a Dean of School of Business, University of Texas, advocated the importance of education on entrepreneurship from an early stage, attracted enterprises and established support organizations in cooperation with the state government, administration, and financial circles, and established the IC2 Institute (1977) to research the commercialization of technologies and to educate specialists. As a result, high-tech companies, such as MCC (Micro-Computer Corporation Consortium) which is a joint research institute of the computer industry, Sematech, IBM, and Motorola, have gradually concentrated in the region and formed a cluster. After that, due to the slump of the American economy in the latter half of the 1980s, spin-offs, who were laid-off engineers of companies like IBM and Sematech increased in the 1990s, but ATI (Austin Technology Incubator established in 1989), established on the initiative of Dr. Kozmetsky, played an important role in keeping excellent engineers in the region. This cluster has grown rapidly from its core role of attracting enterprises to a cluster, and is an example of an acceleration of cluster development by political assistance in contrast with a naturally formed cluster.

San Diego

San Diego in California has a biotechnology cluster where many biotechnology-related companies are concentrated. In San Diego, in addition to research functions including Scripps Institution of Oceanography (1903) and Salk Institute for Biological Studies (1960), there was UCSD (University of California, San Diego), and spin-offs have established many venture companies. One of the major examples is Hybritech Incorporated. This company was established in 1978 by the researchers of UCSD, and the spin-offs from this company have established more than 50 companies. What supported these entrepreneurs was UCSD Connect, established in 1985, which was based on the UCSD. As one of its programs, there is a course called Spring-Board which covers a range from the early stage of business launching to the fund-raising stage and to support formulating business plans from just a business idea through to detailed training. In this Spring-Board program, more than 300 people get together from seven o'clock in the morning and make enthusiastic information exchanges during breakfast meetings. It seems that the existence of such meetings is making the entrepreneur network of San Diego profound, and is promoting spin-offs.

A cluster is a concentration of the necessary business and industry functions needed for innovation. In order to promote innovation throughout Japan it is important to build competitive local innovation systems by developing local clusters with international competitive ability.

In Japan, it has traditionally been common for businesses associated with a specific field to be located near each other geographically, but the connections between businesses and industry-academia-government alliances that form the "inter- relation ships" and "links through similarities and complementary functions" have been inadequate. Therefore, in fiscal year 2002 the "Knowledge

Cluster Initiative" was implemented to form regional clusters, with focused investment of research funds within a relatively limited space in order to develop an industry-academia-government network to leverage the superior technology resulting from the research. There are 18 regions targeted as knowledge clusters in the current project, with 2,145 researchers participating in industry, academia and government, resulting in 1,060 patent applications, and 219 commercialized results (products, start-up companies, etc.). In addition, since fiscal year 2001 an "Industry Cluster Project" has been underway, to build tight networks of researchers at local universities and local middle-ranking/small and medium-sized businesses that attempt to develop new businesses, and to support research and development making use of regional characteristics, and increasing the quality and quantity of information flows between industry, academia and government. There are currently 19 projects being conducted, but in the second phase of the project from fiscal year 2006 to 2010, these will be re-organized and merged into 17 projects, along with the setting of plan goals and targets. However, since it is also possible that the measures implemented by the various ministries and agencies, not just for the clusters, may not necessarily work as desired in the region, a liaison committee of agencies associated with regional science and technology has been formed in fiscal 2004 and there are efforts to achieve cooperation and coordination among agencies and ministries.

Common elements of the successful examples of regional clusters abroad include commonly-held, long-term vision and goals, a supply of the core personnel to drive the projects, a support system that operates effectively to support the network activities within the cluster, and effective utilization of policy support for small and medium-sized business, such as venture, etc. With regard to the regional clusters in Japan, it has been pointed out that the university-based start-ups and spin-off companies[16] that are the effective choices for the commercialization of research results, such as from joint research, are creatively weak. This is said to be influenced by inadequate risk management of venture capital and angel investment, and a lack of people aspiring to be entrepreneurs. The knowledge clusters and industrial clusters are still in the process of being formed, so it is too early to judge the success or failure of the cluster formation. In addition to working to promote further collaboration of the industrial clusters and knowledge clusters, it is important to vitalize regional innovation systems through active promotion of the creation and use of intellectual property using advisors on intellectual property in the local regions.

[16] An independent venture of a parent company through a separate allocation (spin-off) of business resources, such as unused technology, personnel and capital

## ●Innovation activities by private enterprises

The creation of market value in the form of new products based on the results of research and development and industry-academia-government alliances, and the final realization of innovation is achieved through private business.

In December 2004 the “Statistics on Innovation in Japan” was released. This was a statistical study of the conditions and trends in innovation activities in private sector businesses in Japan. It is the first nationwide, comprehensive, objective statistical investigation of innovation conducted in Japan. According to this study, 29% of all businesses conduct innovation activities, and 22% have achieved innovation. The main obstructions reported by the companies that have achieved innovation are “enormous economic risk,” “lack of capable personnel,” “lack of appropriate sources of capital,” and “excessively high innovation costs.” (Figure 1-2-36)

In order to solve the lack of personnel for innovation within a business, it is necessary to encourage joint human resource development efforts by industry and academia and promote activities of those who have earned PhDs in industry. In order to decrease the cost of innovation, there is a need for measures to promote preparation and shared use of research facilities and to conduct research activities efficiently in a short period of time.

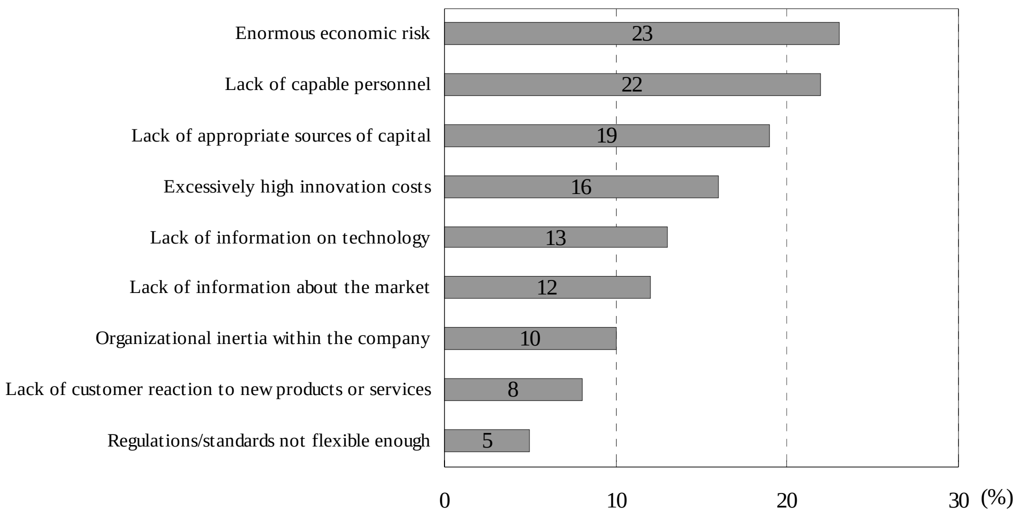



**Figure 1-2-36 Innovation obstructions to innovating companies**

Note: Among the companies that have achieved innovation and responded, the percentage of companies indicating a high level of importance (strong impact) for the obstructions experienced during the time innovation activities were being conducted (1999-2001).

