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ON
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1993

The Relationship between Young People and Science and Technology

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Forward

Science and technology have played a major role in history as a driving force for social and economic development. From now onward, science and technology is expected to play an ever-increasing role in finding solutions to a variety of problems we continuously face; an increasingly grave situation of the global environment, and problems specific to Japan such as the aging population and declining birth rate. However, it has been noted that young people are losing their interest in science and technology.

Our society depends on advanced science and technology. In order to properly manage such a society, numerous excellent scientists and engineers are required. Furthermore, it is also desired that we, the people that make up this society, should have a basic ability to discuss intelligently the matters related to science and technology.

When seen from this perspective, the so-called phenomenon of declining popularity of science and technology among young people is an extremely grave concern to us.

This year's white paper adopting the relationship between young people and science and technology as its main theme, analyzes the declining popularity of science and technology among young people, the dangers of its consequence, its background, and other matters.

It is hoped that this white paper have provided material for a wide range of discussions concerning the relationship between young people and science and technology and that discussions will be deepened in the public concerning ways to deal with this issue.

December, 1993

Satsuki Eda
Minister of State for
Science and Technology

Part 1
The Relationship between Young People and Science and Technology

Introduction

The role played by science and technology on the social and economic development of Japan until the present has been very great. At the time of the establishment of the Meiji Government, as development and diffusion of science and technology were promoting rapid modernization in Europe and America through the Industrial Revolution, Japan was clearly lagging behind in the area of science and technology. In response to this, the Meiji Government introduced the advanced science and technology from Europe and America, trying from an early stage to raise the level of science and technology by sending students abroad to study, inviting scientists and engineers from Europe and America, and preparing organizations of higher education in the fields of science and engineering. In the post-war period, the promotion of science and technology was encouraged for economic development and the solution of various social problems and the building the economic power and affluent lifestyle enjoyed by Japanese today.

In the background of the previously mentioned development of Japan, it can be said that there were expectations regarding science and technology among the Japanese people as a means of closing the gap existing between Japan and the advanced nations of Europe and America through the efforts of the scientists and engineers whose training had been encouraged ever since the Meiji Era and by raising of level in science and technology.

Today, Japan has a very affluent lifestyle in the material sense as a result of the efforts in the past, and the level of science and technology in Japan has made Japan a world leader in many fields in the private industrial sector. However, viewed from an global perspective, we can see that people on earth are confronted with many global problems such as world environmental problems that threaten the very existence of mankind. On a domestic perspective, Japan is being forced to solve new problems, such as the rapidly aging society, declining birthrate, and a decreased in the number of the workforce.

It will be difficult to come to terms with many of these domestic and international problems confronting Japan without further developments in science and technology. To enjoy a peaceful and affluent lifestyle in future, it is indispensable that we strive to further encourage the development of science and technology and use the results of this development to overcome the new problems facing the nation.

On the other hand, looking at the current social situation in Japan, we can see a decrease in the percentage of young people showing an interest in news and topics centering around science and technology, and the declining popularity of science and technology among young people has become a topic of discussion.

Until recently, the interest of Japanese young people in science and technology was high, and this tendency was considered to be only natural. The large number of young people showing an interest in science and technology is the main reason why Japan has been blessed with such a large number of human resources for science and technology with dreams and passions related to the field of science and technology. Also it is the reason why the Japanese people as a whole have been able to so appropriately apply the results of science and technology to practical problems.

However, the interest of young people in science and technology, which until recently had been considered to be only natural, is beginning to wane, and with this transition, it is likely that problems will develop related to the future of Japan in such forms as a lack of human resources for science and technology or a decrease in the overall national interest regarding this area.

Especially, problems related to securing human resources for science and technology in future, are being dealt with as important policies by the government and by General Guideline for Science and Technology Policy (approved by the cabinet of the Government of Japan on April 24, 1992). In addition, on December 2, 1992, to establish a basic policy in relation to securing human resources for science and technology, a Council for Science and Technology was consulted inquiry No.20 "Comprehensive Basic Policy for Securing Scientific and Technological Personnel".

Part one of this White Paper will focus on the phenomenon known as the "declining popularity of science and technology", and will investigate its problem and the background surrounding it. This will also provide the Council for Science and Technology material for discussion, and it will be used as an opportunity to deepen the discussion in Japanese society as the topics that should be addressed by persons in the field of science and technology and by the Japanese as a whole.

1.1 Trends in the Declining Popularity of Science and Technology among Young People

Recently, a tendency of reduction in the interest among young people in regard to science and technology by the younger generation, and concern has held among those in related fields towards this phenomenon as the "declining popularity of science and technology among young people", especially from the viewpoint of securing human resources for science and technology in the future. In Science and Technology Agency survey commissioned in May 1993 surveying 1,457 researchers (1,001 respondents) from the industry, academia and government entitled "Survey on High Tech Researchers and Engineers" 71.3% of the researchers said that they felt the phenomenon of the declining popularity of science and technology among young people.

In this chapter, in addition to an analysis of signs and characteristics of the phenomenon known as the "declining popularity of science and technology among young people", future concerns are also investigated.

1.1.1 Signs of the Declining Popularity of Science and Technology among Young People

1.1.1.1 Trends in the Youth's Interest in News and Topics Related to Science and Technology

Let's take a look at the trends in the interests of the young concerning science and technology related news and topics from the standpoint of such surveys as the "Survey on Science & Technology and Society" implemented by the Prime Minister's Office and "The International Comparative Research on Public Understanding of Science and Technology" Science and Technology Agency, implemented by the Science and Technology Policy.

In 1981, the percent of those in their 20s which showed an interest in news and topics related to science and technology was relatively high among adults, but by 1987 a decrease could already be seen. Results showed a large decrease from 55.3% in 1981 to 41.3% in 1991, and those in their 20s become the least interested among the adults regarding these topics in both 1990 and 1991 (Figure 1-1-1).

Though a deviation can be seen in the percent of people who show an interest in science and technology among 30s, 40s and 50s age groups a gradual increase, as a general tendency, can be seen since the early 1980s (Figure 1-1-1).

In regard to the change in the degree of interest showed towards science and technology for the group in their teens, not enough data could be obtained during in these surveys. However, the data obtained that showed that a decrease in the percent of the readership of a certain scientific magazine of this age group (primarily those in the older half of this age group) has been decreasing ever since the early 1980s.

In addition, similar data was obtained from a different science magazine, making it possible to estimate that members of this group showing an interest in science and technology has also decreased in the same way as in the 20s age group (Figure 1-1-2).

As mentioned previously, there is a recent overall transition towards a gradual rise in the interest showed by members of age groups above 30 years of age concerning news and topics related to science and technology, while at the same time a decrease in interest can be seen only in the group in their 20s. This suggests that the tendency towards a declining popularity of science and technology is a phenomenon that can only be seen in the young members of the adult group.

1.1.1.2 Trends in Choices of Higher Education and Employment among Young People

1.1.1.2.1 Trends in the Applications to University Faculties

To grasp the trends in course selection of recent university applicants, the transition in the percentage of university applicants to going into various academic departments such as engineering, science, science and engineering, law, economics, management and commerce were calculated based on the "Choice of University Applicants among Fields of Study" survey of the National Institute of Science and Technology Policy of the Science and Technology Agency and the "Report on School Basic Survey" of the Ministry of Education (Figure 1-1-3).

According to these calculations, there was an increase in the percentage of applicants entering the engineering development that coincided with the process of recovery in the manufacturing industries from the economic recessions caused in Japan by the two consecutive oil crises that occurred during the 1970s. After this, however, despite the fact that the Japanese economy continued to flourish, and there was a transition to a high level of demand for science and technology personnel among the manufacturers, in the latter half of the 1980s, the number of applicants entering the engineering department began to show a decrease. This tendency was especially evident in the period from 1988 to 1990, and after which the speed of the decrease in the percentage of applicants gradually slowed, and continued until 1992. In addition the percentage of applicants entering the science department has also decreased continuously ever since 1988, along with applicants going into the science and engineering departments which have shown a decline ever since 1987 after a trend towards increase that lasted up until 1985. In contrast, it was noticed that the percentage of applicants going into the economic department has increased sharply during 1987-1990 period.

The above-mentioned circumstances seems to suggest that there is a tendency towards the declining popularity of science and technology among the Young People.

1.1.1.2.2 Trends in Employment of Students Majoring in Science and Engineering

To understand the recent trends regarding the entry of science and engineering students into

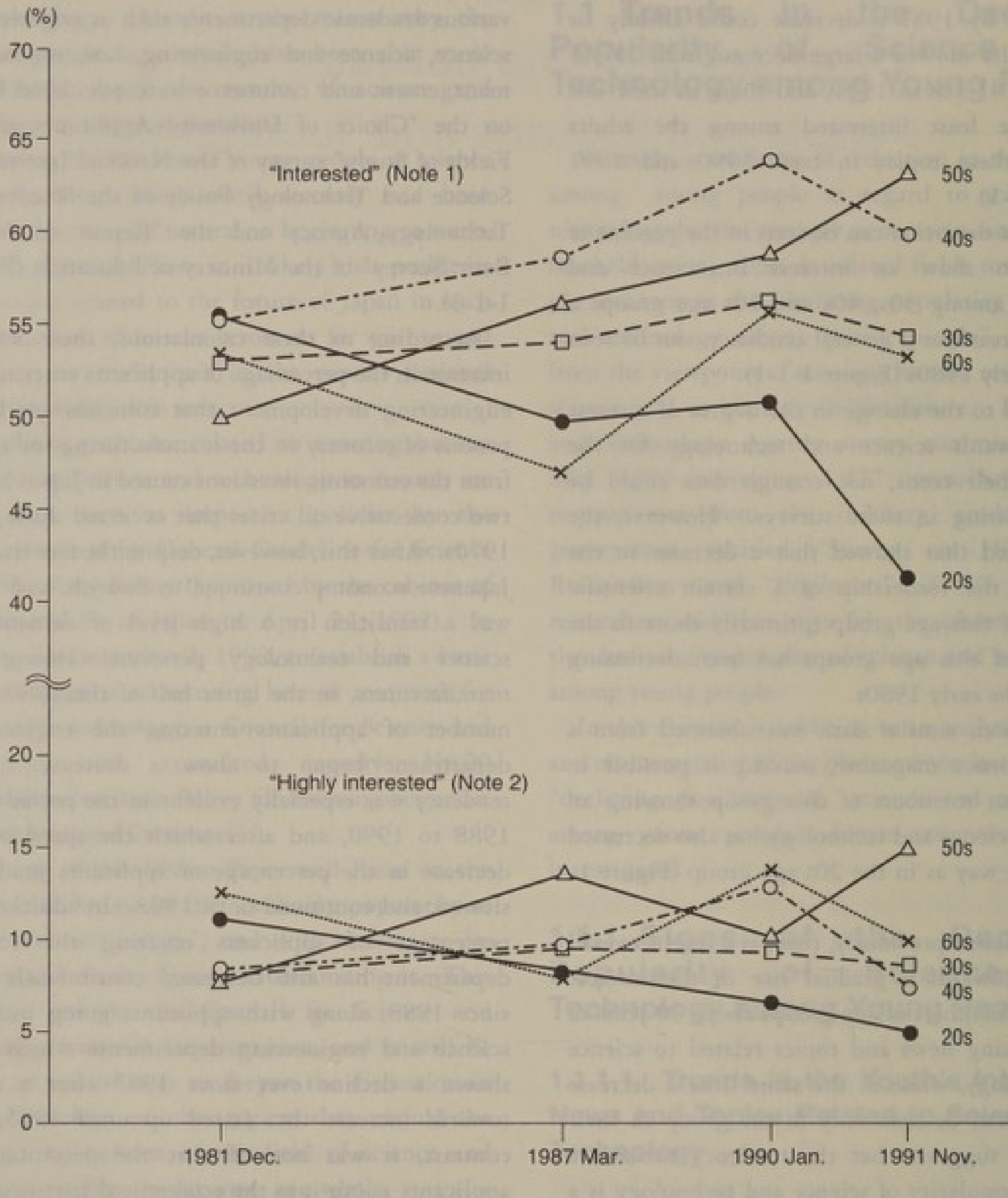


Figure 1-1-1 Changing interest in news and topics relating to science and technology