Source: Ministry of Education, Culture, Sports, Science and Technology, National Institute of Science and Technology Policy “Statistics on Innovation in Japan” (FY2004)

With regard to the fostering of innovation within companies, the main purposes seem to be to discover new business, to increase vitality within the company and to identify the people with an entrepreneurial spirit; and, 1/3 of enterprises currently are working to foster ventures within the company, or plan to in the future. The plan in more than half the cases is to “provide funding, operation and management know-how, research results, and company operation resources, such as research and production facilities.” However, the reason given for not preparing a company-internal venture system in more than half the cases is “want to focus on main business operations rather than internal ventures” (Figure 1-2-37). With regard to government support policies, more than half the companies responding indicated the importance of “expansion of public subsidies and grants for venture enterprises” (Figure 1-2-38).

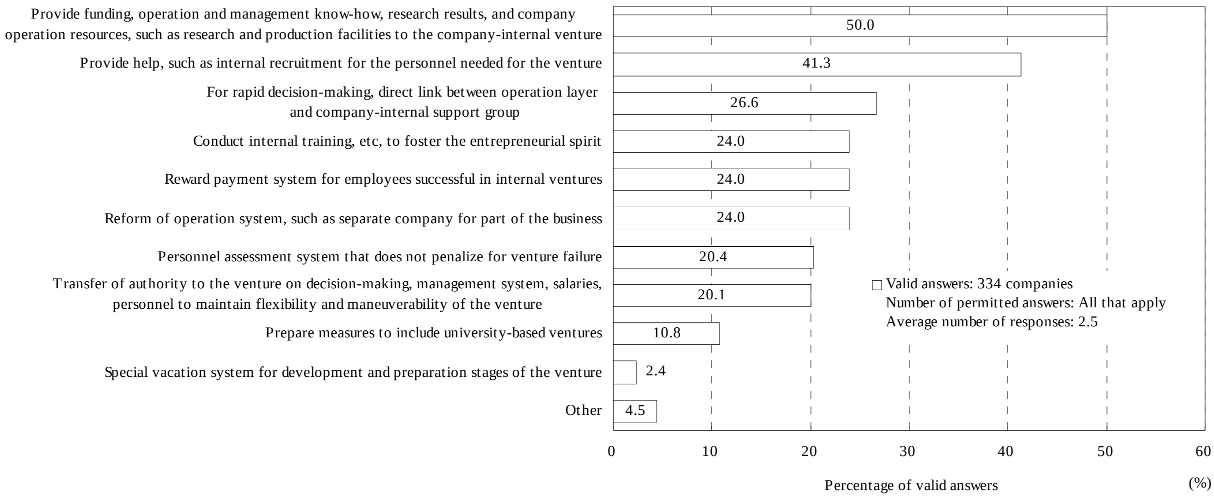



**Figure 1-2-37 Policies to foster company-internal venture enterprises**

Source: Ministry of Education, Culture, Sports, Science and Technology "Survey on Research Activities of Private Businesses (fiscal 2001)"

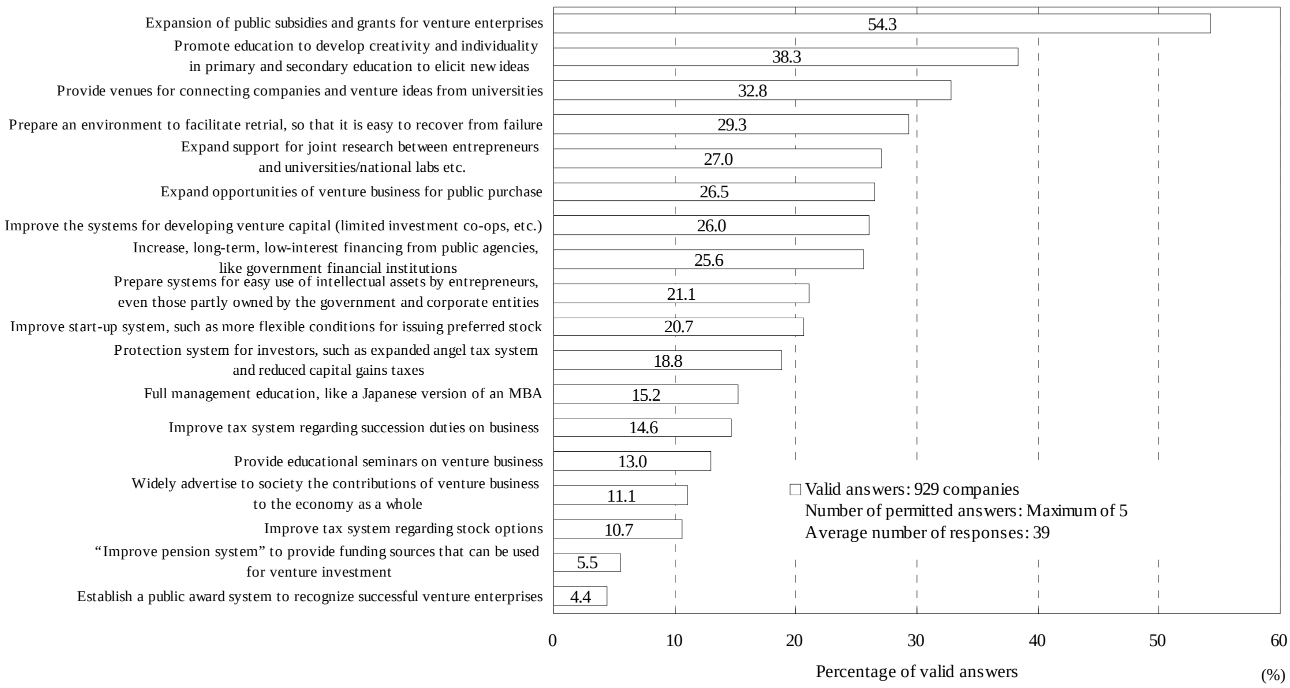



**Figure 1-2-38 Government support measures needed to foster company-internal venture enterprises**

Source: Ministry of Education, Culture, Sports, Science and Technology "Survey on Research Activities of Private Businesses (fiscal 2001)"

Measures in the tax system related to testing and research costs, include a system of tax deductions in cases where the testing and research expenses of a business exceed the average expenditure in the 3 years out of the most recent 5 fiscal years with the largest expenditure, and exceeding the expenditure of the 2 most recent fiscal years, with a deduction equivalent to 15% of the expenditure exceeding the average. A revision in 2003 established a special tax deduction system related to the total testing and research expenses, making it possible to select either the special tax deduction system for increased testing and research expenses or the special tax deduction system for total testing and research expenses. The special tax deduction system related to the total testing and research expenses is a system allowing a deduction from corporate taxes (income tax) of a certain percentage of the total expenditure on testing and research (8-10% (for each project year starting between January 1, 2003 and March 31, 2006, 10-12%)). In the case of a business commissioning research or conducting joint research with a university or public research institute, an amount equivalent to 12% of the testing and research expenses related to that joint or commissioned research (for each project year starting between January 1, 2003 and March 31, 2006, 15%) can be deducted from the corporate tax (income tax). In addition, for small and medium-sized businesses, a tax deduction equivalent to 12% of the total testing and research expenditure is allowed (for each project year starting between January 1, 2003 and March 31, 2006, 15%). In a 2006 revision of the tax system, the special tax deduction system for increased testing and research expenses and the special tax deduction system for total testing and research expenses were combined. If the testing and research expenditure is greater than the average of the last 3 fiscal years, and is greater than the amount in the last 2 fiscal years, the tax deduction rate is increased by 5% for the portion of the expenses exceeding the average.