Notes: 1. This figure represents the percentage of people who replied "highly interested" or "somewhat interested" in response to the question, "Are you interested or uninterested in news and topics relating to science and technology?" .

2. This figure represents the percentage of people who replied "highly interested" in response to the above question.

Sources: Science and Technology Agency, National Institute of Science and Technology Policy, "The International Comparative Research on Public Understanding of Science and Technology(FY1991)". Prime Minister's Office, "Survey on Science & Technology and Society" .

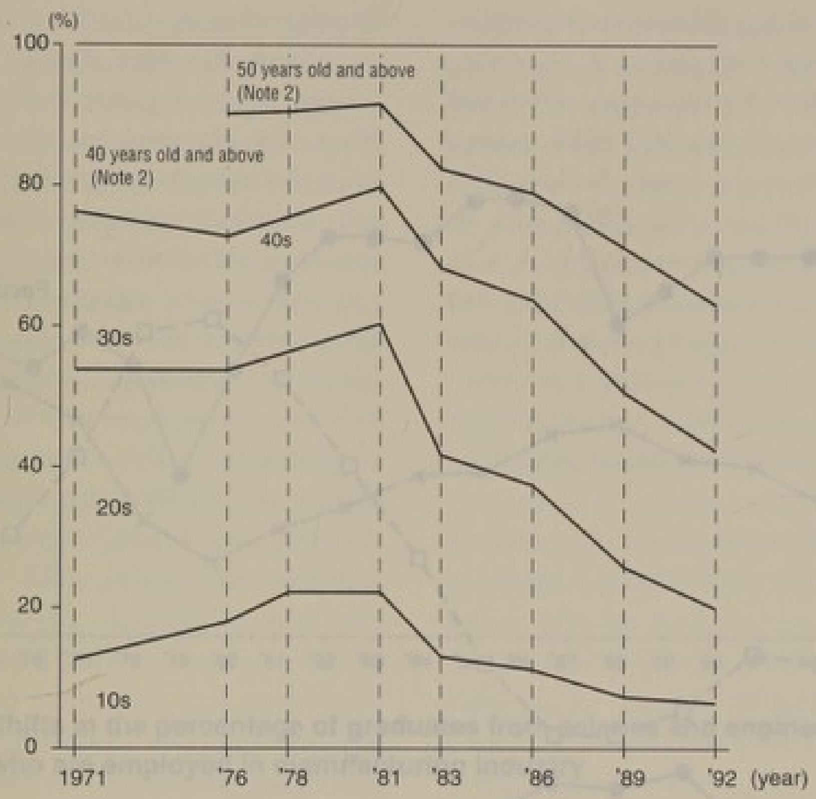


Figure 1-1-2 Examples of the shift in science magazine readership by age group

Notes: 1. An example of one particular science magazine.
2. From 1976-1986, the group in their teens including the 20years old, the 20s group was actually 21-30, the 30s group was 31-40, the 40s group was 41-50, and the 50 and above group was 51 and above.
3. The percentage of readers that is unclear is 4.1% in 1971, 0.3% in 1983, 0.8% in 1986, 1.5% in 1989, and 1.7% in 1992.

Source: Science and Technology Agency investigation (FY 1993).

manufacturing industries, let's take a look at the transition in the percentage of new university graduates and graduate degree holders seeking employment with manufacturers from "Employment Trends of Science and Engineering Graduates" compiled by the National Institute of Science and Technology Policy of the Science and Technology Agency, and "Report on School Basic Survey" compiled by the Ministry of Education (Figure 1-1-4). According to these reports, the percent of science and engineering students entering manufacturing industries dropped drastically during the 1987-1988 period. This phenomenon received attention as a sign of the "declining popularity of the manufacturing industries for science and engineering students". Following this period, this ratio showed a slight signs of recovery up until 1990, due to the expansion of employment in manufacturing industries that accompanied the favorable economic conditions of the 1980s, however, after hitting its peak in the 1990-1991 period, up until 1992, it could not come up to a ratio reached in 1987.

Looking at the transition of the percentage of new science and engineering university graduates and graduate degree holders amongst the total

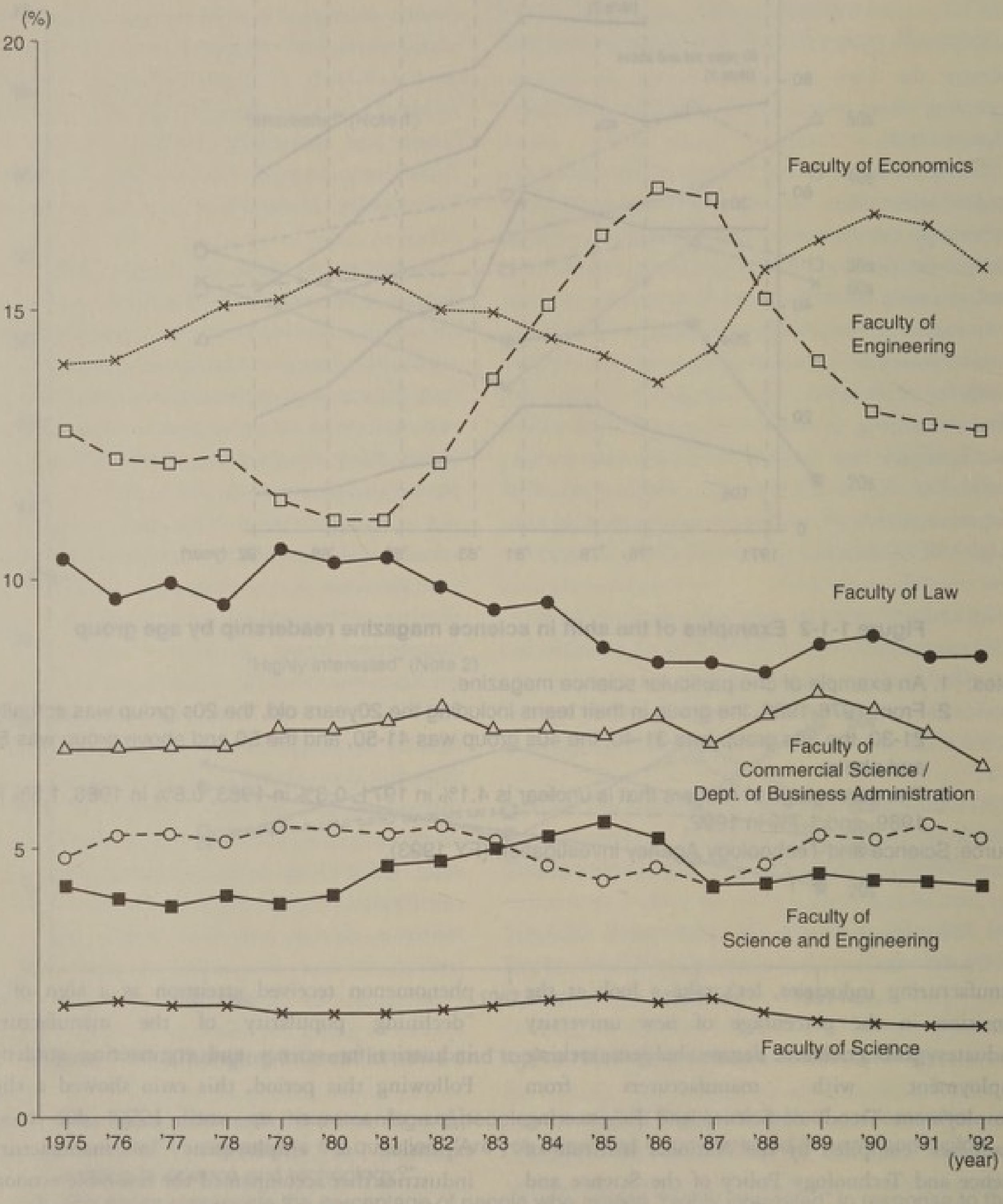


Figure 1-1-3 Shift in the percentage of university applicants to selected faculties

Sources: Science and Technology Agency, National Institute of Science and Technology Policy, "Choice of University Applicants among Field of Study(FY1990)".
Ministry of Education, "Report on School Basic Survey".

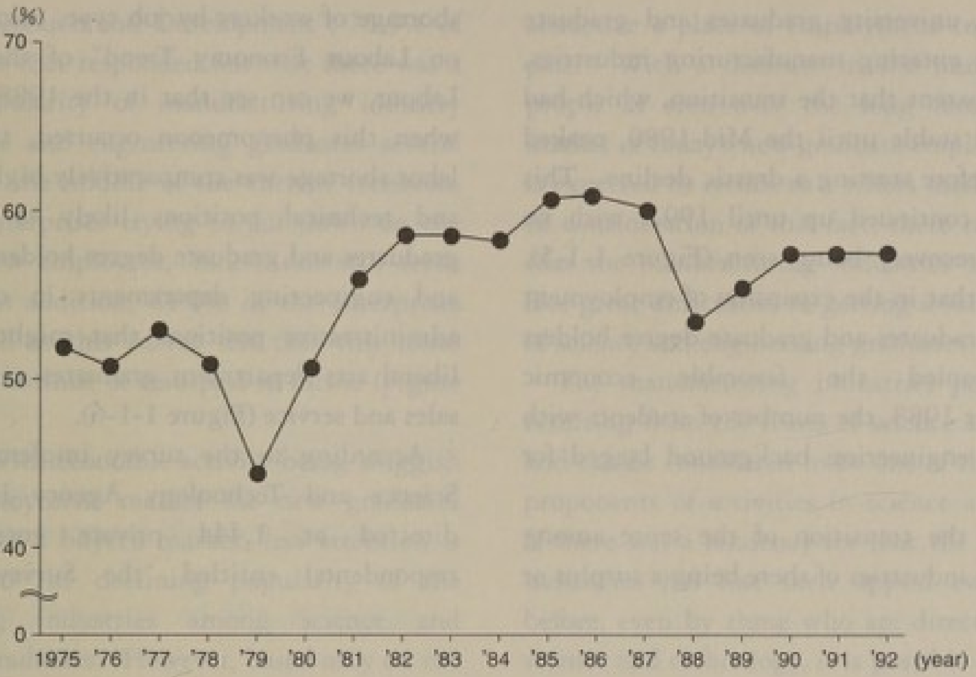


Figure 1-1-4 Shifts in the percentage of graduates from science and engineering faculties who are employed in manufacturing industry

Sources: Science and Technology Agency, National Institute of Science and Technology Policy, "Employment Trends of Science and Engineering Graduates (FY1989)".
Ministry of Education, "Report on School Basic Survey".

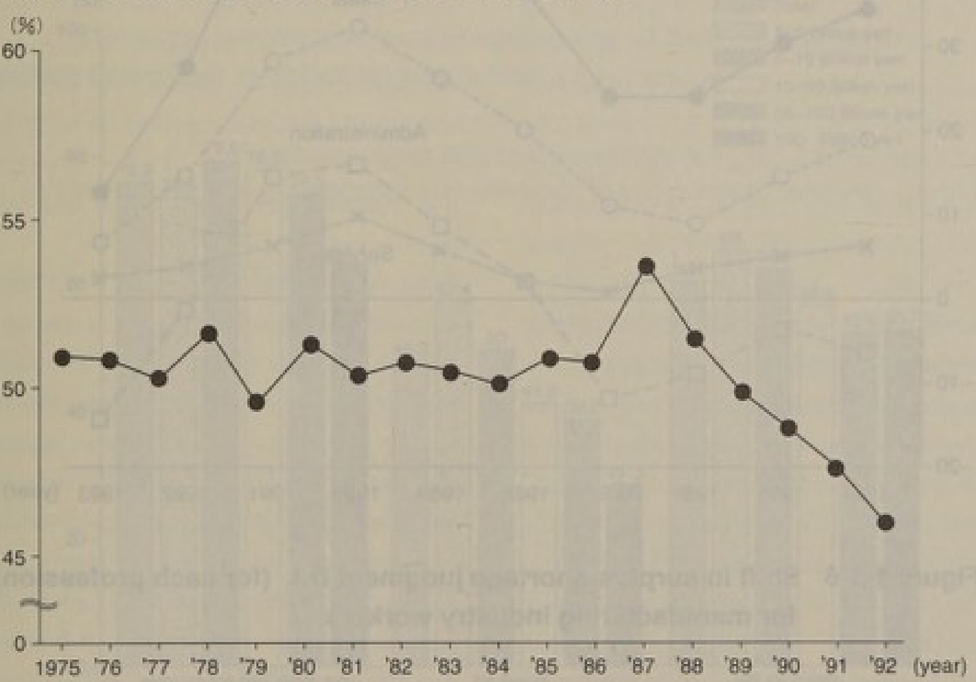


Figure 1-1-5 Shift in the percentage of science and engineering department graduates and graduate degree holders in total number of graduate and graduate degree holders entering companies in the manufacturing industry

Source: Ministry of Education, "Report on School Basic Survey".

group of new university graduates and graduate degree holders entering manufacturing industries, it become apparent that the transition, which had been relatively stable until the Mid-1980, peaked out in 1987 before starting a drastic decline. This tendency had continued up until 1992, with no sign of any recovery being seen (Figure 1-1-5). This indicates that in the expansion of employment of university graduates and graduate degree holders that accompanied the favorable economic conditions after 1988, the number of students with a science and engineering background lagged for behind.

Looking at the transition of the sense among manufacturing industries of there being a surplus or shortage of workers by job type, using the "Survey on Labour Economy Trend" of the Ministry of Labour, we can see that in the 1988-1992 period, when this phenomenon occurred, the sense of a labor shortage was comparatively high for specialist and technical positions likely to be filled by graduates and graduate degree holders from science and engineering departments in comparison to administrative positions that might be filled by liberal arts department graduates and positions in sales and service (Figure 1-1-6).

According to the survey implemented by the Science and Technology Agency in June 1993 directed at 1,444 private enterprises (840 respondents) entitled "the Survey on Private

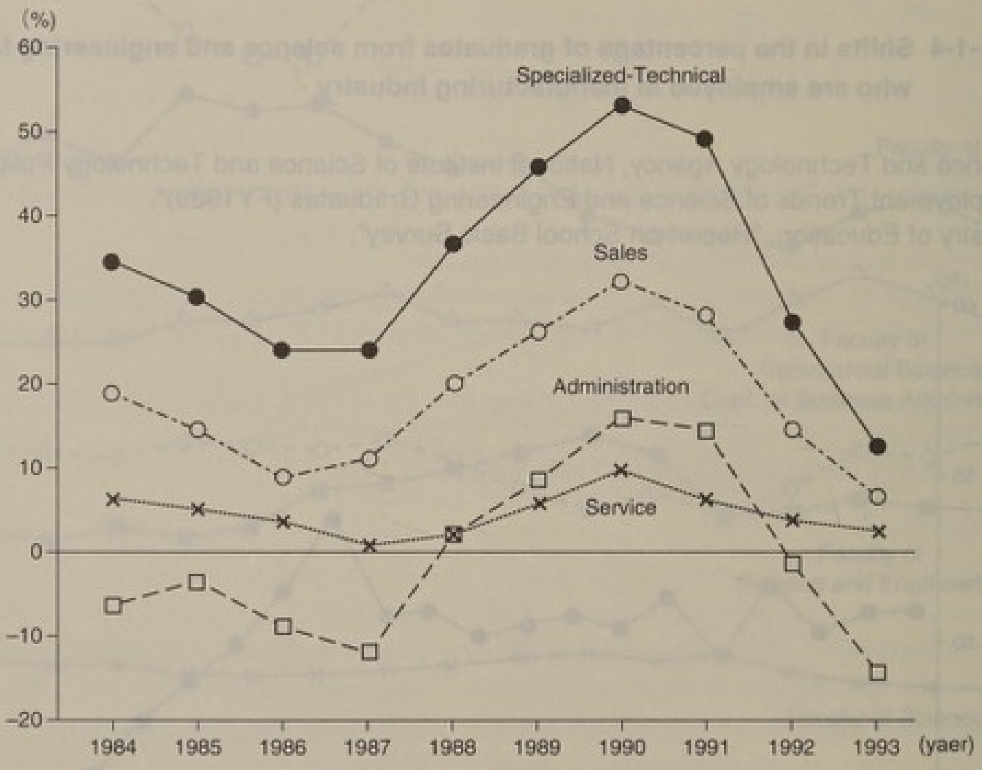


Figure 1-1-6 Shift in surplus-shortage judgment D.I. (for each profession) for manufacturing industry workers

Notes: 1. The value of a subtraction of the percentage of companies that responded that there was a shortage of workers from the percentage of companies that responded that there was a surplus. D.I. is an abbreviation for diffusion index.

2. The figures for August were adopted from the "Survey on Labour Economy Trend" carried out four times annually. However, the May figures were taken for 1985, 1986, and 1993.

Source: Ministry of Labour, "Survey on Labour Economy Trend".

Enterprise's Research and Development", 75.9% of the enterprises that responded felt that there was a declining popularity of manufacturing industry among science and engineering graduates several years ago. In the middle of the current recession, with many enterprises trying to cut down on the number of new employees, 48.2% can still sense this trend. In addition, 61.0% of the enterprises that responded to this survey felt that this trend would either continue or resurpass in future (Figure 1-1-7).

Currently, with economic activity being sluggish and the employment market for new graduates developing into a buyer's market, less attention is being paid to the declining popularity of the manufacturing industries among science and engineering graduates. However, based only on the previously mentioned viewpoint it is possible to suggest that the tendency continues in the consciousness of science and engineering students of not regarding manufacturing industries as attractive a place of employment compared to the past. With a decrease in the number of young people as seen over the long term, the buyer's market of today's new graduate employment market is expected to return to a sellers market once again. In consideration of this fact, there is great concern that the manufacturing industries will once again face great difficulties in getting a sufficient number of science and engineering graduates.

The manufacturing industries provide us with resulting from the fruits of science and technology, and can be considered to be one of the most typical proponents of activities in science and technology. If there was a tendency for that the manufacturing industries has lost their appeal even more than before, even by those who are directly involved in science and technology, it is possible to suggest that there is an overall tendency of the declining popularity of science and technology among young people.

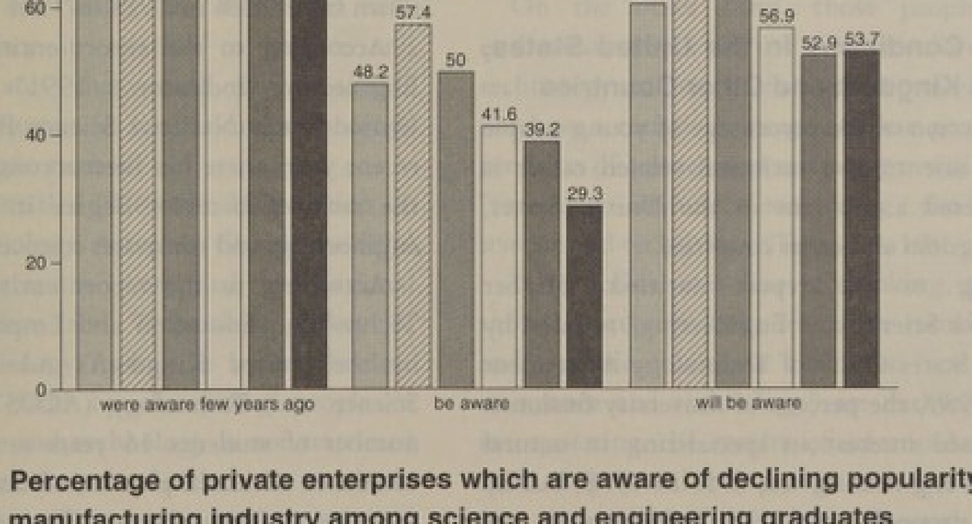


Figure 1-1-7 Percentage of private enterprises which are aware of declining popularity of the manufacturing industry among science and engineering graduates

Source: Science and Technology Agency, "Survey on Private Enterprises'Research and Development(FY1993)".