Public procurement is also important not only for enhancing the activities or improves efficiency of the public sector, but also from the perspective of encouraging a return of research results to society. In particular, the procurement of products, etc. of research and development-based venture enterprise by the public sector increases the business credibility, and helps to ensure revenue during the early stages of business. It is necessary to make efforts to stimulate innovation in the private sector and form new markets, such as the example of the introduction of low-emissions vehicles through the plan to promote the development and adoption of low-emission vehicles by the various ministries and agencies.

### 1.2.2.3 To Build Innovation Systems

As society continues to age and the number of children declines it is crucial for the country to have continuous innovation in order to maintain economic vitality and international competitiveness. In the future it will be necessary for industry, academia and the government to work together and strengthen the innovation systems so that the latent abilities of the nation are utilized to the fullest extent in order to continuously and effectively achieve innovation for the ground-breaking research and development results including the basic research results from universities and public research agencies. As a nation it is necessary to prepare a variety of research funding systems to correspond to the various stages of R&D development, and to build the mechanicsms to develop promising research results from the basic research stage through the creation of useful products. Furthermore, in the midst of intense international competition, it is absolutely necessary for Japan to continuously create innovation from our own research results. Therefore, the industry academia-government alliances are important and there must be development of sustained, evolving industry-academia-government alliance system. From this there must be an effective innovation system built through promotion of the alliances, with a mutual understanding maintained through the interaction and exchanges of personnel among the various organizations. In conjunction with this, it is important to have a mechanism to eliminate the systemic and operational bottlenecks hindering smooth science and technology activities and return of the results.

[Column 12]

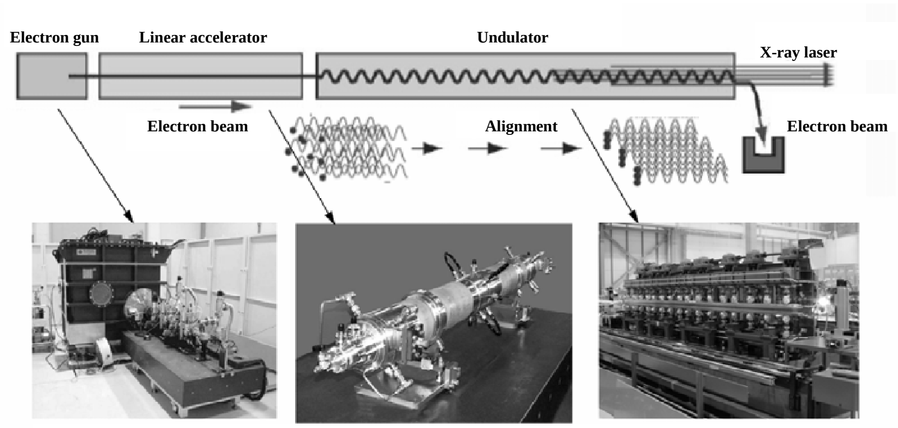
## Research Facilities That Carry Japan's Development

As cutting-edge technologies that support the science and technology of Japan, the X-ray Free Electron Laser (XFEL) and state-of-the-art high-performance general-purpose super computer are introduced here.

-X-ray Free Electron Laser (XFEL)

RIKEN Japan has already established the technology necessary to realize XFEL, and to develop the technology necessary to research its use, is building at present a prototype machine to oscillate vacuum ultraviolet laser of 60 nanometer ($10^{-9}$) wavelength. This XFEL has the feature of a radiant light radiating strong X-ray, enabling the capture of short time phenomenon by using the characteristics of "laser," and is called "dream light." It is a technology to realize the structure analysis of atoms and molecules in a short period of time, the capture of faster movement and change, and higher preciseness of measurement, by enabling the free electron laser's high-energy and very short wave within the X-ray range.

By using such XFEL, structure analysis of one molecule in a giant protein or clarification of ultra high-speed phenomena of electron behavior in electronic parts will be possible. It will contribute to strengthening the international competitiveness of industries such as drug discovery and electronics and it is expected to improve conveniences and the health of people.




**<u>Heat-driven electron gun:</u> Generates a sharper electron beam**

**<u>C-band linear accelerator:</u> Accelerates to high energy in a short distance through an acceleration gradient**

**<u>Vacuum-sealed undulator:</u> Oscillation of short wavelength, high interference, high intensity x-ray laser**

-State-of-the-art high-performance general-purpose super computer

Aiming at realizing the world's most efficient science, technology, and computer environment, the following developments are made:

(1) Development and dissemination of software to use its functions to the utmost extent
(2) Development and improvement of the world's most cutting-edge and most efficient general-purpose 10 petaflop computer system
(3) Formation of the world's top-level base for super computing research education with the above (2) as its core

Regarding a complicated and wide variety of phenomena in a wide range of areas, simulation of entire systems and sophisticated information processing and analysis become possible by using the super computer, and international leadership can be established in leading-edge super computing. It is also expected to contribute to the enforcement of competitiveness in science and technology and industry.

Furthermore, by the development and use of such state-of-the-art high-performance general-purpose super computer, the return of benefit to the society and economy, such as the building of a strong base for science and technology, new product development using nanotechnology and biotechnology, realization of new medical care by the fusion of multiple fields, and practical application of new disaster prevention or disaster decrease technologies is expected.

[Column 13]