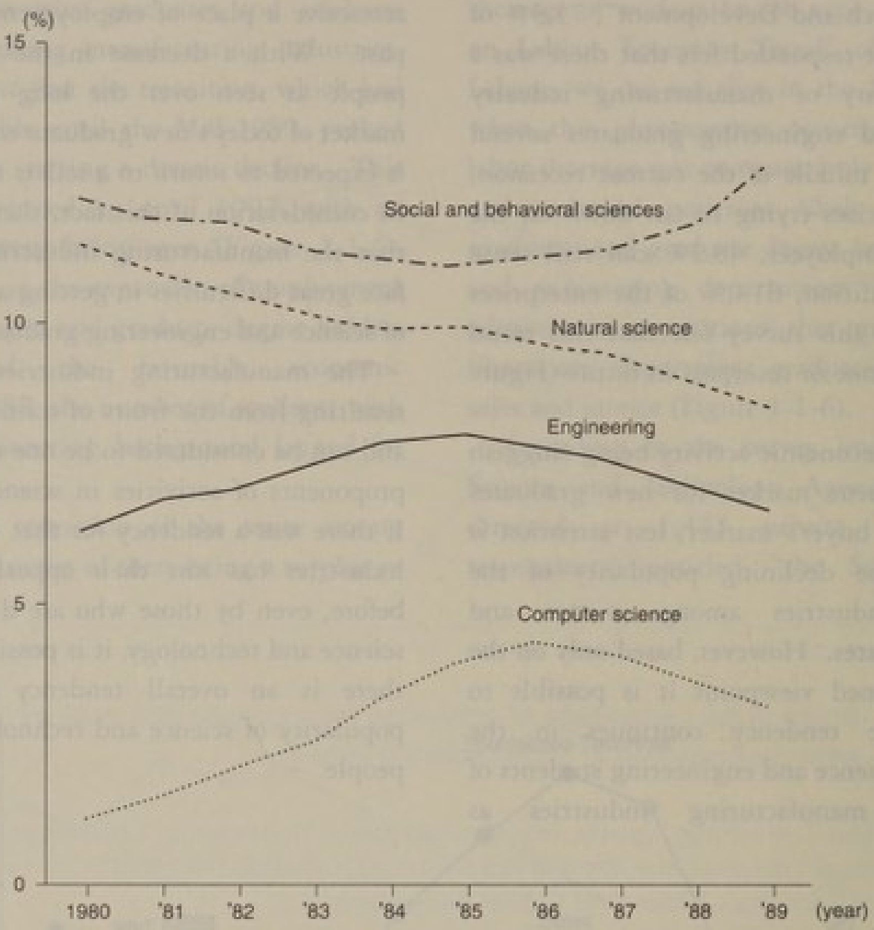


Figure 1-1-8 Shift in percentage of bachelor degree recipients according to field of specialization in the United States

Note: The percentage among the total number of bachelor degree recipients.
Source: United States National Science Board "Science and Engineering Indicators: 1991".

1.1.1.2.3 Conditions in the United States, the United Kingdom and Other Countries

The reduction of the percentage of young people choosing a scientific or technical related career is also considered a problem in the United States, United Kingdom and other countries.

According to the report entitled "Higher Education for Science and Engineering" released by the United States Office of Technology Assessment (OTA) in 1989, the percent of university freshman who expressed interest in specializing in natural sciences and engineering was 27% in 1978, but by 1986 had dropped to 24%. Furthermore, the percent of students expressing interest in a career in science and technology related research had gone down from 9.5% in 1978 to 7.0% in 1986.

According to the report entitled "Science and Engineering Indicators: 1991" released by the United States National Science Board in 1991, in recent years there has been a consistent decrease in the ratio of bachelor degree in natural sciences, engineering, and computer sciences (Figure 1-1-8).

According to the report entitled "Science and Technology: Education and Employment" released by the United Kingdom's Advisory Council on Science and Technology (ACOST) in 1991, the number of students 16 years or older that chose courses in advanced physics, advanced mathematics, and advanced chemistry, in the period from 1989 to 1990, decreased respectively from 44,871 to 42,564, from 82,987 to 72,277, and from 47,559 to 47,286. The number of applicants for engineering and technology course decreased from 81,000 in 1985 to 67,000 in 1989.

Finally, in the report entitled "Technology and the Economy: The Key Relationship" released by the Organization for Economic Cooperation and Development (OECD) in 1992, the same tendency that is being seen in the United States and United Kingdom can be seen in such countries as Canada and Italy.

1.1.2 Features of the Declining Popularity of Science and Technology among Young People

1.1.2.1 Two Aspects of the Interest in Science and Technology

As mentioned in the previous chapter, it is possible to see a decrease in the interest of the youth in relation to science and technology in terms of showing an interest in news and topics related to science and technology and in terms of academic course selections. However, there are no signs that the young are negative in regard to the use of the results of science and technology. Young people are the most positive in accepting personal computers and word processors which are the products of advanced science and technology, into everyday life (Figure 1-1-9).

The fact that the young are showing a self-contradictory stance in relation to science and technology indicates that there is no simple structure in the interest in science and technology measured by a single method.

In the survey entitled "How the Information on Science and Technology Activities Should be Send to Younger Generations" compiled by National Institute of Science and Technology Policy of Science and Technology Agency, it was made clear that the interest held by the young people in relation to science and technology is not restricted to one area, but rather can be divided into two basic representative ways. One is the consciousness or attitude of "interest in the direction of new science and technology" and "reading with interest newspaper articles related to science and technology", and the other is "appreciating the fact that life becomes more comfortable with the new developments in computers" or "appreciating the speeding up of transportation through the development of new technologies, such as linear motor cars". The first of these attitudes can be said to have a strong connection with people's decision in regard to education or career path selection.

The fact that young people are very enthusiastic regarding using the results of the latest science and technology. On the other hand, they show little interest in news and topics related to science and technology. This is quite understandable when one understands the two-sided viewpoint which exists among young people concerning science and technology.

In this section the enthusiastic attitude in terms of wanting to know about and becoming involved with the activities of scientists and engineers, or about the manufacturing process, construction and working principle of manufactured goods, represented by such comments as "I'm interested in the direction of new science and technology", "I will select a future in the field of science and technology", "I think science is interesting", "I am interested in the manufacturing method, construction and working principle of manufactured goods", will be referred to as "active interest" in science and technology (Table 1-1-10).

On the other hand, those people who are enthusiastic about the use of the results of the latest technology as convenient tools or products, but do not have a conscious image of these goods as being products of science and technology, will be called a "receptive attitude" concerning the results of science and technology (Table 1-1-10).

If we follow this line of thinking, people who show a "receptive attitude" to the results of science and technology without having an "active interest" in science and technology" are enthusiastic about incorporating the results of advanced technology, such as personal computers and word processors into their jobs and daily life. However, they show almost no interest in the activities of the scientists and engineers involved in the development of these

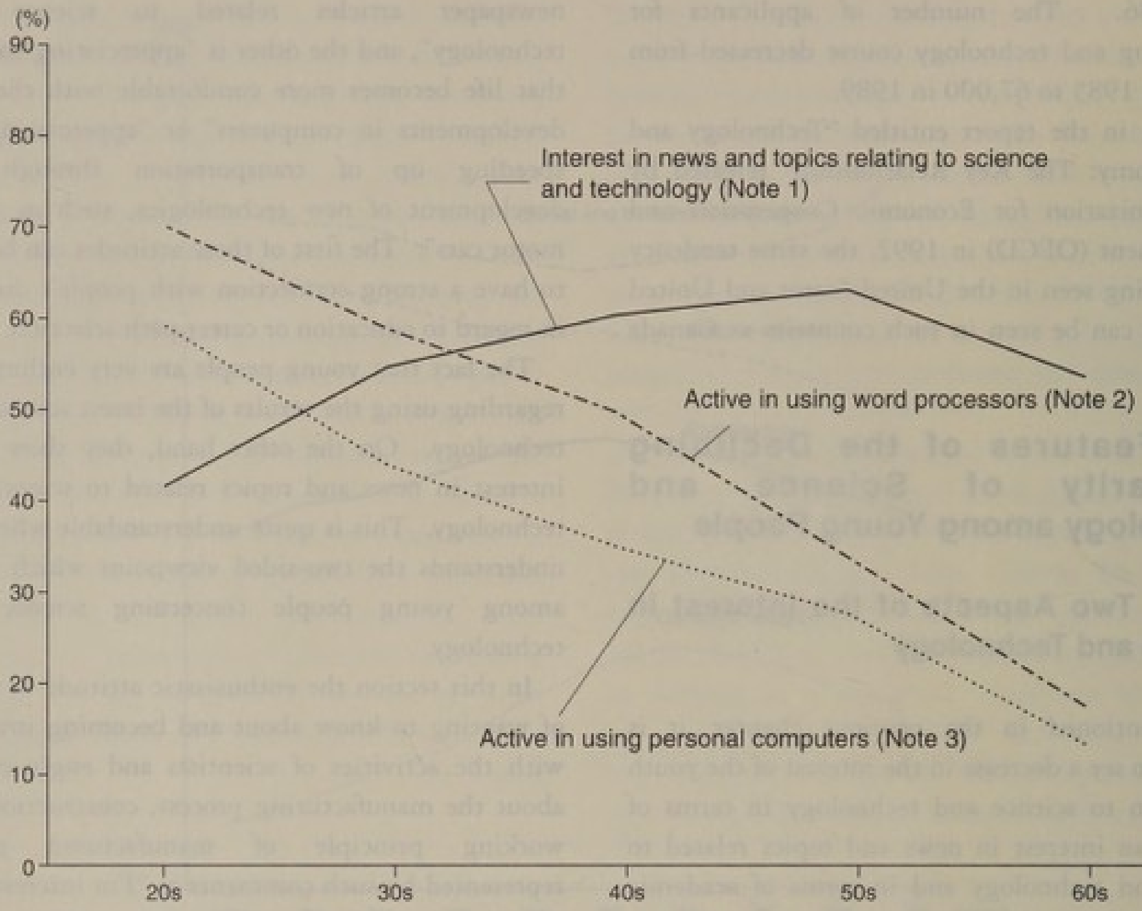


Figure 1-1-9 The relationship between awareness and attitudes concerning science & technology and age

Notes: 1. This figure represents the percentage of people who replied "highly interested" or "somewhat interested" in response to the question,"Are you interested or uninterested in news and issuers relating to science and technology?"