## Productivity in Service Industries

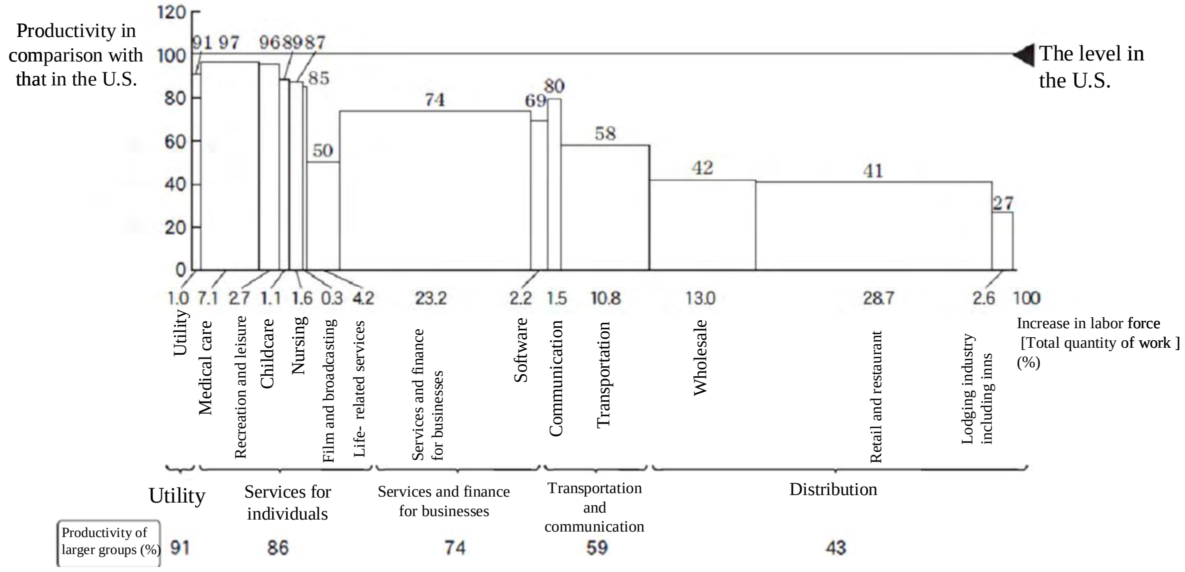
In present Japan, the rate of the service industry, rather than manufacturing industry, is increasing in both the GDP and number of workers. Especially, the rate of workers in the narrow sense of service industry such as medical care, welfare, and business service is increasing. In the recent economic growth, service industries have played a role of accepting employees from manufacturing industries who were laid off due to the improvement of production efficiency, and decline in the productivity of service industries has become conspicuous with the increase in labor force. It is pointed out that improvement of labor productivity is the key for Japan's economic growth in the future.

Comparing the productivity of service industries in Japan with those in the U.S., in every field, it is lower. It is especially low in wholesale, retail, restaurant, and lodging industry including inns. If the productivity of Japan's service industry continues to be low as it is, the productivity of the entire macro economy may see sluggish growth and may lead to a decline in international competitiveness.

It is considered that in service areas for which productivity is low from an international viewpoint, innovation by science and technology may greatly contribute towards improvement of international competitiveness. Furthermore, it is expected that excellent results of human and social science related to science and technology may contribute to adding high value to the manufacturing industry. For these reasons, it is important, for promoting innovation, to develop human and social science and to integrate that knowledge with natural science.

### The comparison between the productivity of service industries in Japan and those in the U.S.

(Index: That in the U.S. in 1999 as 100)




Source: Ministry of Economy, Industry, and Trade “Input-Output Table,” Ministry of Internal Affairs and Communications "Labor Force Survey," BEA "Industry Accounts," BEA "NIPA Tables," and McKinsey analysis

Reference: "Survey research and factor analysis on the productivities of tertiary industries in Japan and the U.S." by the Japan Industrial Policy Research Institute and McKinsey & Company, Inc., Japan

## 1.2.3 Science and Technology Contributing to Building a Spiritually Wealthy Society


### Summary

In an aging society with fewer children the average lifespan is increasing. If it is possible to extend the healthy lifespan (meaning the period of time of healthy independence, in terms of the quality of daily life and health of both mind and body) through science and technology, this is expected to lead to a society in which people can live a long life of health and wealth. Furthermore, there is a growing percentage-e of people who feel that “from now on there should be an emphasis on a life of spiritual wealth and ease.” The things that create a sense of spiritual wealth differ depending on the individual, but it is no exaggeration to say that cultural arts and crafts, sports, and intellectual curiosity are important. Contributing to the realization of a “spiritually wealthy society” that enables appreciation of cultural arts and crafts, participation in/viewing of sports and intellectual stimulation is one of the roles demanded of science and technology.


### 1.2.3.1 Science and Technology Contributing to Achieving Spiritual Wealth

In an aging society with fewer children, if it is possible to extend the average lifespan and increase the healthy lifespan (meaning the period of both mental and physical health, taking into account the quality of daily activities and health) through progress in science and technology, then it is possible to realize a society in which people can live long and productive lives. There is also a growing percentage of people who feel that “since there is already a certain level of material wealth, there should from now on be an emphasis on a life of spiritual wealth and ease.” With a longer healthy lifespan and a decrease in annual labor hours, peoples’ total disposable time (time which can be used freely) is expected to continue to grow, increasing the opportunities to achieve a sense of spiritual wealth through intellectual and creative activities outside of work. Over 80% of people feel that the progress of science and technology in the future should contribute not only to material wealth, but also to achieving spiritual wealth. Therefore, it is necessary for science and technology to contribute to spiritual wealth in the future (Figure 1-2-39, -40, Table 41).

The things that create a sense of spiritual wealth differ depending on the individual, but it is no exaggeration to say that cultural arts and crafts, sports, and intellectual curiosity are important. Contributing to the realization of a “spiritually wealthy society” that enables appreciation of cultural arts and crafts, participation in/viewing sports and intellectual stimulation is one of the roles demanded of science and technology.

The following section discusses science and technology for the purpose of helping people enjoy a new appreciation of life and spiritual wealth includeng the following:

- Science and technology contributing to the preservation and use of cultural heritage and creation of arts and crafts
- Sports and technology contributing to sports activities
- Science and technology developing intellectual value to satisfy intellectual curiosity

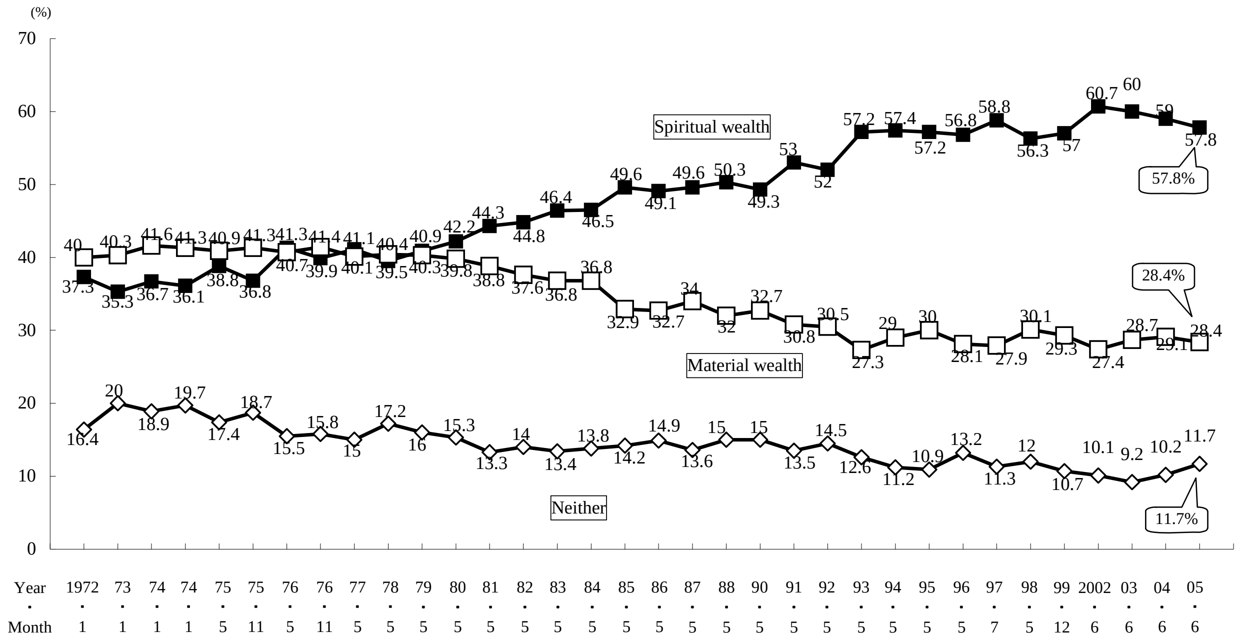



**Figure 1-2-39 Trends in the wealth demanded by people**

Note: Spiritual wealth → "Since there is already a certain level of material wealth, from now on there should be an emphasis on a life of spiritual wealth and ease"
Material wealth → "Still should be emphasis on material wealth in daily life"
Source: Cabinet Office "Public Opinion Poll on Citizens' Lives" (2005)