2. This figure represents the percentage of people who replied "currently using a word processor" or "not currently using a word processor but would like to use one in the future" in response to the question, "Are you currently using a word processor in your home or workplace?"

3. This figure represents the percentage of people who replied "currently using a personal computer " or "not currently using a personal computer but would like to use one in the future" in response to the question, "Are you currently using a personal computer in your home or workplace?"

Source: Science and Technology Agency, National Institute of Science and Technology Policy, "The International Comparative Research on Public Understanding of Science and Technology (FY1991)" .

Table 1-1-10 Two aspects of interest in science and technology

Type of Interest	Features	Examples of Awareness and Attitudes which Indicate the Level of Interest
"Active" interest in science and technology	Expression of positive awareness and attitudes indicating an eagerness to learn about and be involved in the activities of scientists and engineers, such as inventions and discoveries, and the construction, manufacture and working principles of appliances and other products. Tendencies to recognize the products of science and technology as such. Eagerness to use the results of science and technology in the form of tools and other products.	- An interest in new trends in science and technology. - An eagerness to read newspaper articles on science and technology. - An interest in news and issues related to science and technology. - The choice of higher education for employment in the field of science and technology. - Thinking science is interesting. - Reading books on science often. - An interest in the construction, manufacture and working principles of appliances and other products.
"Passive" interest in the results of science and technology	Expression of awareness and attitudes which indicate a tendency not to recognize the products of science and technology as such, but an eagerness to use such products as long as they are useful.	- Having a favorable view of the development of computers to make society more convenient. - Having a favorable view of the further development of the linear motorcar and other forms of rapid transport. - Active use of personnel computers and word processors.

Source: Make reference to STA/NISTEP report "How the Information on Science and Technology Activities Should be Sent to Younger Generations(FY1992)".

products or in anything other than the basic knowledge necessary to use the products, such as manufacturing process, construction or operation principle. They simply regard these products as convenient.

The young people are very enthusiastic as regards the use of personal computers and word processors but show little interest in news and topics related to science and technology. This can be seen as straying away from a future science and technology. Their "receptive attitude" concerning the results of science and technology strong but they are gradually losing any "active interest" in science and technology. In other words, the true nature of the change in the consciousness of youth that has been referred to as the "declining popularity of science and technology" among young people, is a decrease in "active interest", and does not imply that the young have any negative attitudes regarding the use of the results of science and technology.

1.1.2.2 Shifts in Active Interest in Science and Technology by Age Group

1.1.2.2.1 Changes occurring in the 1980s

The following is an analysis of the changes that occurred regarding in the "active interest" in science and technology for each of the different age groups in their teens, 20s, 30s, 40s, 50s, in 1981. This analysis focuses mainly on the 1980s.

Data was collected in 1981 as regards the "interest concerning news and topics related to science and technology" for the 20s, 30s, 40s, and 50s, and ten years later for these same groups that were now in their 30s, 40s, 50s, 60s in 1991 regarding "interest concerning news and topics related to science and technology" and "whether they liked or disliked science as a primary school student" (Table 1-1-11). The attitudes regarding "interest concerning news and topics related to

Table 1-1-11 Shifts in interest concerning news and topics related to science and technology according to age group

Age group \ Age	At the time of elementary school (see note 1)	During 20s (see note 2)	During 30s (see note 2)	During 40s (see note 2)	During 50s (see note 2)	During 60s (see note 2)
10s in 1981	52.1	41.3				
20s in 1981	50.6	55.3*	54.4			
30s in 1981	47.1	—	52.9*	59.9		
40s in 1981	50.9	—	—	55.1*	63.1	
50s in 1981	46.3	—	—	—	49.9*	53.2

Notes: 1. The percentage of those who responded to the question "When you were in elementary school did you like science?" with "Yes, very much" or "Yes" (Survey date: November 1991).
The figure in the " Xs in 1981" column is a ratio arrived at by a survey carried out in November 1991 of the X + 10 years age group.
2. The percentage of those who responded to the question "Are you interested in news and topics related to science and technology?" with "Yes, very much" or "Yes, to some extent" (Survey date: December 1981 (The figure marked with a *) and November 1991).
The figure in the "Xs" column for the "Xs of 1981" by a survey of the Xs group conducted in December 1981. Similarly, the figure in the "X + 10 year age group" column is a ratio arrived at by a survey on the X + 10 year age group carried out in November 1991.

Sources: Science and Technology Agency, National Institute of Science and Technology Policy, "The International Comparative Research on Public Understanding of Science and Technology (FY 1991)".
Prime Minister's Office "Survey on Science & Technology and Society".

science and technology" and "whether they liked or disliked science", are thought to show "active interest" in science and technology (Table 1-1-10). Therefore, the data related to this attitude is thought to be useful in analyzing the transition in this area.

According to Table 1-1-11, there is no significant difference according to age group with regard to "whether they liked or disliked science as a primary school student". In fact, it can be seen that the younger generations tended to like science slightly more than the older groups. Furthermore, there was little difference among the groups in relation to "interest concerning news and topics related to science and technology" as of 1981. However, in 1991, those in their 20s, in other words, the group that was 10s in 1981, had come to show a very low "interest concerning news and topics related to science and technology".

If we continued to think that the "interest concerning news and topics related to science and technology" and "whether they liked science as a primary school student" represent "active interest", then these results seem to suggest that there was an actual decline in "active interest" in science and technology for the age group that was 10s in 1981 during the ten years that followed leading up to 1991. In addition the "active interest" in science and technology for the group that was 20s in 1981 remained almost the same, while there was a tendency for some increase in the 30s, 40s, and 50s age groups.

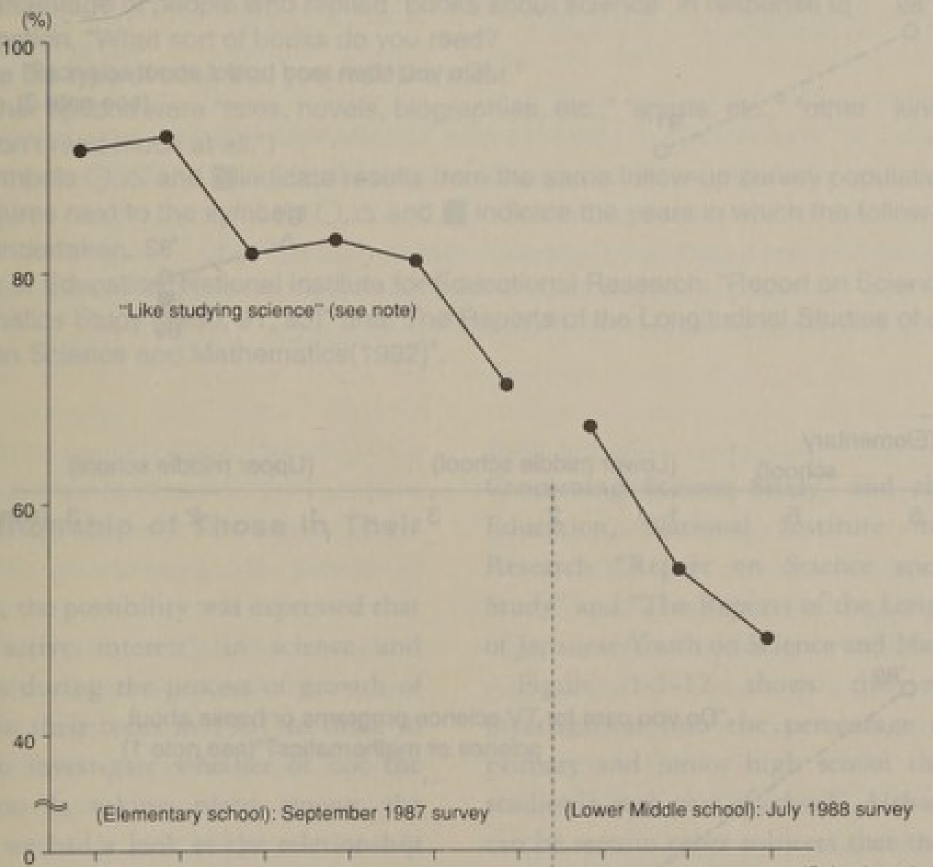
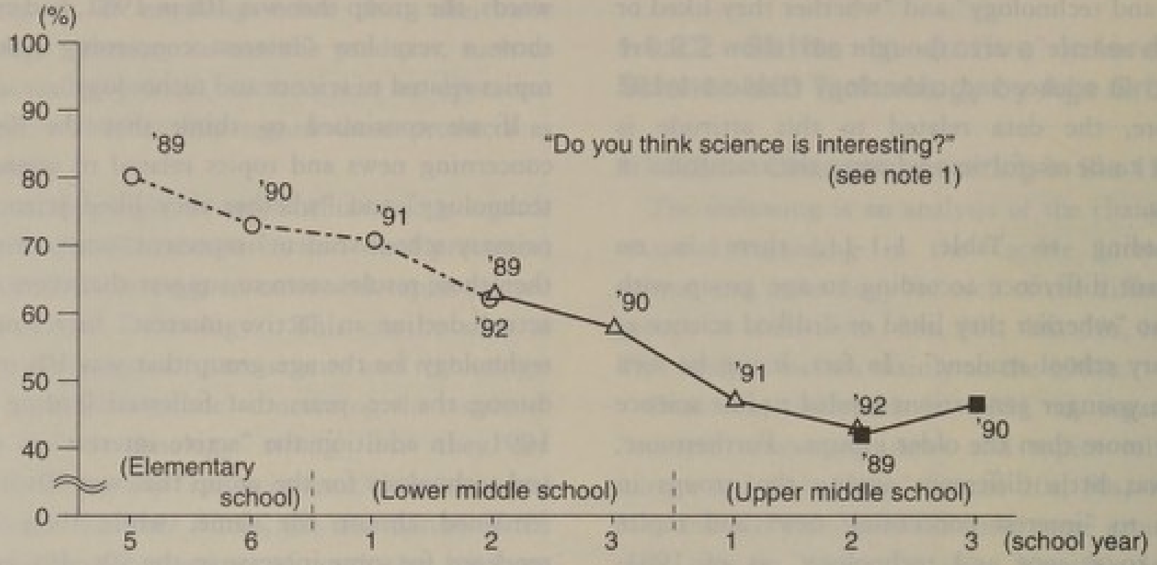
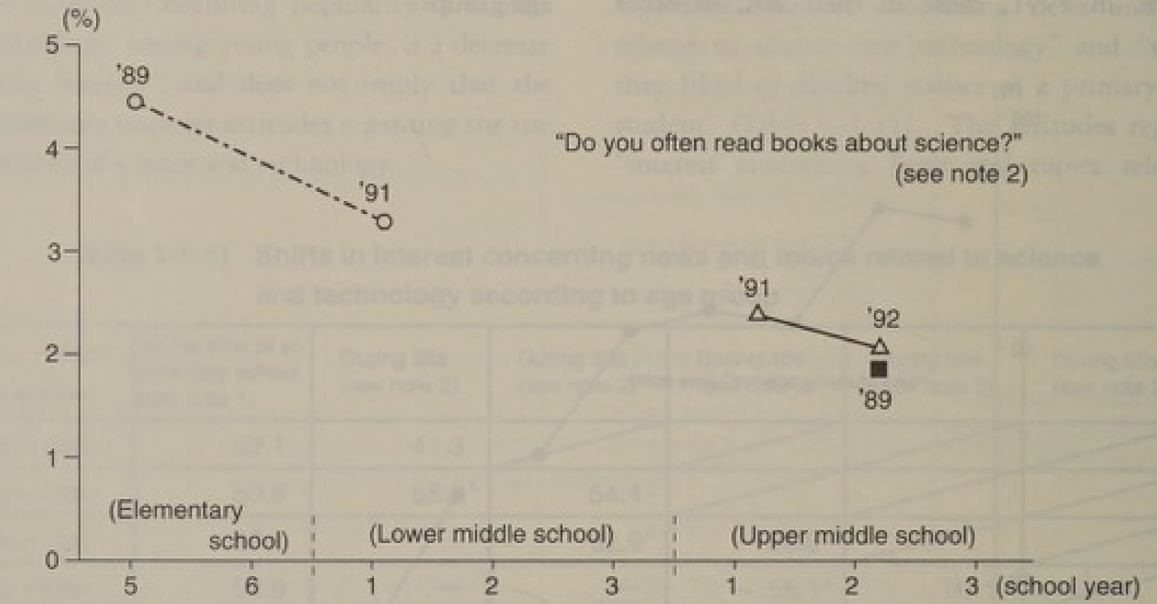