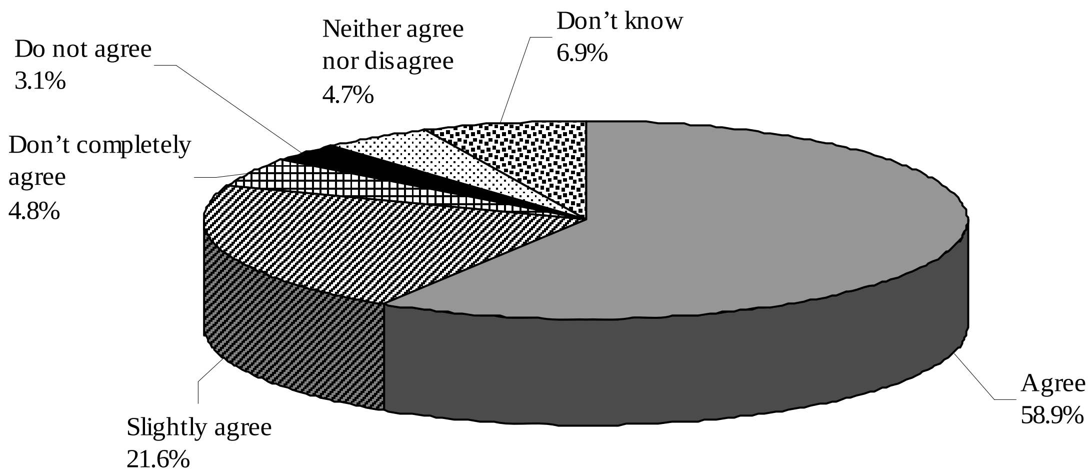



**Figure 1-2-40 Science and technology development should focus on spiritual wealth**

Note: Responses to the statement "The progress of science and technology in the future should not only be for material wealth, but also directed at achieving spiritual wealth"
Source: Cabinet Office "Public Opinion Poll on Science & Technology and Society" (2004)

**Table 1-2-41 Increase in total disposable time**

| | 2002 | 2030 | Remarks |
|---|---|---|---|
| Worker lifetime disposable hours | 183,000 hours<br>(20.9 years) | 205,400 hours<br>(23.4 years) | ● Longer healthy life<br>● Work hours between ages of 61-65 similar to part-time jobs (1,184 hours)<br>● 2 years at school, such as graduate school |

Notes: 1. Values in parentheses are calculated by dividing total disposable hours by [24 (hours) x 365 (days)]
2. Assuming the number of annual labor hours in 2030 (2002: 1,954 hours) continues to shift toward the 2002 levels in the west (1,726 hours), the total will be 213,600 hours (24.4 years), an increase of about 17% from the current level.
Source: Council on Economic and Fiscal Policy's survey report on "Japan's 21st Century Vision" (2005)

## 1.2.3.2 Science and Technology to Contribute to Preservation/Utilization of Cultural Heritage and Creation of Arts

### ●Science and technology contributions to preservation and restoration of tangible cultural heritage

For the preservation and restoration of tangible cultural heritage, preservation and restoration techniques are being developed using the latest science and technology.

For example, inlaid pommels from the Tumulus period (knob on a sword hilt) become corroded while buried in the ground and covered with a thick layer of rust, making it impossible to directly see the inlays. A method to remove the rust only from the surface using a hydrogen plasma technique has been developed, making it possible to see the patterns in the inlaid relics (Figure 1-2-42).

**When excavated**

**After restoration**

**Figure 1-2-42 Pommel inlaid relics**

Source: Ministry of Education, Culture, Sports, Science and Technology, Council for Science and Technology, Resource Survey Subcommittee report "Promotion of Science and Technology to Support the Preservation, Use and Creation of Cultural Resources" (2004)

The establishment of preservation and restoration technology for inlaid relics using plasma, is not only for delicate preservation and restoration; it also has an important role in clarifying history. In this way science and technology development plays an important role in supporting the maintenance of their value as cultural relics.

### ●Science and technology contributions to preservation and restoration of intangible cultural heritage

Science and technology makes a large contrib. ution to the preservation and passing down of skills that have historical and artistic value, such as the movements of the human body, as in the traditional techniques of pottery artists, etc.

For the preservation and transfer of the skills of intangible cultural assets, where the value is the act-ion itself, text and diagrams in written documents are not adequate. Recent advancements in 3-D imaging technology have made it possible to make detailed recordings of movements. Specifically, a special camera with two lenses records the hand movements of an artist in 3D video, the movements of the artist's arms and hands are measured using motion capture technologies with magnetic sensors and data gloves, and a database is created. The movements of the artist are regenerated from the database using computer graphics, making it possible to observe even the motions that are ordinarily hid den from view. This kind of technique is valuable as an effective means of recording and preserving intangible cultural assets (Figure 1-2-43).

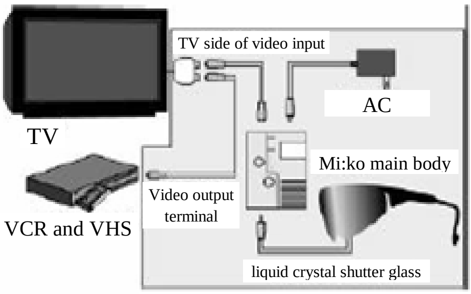


Image 1: 3D stereoscopic viewing system

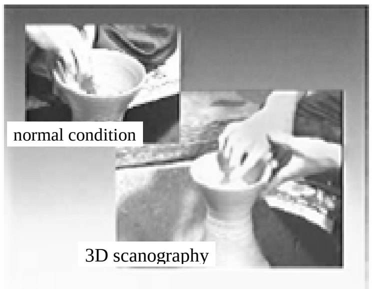


Image 2: 3D video example


Image 3: Motion capture


Image 4: Data gloves

**Figure 1-2-43 3D stereoscopic viewing system and images, motion capture, and data gloves**

Source: Ministry of Education, Culture, Sports, Science and Technology, Council for Science and Technology, Resource Survey Subcommittee report "Promotion of Science and Technology to Support the Preservation, Use and Creation of Cultural Resources" (2004)

### ●Cultural heritage on-line

The Agency for Cultural Affairs and the Ministry of Internal Affairs and Communications are working on the "Cultural Heritage On-line Concept" to actively disseminate information on tangible and intangible cultural heritage of local regions and the nation using broadband technology. Under this plan it will become possible for citizens to easily obtain information on cultural heritage and traditional arts even on a distance basis. Digital archive technology is expected to make a large contribution to the preservation, spread and use of cultural assets and recording of relics (Figure 1-2-44).

Trial posting of Cultural Heritage Online
(top page image) http://bunka.nii.ac.jp

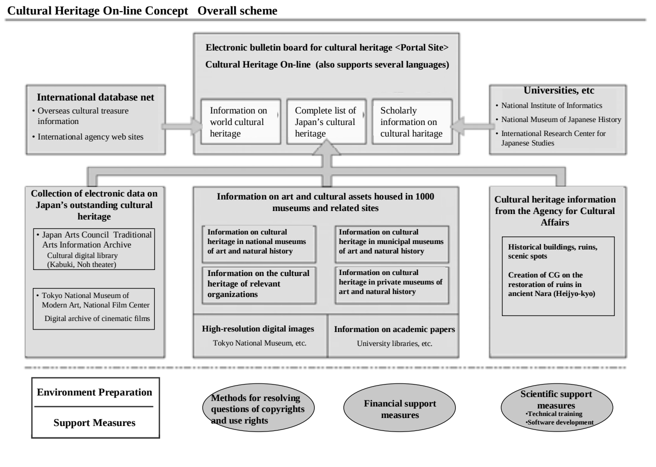



**Figure 1-2-44 Concept of cultural heritage online**

Source: Agency for Cultural Affairs "Culture Policy in Japan" (2005)

[Column 14]

## Restored Scroll Paintings of the Tale of Genji

Scroll paintings of a national treasure, the "Tale of Genji," painted in the 12th century are the oldest existing scroll paintings in Japan.

In 1999, a project to analyze and restore the scroll paintings was started by a team of specialists from different fields, i.e. scientists, researchers on art history, and painters. The background to this project's materialization was the improvement in analyzers.

Conventionally, research and analysis of cultural properties are conducted by taking the work of art to a research institute where an analyzer exists. However, moving a national treasure is difficult from the viewpoint of its conservation. Many of the treasures are not movable, such as buildings and big statues of the Buddha, resulting in the irony that the more important a cultural property is, the more difficult it is to research it. Therefore the National Research Institute for Cultural Properties, Tokyo, started to develop a portable fluorescent X-ray analyzer. The apparatus was completed in 1999, and the first work analyzed was the scroll paintings of the Tale of Genji. There are three purposes for material examination of cultural properties, which are: 1) to use the same material for repair by determining the original material used, 2) to create a suitable environment (including temperature and humidity) for conservation through knowledge of the material, and 3) to contribute to judging the value of the work by knowing the work's technical level.

For the analysis to determine the pigments used in the scroll paintings of the Tale of Genji, a portable fluorescent X-ray analyzer was used for inorganic pigments, and fluorescent photography for organic pigments, and many facts were discovered. One of them is the design of the kimono the woman in Photo 1 is wearing. The design painted by organic pigment had become invisible to the naked eye due to the color fading (Photo 2), but fluorescent photography, which can detect small amounts of remaining pigment in the fibers, clearly showed the design.

By fluorescent X-ray analysis, various types of used pigment were clarified. Taking the white pigment used for faces, for example, it was newly discovered that white pigment containing hydrargyrum had been used in addition to three kinds of conventionally known white pigments. It was the first time to discover that what was used as face powder was also used in traditional Japanese paintings. The painting of the scroll paintings of the Tale of Genji, consisting of 54 volumes, is said to have been divided between some groups, and the discoveries made may provide new information to examine and research art history. By this project, reproductions were painted by Japanese-style painters by analytically determining the pigments and organic dyes to assume the color at the time it was painted and using the same pigments for the reproductions.

The scroll paintings of the Tale of Genji, whose originals had given the image of faded color, were restored and revived in front of us in the 21st century to the state they originally were in the Heian period thanks to the achievement of analyzing technology.

### ●Science and technology contributing to the creation, transmission and use of arts and crafts culture

Japan has seen remarkable progress in IT/telecommunications technology, with the now widespread use in computers and broadband connections. This is now an era in which anybody can view the information they want at almost any time. Amidst these developments a new field of art has been created, known as media art, which includes movies, animation, CG (Computer Graphic) art and game software that use the multifunctionality and flexibility pro- vided by the latest digital technology.

In eras when walls and stone were expressive media, ink and paint were actively utilized. In the era of papyrus and paper, paper production technology progressed, and information sharing became common through the discovery of printing technology. With the advances in engineering and precision machinery technology and the appearance of the camera, photographs and movies became a new source of creativity. Subsequently, developpments in electronics technology leading to radio and television further advanced the popularization of media. The appearance of computers and the Internet, has now led to an era in which anyone can view any work they desire at anytime. In the future, it will be easy to not only view, but also to create and release works, through a two-way connection with media and a rapid expansion in the diversity of expression methods. As a result, it will be easier for the public to participate in art creation. The development of digital science and technology has led to an era in which ordinary people can release ideas and content that utilize their own creativity (Figure 1-2-45).

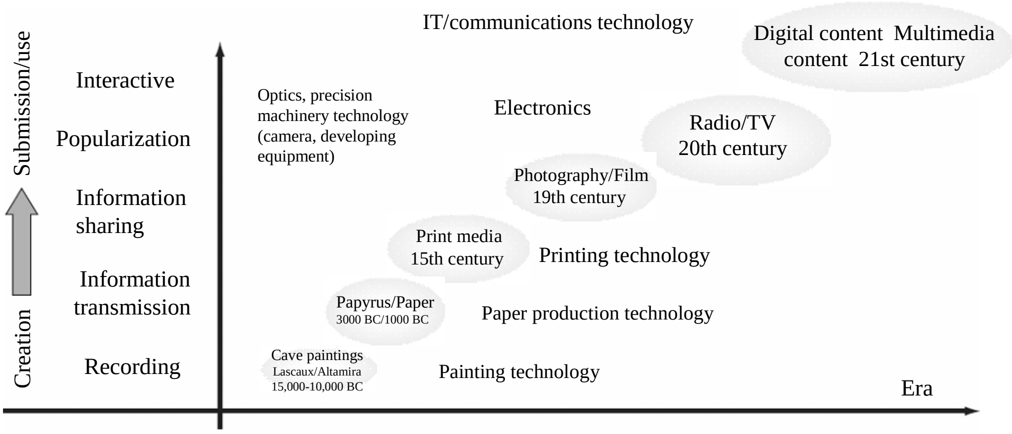



**Figure 1-2-45 Art culture development history through media**

Source: Ministry of Education, Culture, Sports, Science and Technology, Council for Science and Technology, Resource Survey Subcommittee report “Promotion of Science and Technology to Support the Preservation, Use and Creation of Cultural Resources” (2004)

Currently research and development is steadily progressing on a variety of expression methods, toward achieving an era in which anyone can create and transmit content. Japan leads the world in research and development on diverse expression methods, producing 2/3 of the new technology programs announced at SIGGRAPH (special interest group on graphics of the US Association of Computing Machinery), the leading computer graphics international conference in the world.