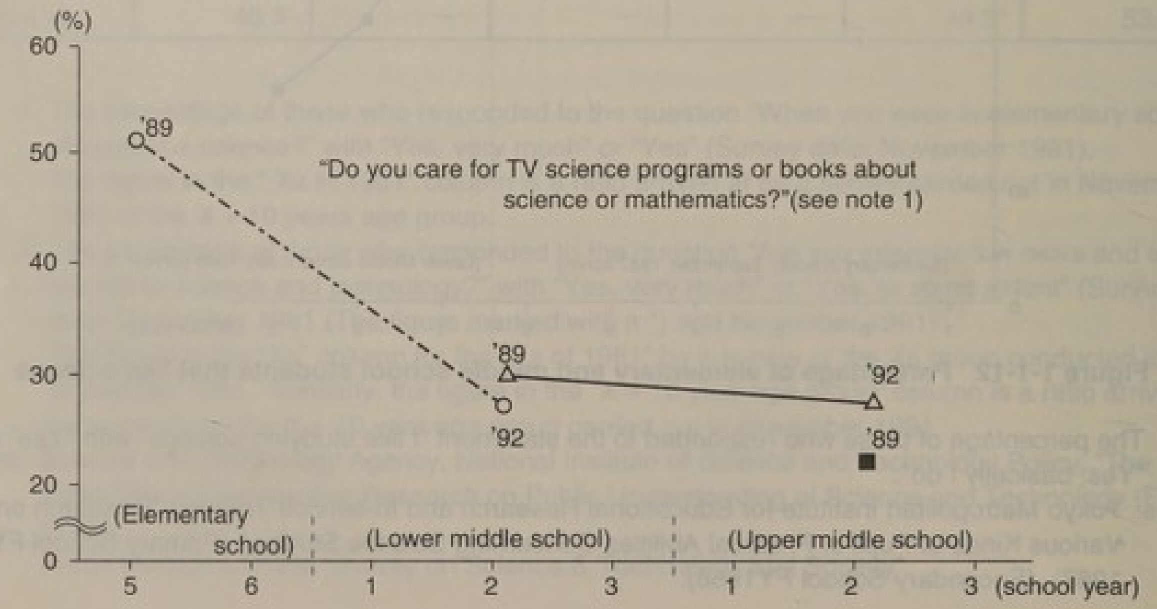
Figure 1-1-12 Percentage of elementary and middle school students that like science

Note: The percentage of those who responded to the statement "I like studying science" with "Yes" or "Yes, basically I do".

Sources: Tokyo Metropolitan Institute for Educational Research and In-service Training "Research on Various Kinds of Pupil's, Practical Abilities Concerning Science Studies" (Primary School FY 1987), (Secondary School FY1988).


(%)
"Do you think science is interesting?" (see note 1)
(Elementary school)
(Lower middle school)
(Upper middle school)
(school year)


(%)
"Do you often read books about science?" (see note 2)
(Elementary school)
(Lower middle school)
(Upper middle school)
(school year)


(%)
"Do you care for TV science programs or books about science or mathematics?"(see note 1)
(Elementary school)
(Lower middle school)
(Upper middle school)
(school year)

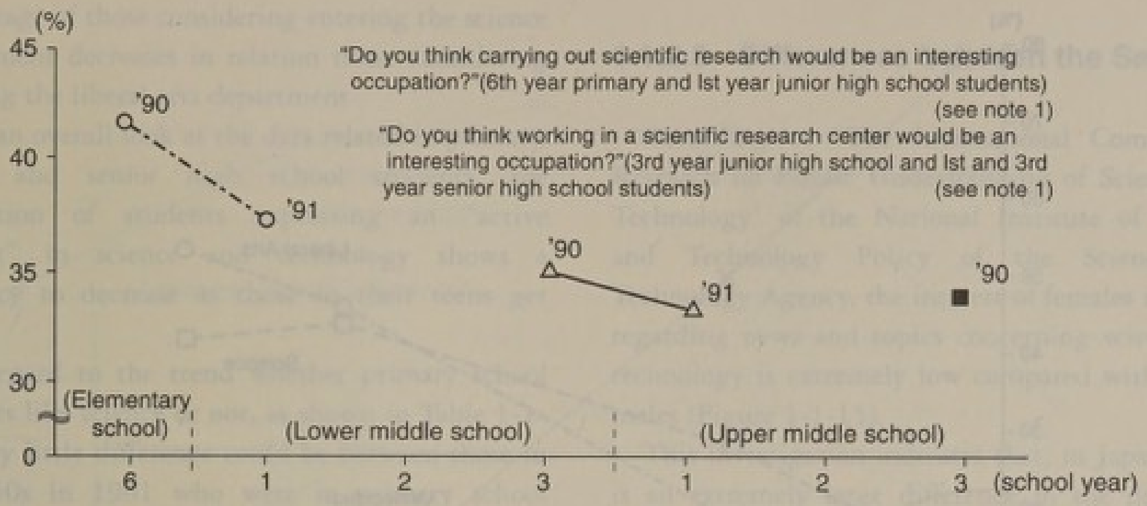


Figure 1-1-13 Interest of school children and high school students in science and technology

Notes: 1. The percentage of people who replied "yes" or "maybe" to this question.
2. The percentage of people who replied "books about science" in response to the question, "What sort of books do you read? Choose the type of book that you read the most." (The other options were "tales, novels, biographies, etc.," "sports, etc.," "other kinds of books" and "don't read much at all.")
3. The symbols ○,△ and ■ indicate results from the same follow-up survey populations.
4. The figures next to the symbols ○,△ and ■ indicate the years in which the follow-up surveys were undertaken.

Sources: Ministry of Education, National Institute for Educational Research, "Report on Science and Mathematics Study (1990, 91, 93)" and "The Reports of the Longitudinal Studies of Japanese Youth on Science and Mathematics(1992)".

1.1.2.2.2 Relationship of Those in Their Teens

In this analysis, the possibility was expressed that a decrease in "active interest" in science and technology occurs during the process of growth of those who were in their teens in 1981 to those in their twenty. To investigate whether or not the same phenomenon is taking place among the minors of today, we had a look at the relationship between age and the "active interest" in science and technology of minors today, and an analysis was conducted based on data thought to be related to "active interest" in science and technology using the Tokyo Metropolitan Institute for Educational Research and In-service Training "A Research on Various Kinds of Pupil's Practical Abilities Concerning Science Study" and the Ministry of Education, National Institute for Educational Research "Report on Science and Mathematics Study" and "The Reports of the Longitudinal Study of Japanese Youth on Science and Mathematics".

Figure 1-1-12 shows the results of an investigation into the percentage of students in primary and junior high school that like science studies in each year of school. Although a tendency can be seen in other subjects that the percentage of students who like a subject decrease with age, a rapid decrease can be seen in the percentage of students who like science in the period between the sixth year of primary school and the third year of junior high school.

Figure 1-1-13 shows the results of a tracking survey targeted at students from the third grade of

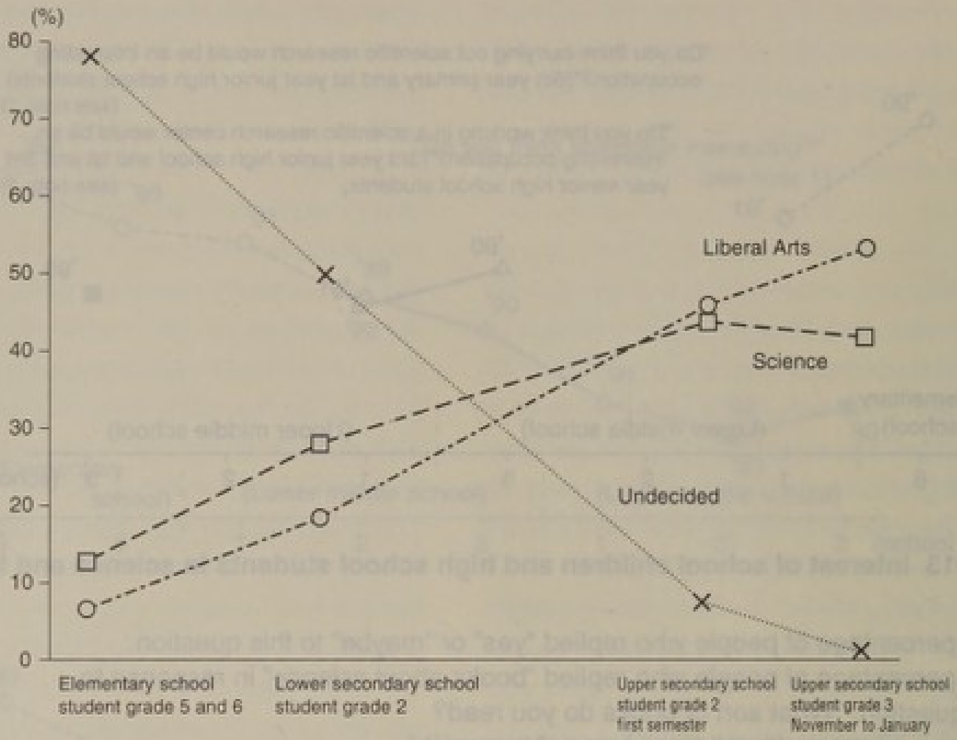


Figure 1-1-14 Percentage of students who had decided to follow a university (junior college, technical school) program in science or liberal arts

Note: This survey was conducted from November 1989 to January 1990.
Source: Science and Technology Agency, National Institute of Science and Technology Policy "Choice of University Applicants among Fields of Study(FY 1990)".

primary school to the third year of senior high school, indicating the process of change, as school years progress, in relation to the percentage of students who find science interesting, the percentage of students that often read books related to science, the percentage that likes books related to math and science and scientific television programs, and the percentage of students that felt that working in the future as a scientific researcher would be appealing. These results showed that for all a decrease shown as they went on to higher grades.