In addition, a variety of devices have been developed for use throughout the many processes involveed right from the creation of digital images to their presentation and display. These devices have been released on the market, but if these are combined at random a good quality image might not be reproduced properly, and the image intended by the creator may not be presented correctly. Therefore research and development has progressed on the establishment of standards to ensure the quality of original digital images in their final presentation (Figure 1-2-46).

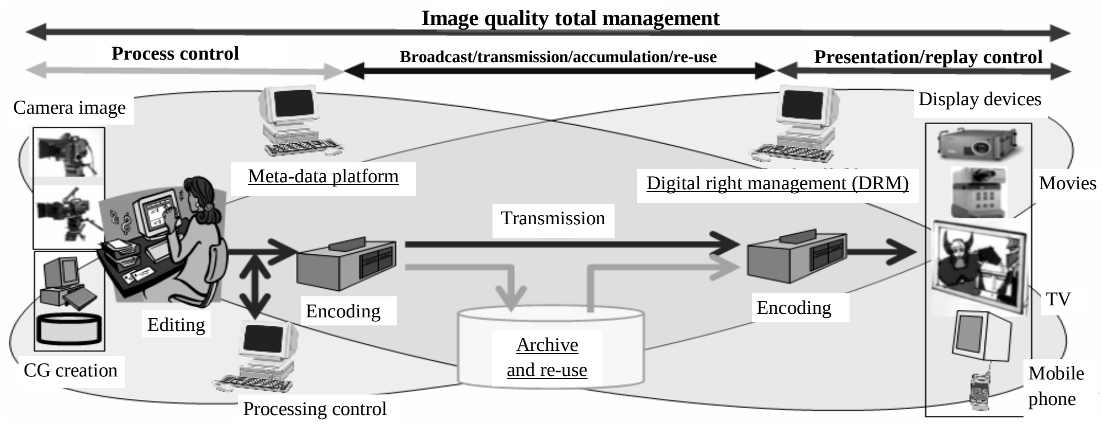
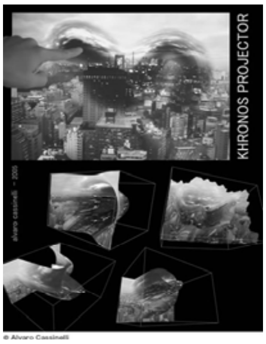



**Figure 1-2-46 Research on digital cinema standards technology**

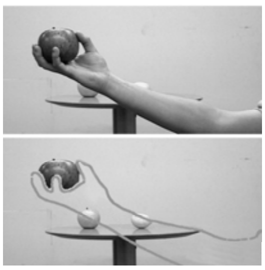
Source: Ministry of Education, Culture, Sports, Science and Technology "Research on Digital Cinema Standard Technology Standards" Project

At the FY2005 Media Arts Festival, a symposium on the fusion of art and technology was held, and the latest technologies were introduced (leading edge technology showcase), drawing a high level of interest (Figure 1-2-47).

Symposium
"Fusion of art and technology" -It's future




FY2005 Media Arts Festival, Agency for Cultural Affairs
Grand prize winner in the art division
[Title] Khronos Projector
[Summary of work] When the observer touches the screen the time for the video in the portion of the screen that is deformed can be changed to move forward or backward. The image changes in realtime based on the observer's actions, providing a sense of ability to freely control time.
[Artist] Alvaro CASSINELLI (Uruguay)
Source: Agency for Cultural Affairs



From the "Cutting-edge technology showcase" providing future art expression from the technology perspective
[Title] Invisible Man / Mosaic Man <Thermokey>
[Summary of work] The color and temperature of the person are precisely measured and a image is created with the human portion extracted. The research for this technology was done as a basic technology for making movies, eliminating the need for the blue screen as in the past. With the ability to automatically create images in real time for any background this is a technology that can applied in a variety of ways, including interactive entertainment, or protection of privacy by automatically applying a mosaic to the images of people
Source: Japan Science and Technology Agency Basic Research Programs "Foundation of technology supporting the creation of digital media contents"

**Figure 1-2-47 FY2005 Media Arts Festival, Agency for Cultural Affairs**

[Column 15]

### Science and Technology Reflected in the Skills of an Artisan's "Man-nen Dokei" (perpetual chronometer)

Hisashige Tanaka, an engineer at the end of the Edo period, known by the nickname "Karakuri-Giemon (The Gadget Wizard Giemon)" made an historic perpetual chronometer, the so-called "Man-nen dokei" (this literally means a clock that works for tens of thousands of years), which is the best work in traditional Japanese clocks, in 1851 as the summation of his skills. With the temporal hour system of the Edo period based on sunrise and sunset, both day and night were divided into six equal parts, and each basic unit of time was called a "koku," so that the length of a "koku" differed between day and night, as well as changing from season to season. A conventional old Japanese clock required replacement of the panel depending on the season. However, this Man-nen dokei was epoch-making in that just by winding a spring once a year it could automatically move the pieces showing the clock times corresponding to the season, and it could be used all year round.

The Man-nen dokei is crowned with a celestial globe that shows the positions of the sun and the moon, and beneath are six multifunctional clock faces: 1) a traditional Japanese clock with Japanese figures to show clock time, 2) a clock plate with 24 seasonal datum points, 3) a display of the seven days of the week and number of sounds to tell the time, 4) a display of dates by sexagenary cycle, 5) a display of the age of the moon, and 6) a Western clock. With energetic challenging spirit, Hisashige Tanaka tried to automatically display for one year, by using a spring mechanism, all the information concerning "time" and "calendars" that the people of Edo period needed by utilizing new knowledge and technology that came from Western countries at the end of the Edo period. The Man-nen dokei not only has originality and the idea of a mechanism where the entire system works in conjunction, but also beautiful decorations of Japan, mother-of-pearl, and metal carving, making it exemplary of the fruits of the skills of an artisan

With the Man-nen dokei, pieces to show the time automatically move, coping with the temporal hour system of the Edo period, and change the length of clock time.

What enabled the realization of this was an insect-shaped gear. The gear is very much different from an ordinary gear, and the angles and intervals of the eight gear teeth are different. To know how the insect-shaped gear operates, a gear that satisfies the target operation of day and night was designed and produced by using knowledge of modern astronomy, and a gear copying the insect-shaped gear of the Man-nen dokei was made, followed by an experiment conducted to compare these. As a result, concerning the operation of the insect-shaped gear, it was verified that the difference from the target operation is small, although there is a small time lag when reversing and the revolution of the gear is smooth.

It is amazing that the artisan, Hisashige Tanaka, understood advanced astronomy and realized almost every feature of the Man-nen dokei by manual work, and it shows the excellence of his knowledge and skill.

The Man-nen dokei did not just introduce and use the advanced knowledge and technology of Western countries, but was made to fit in with the lives and culture of the Japanese people. The technology of the Man-nen dokei, which displays the difference in seasons and time in accordance with the natural lapse of time, questions us who live in modern times, in particular, about the desired relationship between spiritual wealthy and science and technology.

### ●Sports to provide "spiritual wealth"

Sports are not simply a spectator form of entertainment, but also offer a great deal of enjoyment to those who participate. Participation in sports not only improves health and physical condition through physical exercise, but also contributes to "spiritual wealth" through the sense of pleasure and mental enjoyment, including feelings of exhilaration, accomplishment and connection. Science and technology makes a large contribution to the analysis of the basic principles of sports in order to imp- rove records, as well as to the advancement of related equipment and materials. As science and technology advance, the materials in the equipment change, and more people can enjoy participation in sports.

[Column 16]

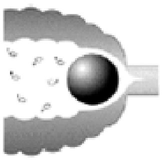
## Science of a golf ball with a long carry

Why is the carry of a ball with a rough surface longer than one with a smooth surface? The reason is dimples, the roughness. There are two secrets to this.

[Dimples cause lift]

When a ball is hit and rolls with the face up (back spin), the air current above the ball is faster than that below the ball and it causes a difference in air pressure which creates lift. If the ball has dimples, the air becomes susceptible and the difference in the speed of the air currents above the ball and below the ball becomes bigger and the lifting power becomes higher. As a result, the ball does not fall easily and the carry becomes longer.

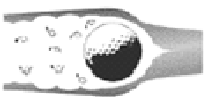
Bigger pocket of air in the wake that drags the ball



Direction of fluid flow

**Smooth ball**

Smaller pocket of air in the wake that drags the ball = long



Direction of fluid flow

**Ball with dimples**

Source: Information of Descente, Ltd.

[Dimples decrease air resistance]

The air current around the ball flows to the back of the ball and makes a pocket of the air that moves drawn by the ball. It becomes power to draw the ball back (air resistance) and make the carry shorter. If the ball has dimples, the air current hugs the ball closely and the air pocket becomes smaller. As a result, air resistance becomes smaller and the carry becomes longer.

This phenomenon is used for other sports. Nowadays, swimming suits or ski suits with rough surfaces are used all over the world. It is one of the achievements of science and technology.

### 1.2.3.3 Science and Technology Creating Intellectual Value and Providing Answers to Intellectual Curiosity

The new understanding and discovery arising from the investigation of the human frontiers of space, the earth and life contribute to the shared intellectual assets of mankind and provide answers to the intellectual curiosity of people throughout the world who desire to know the truth.

There is no end to mankind's quest for knowledge. The range of activities of humans and the objects of curiosity cover a range that is not seen in other animals. Human curiosity and activity is not limited to things on land; the range of activity has expanded to the ocean, the air and even space. The driving force has been mankind's ceaseless quest for further knowledge.

**●Unraveling the mysteries of space with *Hayabusa***

The purpose of Hayabusa is to obtain samples from asteroids to investigate the mysteries of the origins of the solar system. Hayabusa is a crystallization of mankind's quest for knowledge in space.

*Hayabusa*, the asteroid explorer launched in 2003, landed on the asteroid Itokawa in November 2005, approximately 300 million kilometers from earth. An asteroid is a body in space that is like a fossil containing a relatively good record of the time when the planets were born. If the technology to bring back the samples obtained from the asteroid can be realized, this is expected to provide clues about conditions inside the solar nebula at the time the planets were born (Figure 1-2-48).

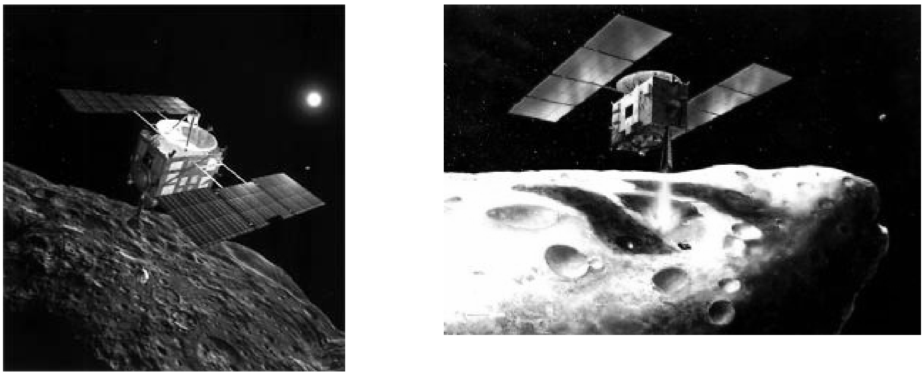


**Figure 1-2-48 Asteroid explorer *Hayabusa***

Source: Japan Aerospace Exploration Agency

### ●Deep Sea Drilling Vessel *Chikyu*

What is the inside of the earth like? To fulfill the boundless curiosity of mankind, Japan has developped the deep-sea drilling vessel *Chikyu*. Since major earthquakes occur at plate boundaries, it is necessary to investigate the structure of the plate boundaries in order to learn the mechanism of earthquakes. *Chikyu* is expected to reach the mantle of the earth and be able to investigate the massive earthquake zones in the ocean trenches.

Chikyu is also being used to track down the origins of life on earth. The first life was born on primeval earth which was characterized by high temperatures, high atmospheric pressure and no oxygen. Even today, deep in the earth there exists an environment that resembles that of primeval earth. In addition, earthquake measurement equipment will be buried in the holes dug by *Chikyu* to help build an earthquake measurement network system to quickly relay information at the moment an earthquake occurs. This is expected to make a large contribution to future earthquake prediction and disaster preparedness in urban areas (Figure 1-2-49, Figure 1-2-50).

**Figure 1-2-49 *Chikyu***

Source: Japan Agency for Marine-Earth Science and Technology

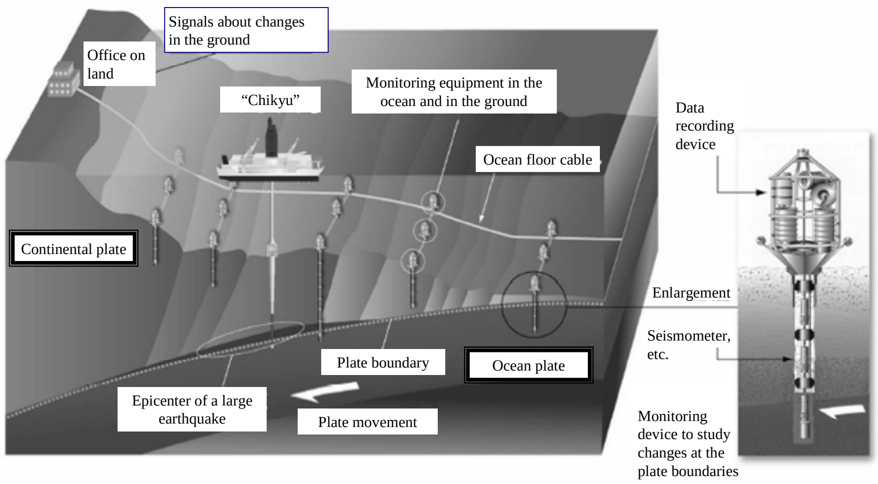



**Figure 1-2-50 *Chikyu* and plate boundaries**

Source: Japan Agency for Marine-Earth Science and Technology