Figure 1-1-14 shows the results of an investigation in which students in the third grade of senior high school were asked whether they were considering science or liberal arts as a university study (including junior colleges or technical schools) at different times during their school year: the fifth and sixth year of primary school, the second year of junior high school and first semester of the second year of senior high school, and from November to January of their senior year. According to this investigation, the percentage of students planning on entering into the science department was much greater than those planning to enter the liberal arts department for the junior high school in their second year, but by the first semester of the second year of senior high school, the number planning to enter the liberal arts department had surpassed those planning to enter the science department. This trend was strengthened even more during the period between November and January of the senior year. From this investigation, there can been seen a trend among the young in Japan, that as students progress from junior to senior high school the percentage of those considering entering the science department decreases in relation those considering entering the liberal arts department.

For an overall look at the data related to primary, junior and senior high school students, the proportion of students expressing an "active interest" in science and technology shows a tendency to decrease as those in their teens get older.

In regard to the trend whether primary school students like science or not, as shown in Table 1-1-11, very little difference could be between those in their 50s in 1981 who were in primary school during the 1930s and those in their teens in 1981 who were in primary school during the 1970s. The proportion that selected "I liked it very much" or "I liked it" was roughly 59% for both groups.

According to "A Research on Various Kinds of Pupil's Practical Abilities Concerning Science Study" (FY 1987) of the Tokyo Municipal Institute for Educational Research and In-service Training, in response to the statement "I like science", 82% of fourth graders, 80% of fifth graders and 70% of sixth graders said that this statement "corresponded well" with their opinion or "basically corresponded" with their opinion (Figure 1-1-12). According to the "Longitudinal Study of Japanese Youth on Science and Mathematics" (FY 1990, 1991) of Ministry of Education National Institute for Educational Research, in response to the statement "I find science interesting", 80.5% of fifth graders and 73.2% of sixth graders responded "I think so" (Figure 1-1-13).

Only looking at this enthusiasm as regards to science study might lead one to believe that "active interest" in science and technology remains ever now at a relatively high level among those in their teens. However, this high level of interest has stopped having a direct link to a high level of interest after becoming adults. Actually, as teenagers progress into adulthood, the decrease in "active interest" in science and technology can be clearly seen.

1.1.2.3 Differences between the Sexes

According to "The International Comparative Research on Public Understanding of Science and Technology" of the National Institute of Science and Technology Policy of the Science and Technology Agency, the interest of females in Japan regarding news and topics concerning science and technology is extremely low compared with the to males (Figure 1-1-15).

This investigation indicates that, in Japan, there is an extremely large difference in the degree of "active interest concerning science and technology" between males and females. In the same survey, the data shown in Table 1-1-16 was obtained showing results of efforts to make a comparison between the United States and Japan concerning the difference between males and females regarding the level of interest in news and topics concerning science and technology. It is difficult to make a comparison between Japan and the United states concerning their absolute levels of interest in news and topics concerning science and technology, because of differences in the number and content of the questions that appeared in the American and Japanese surveys, but it is still quite clear that the difference between males and females regarding the level of interest concerning news and topics related to science and technology is much greater in Japan than in the United States.

It seems that the level of "active interest" in science and technology has a large influence on the state of those entering science and technology related fields. From this viewpoint, the state of females entering science and technology related fields can be viewed.

Look at the state in Japan of females entering science and technology related fields in comparison to those entering other fields, consulting the survey "Female Researchers in Japan" of the National Institute of Science and Technology Policy of the Science and Technology Agency. The percentage or women in undergraduate, masters degree and doctoral degree programs in natural sciences faculties (namely, those of sciences, engineering,

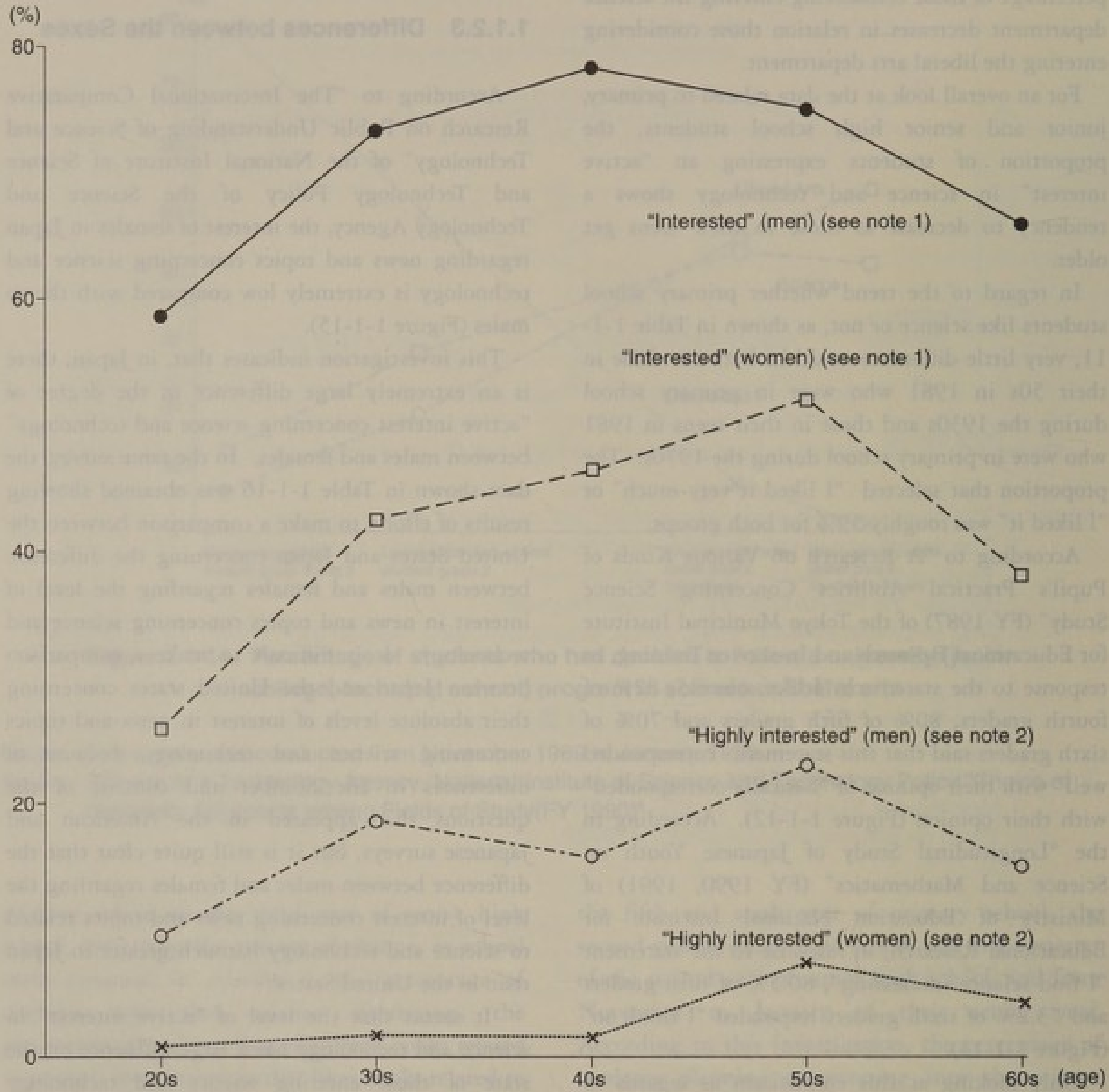


Figure 1-1-15 Differences between men and women in interest in news and topics relating to science and technology

Notes: 1. This figure represents the percentage of people who replied "highly interested" or "somewhat interested" in response to the question, "Are you interested or uninterested in news and issues relating to science and technology?"

2. This figure represents the percentage of people who replied "highly interested" in response to the above question.

Source: Science and Technology Agency, National Institute of Science and Technology Policy, "The International Comparative Research on Public Understanding of Science and Technology"(FY1991).

Table 1-1-16 Comparison of Japan and the United States regarding interest concerning news and topics related to science and technology

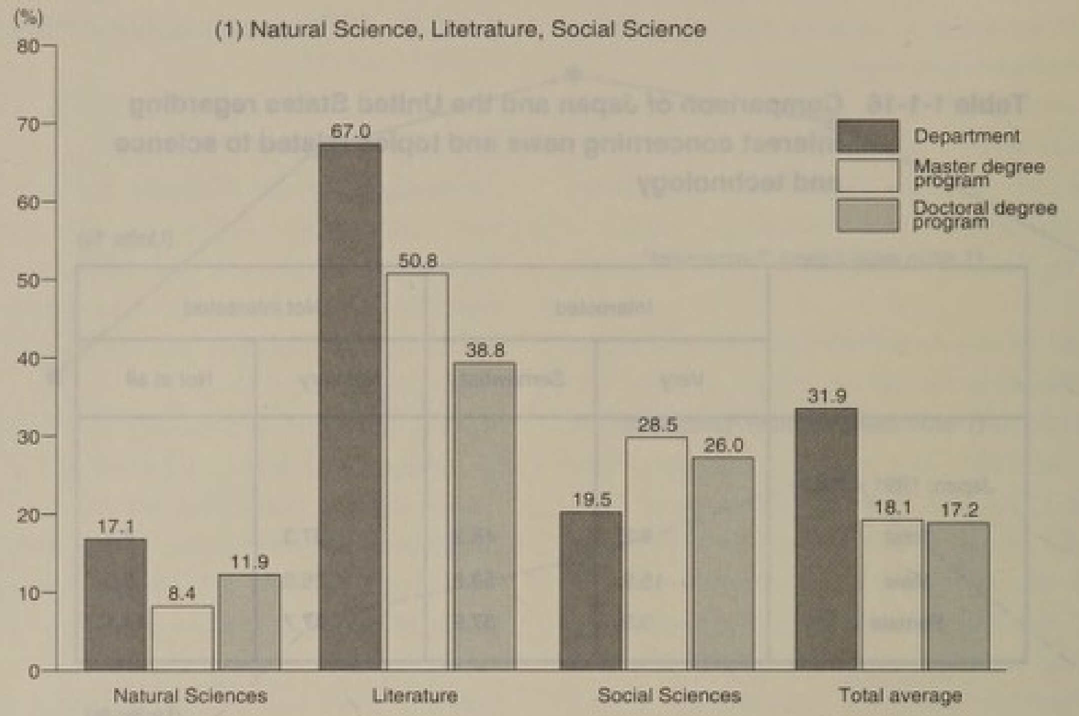
(Units: %)

	Interested		Not interested	
	Very	Somewhat	Not very	Not at all
Japan: 1991 survey				
Total	9.2	45.2	37.3	8.2
Male	15.9	53.6	25.5	5.0
Female	3.3	37.9	47.7	11.1

(Units: %)

	Very interested	Somewhat interested	Not at all interested
United States: 1990 survey			
Total	50.4	44.8	4.2
Male	54.5	41.9	3.4
Female	46.7	47.6	5.0

Source: Science and Technology Agency, National Institute of Science and Technology Policy "The International Comparative Research on Public Understanding of Science and Technology (1991)."
Reference: Northern Illinois University Public Opinion Survey Research Institute "The Public Understanding of Science and Technology in the United States, 1990".



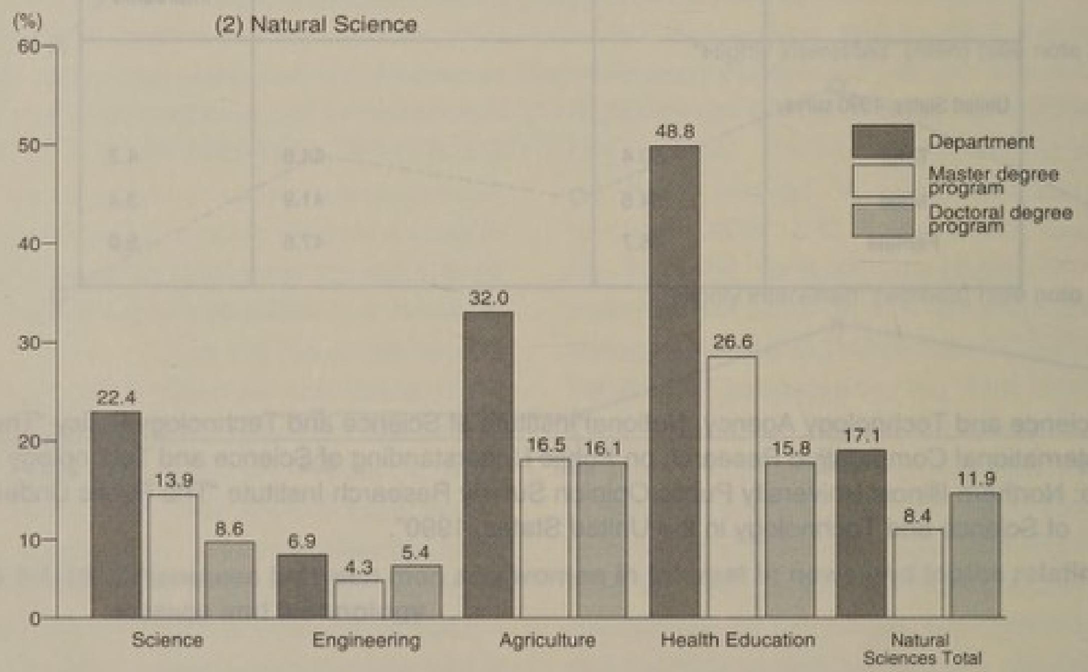


Figure 1-1-17 Percentage of women according to major in university and graduate school

Note: Health Education includes medicine, dentistry and nursing, etc.
Source: Science and Technology Agency, National Institute of Science and Technology Policy, "Female Researchers in Japan (FY 1993)".
Reference: Ministry of Education "Report on School Basic Survey".

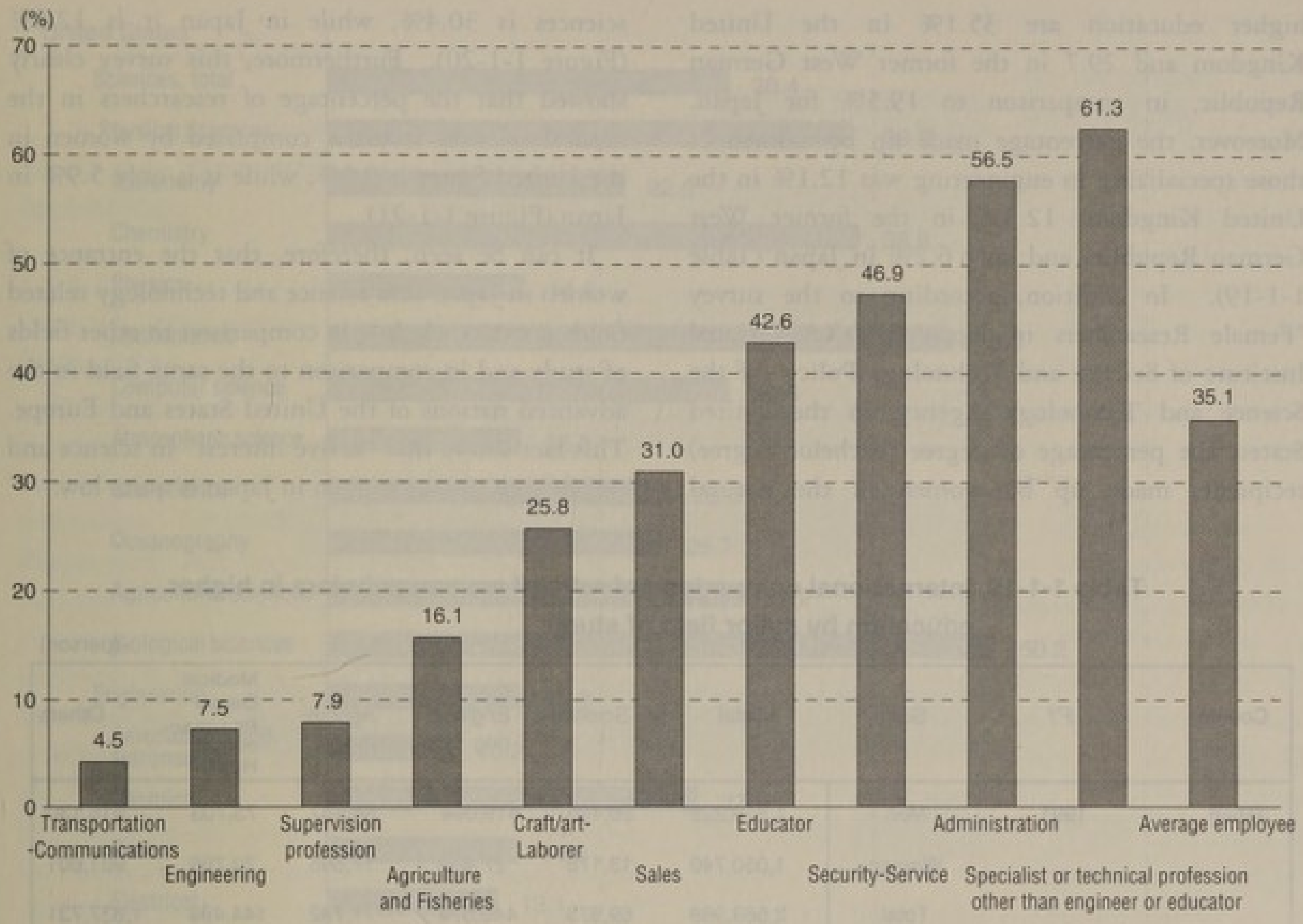


Figure 1-1-18 Percentage of women according to profession (1992)

Note: Only applies to regularly employed women.
Source: Science and Technology Agency, National Institute of Science and Technology Policy "Female Researchers in Japan (FY 1993)".
Reference: Management and Coordination Agency, Statistics Bureau, "Annual Report on the Labour Force Survey".

agriculture and medicine) are 17.1%, 8.4%, and 11.9%, respectively. This is extremely low in comparison to the percentage of women involved in the department of literature and social sciences (Figure 1-1-17 (1)). Within the field of natural sciences itself, the number of women entering engineering faculty is noticeably few (Figure 1-1-17 (2)). Furthermore, a look at the percentage of positions occupied by women for each profession in society will show that the percentage of women among the total number of those engaged in engineering profession is 7.5%, which is low in comparison to the percentage of women involved in other professions (Figure 1-1-18).

Taking a comparative look at the percentage of women entering science and technology fields relative to the percentage in the advanced nations of the United States and Europe, according to the "International Comparison of Educational Indicator" compiled by the Ministry of Education, the percentage of women that make up those students specializing in sciences enrolled at institutions of higher education are 35.1% in the United Kingdom and 29.7 in the former West German Republic, in comparison to 19.5% for Japan. Moreover, the percentage made up by women of those specializing in engineering was 12.1% in the United Kingdom, 12.3% in the former West German Republic, and only 6.2% in Japan (Table 1-1-19). In addition, according to the survey "Female Researchers in Japan" of the National Institute of Science and Technology Policy of the Science and Technology Agency, in the United States, the percentage of degree (bachelor degree) recipients made up by women in the natural sciences is 30.4%, while in Japan it is 12.6% (Figure 1-1-20). Furthermore, this survey clearly showed that the percentage of researchers in the natural sciences faculties comprised by women in the United States is 9.5%, while it is only 5.9% in Japan (Figure 1-1-21).

It can be seen, therefore, that the entrance of women in Japan into science and technology related fields is extremely low in comparison to other fields of study and in comparison to the same field in the advanced nations of the United States and Europe. This fact shows that "active interest" in science and technology among women in Japan is quite low.

Table 1-1-19 International comparison of ratio of women scholars in higher education by major field of study

(person)

Country	FY	Sex	Total	Science	Engineering	Agriculture	Medical Dental Pharmaceutical Health	Others
Japan	1991	Men	1,519,229	56,195	419,094	54,107	73,703	916,130
		Women	1,050,740	13,178	27,480	17,685	70,796	921,601
		Total	2,569,969	69,373	446,574	71,792	144,499	1,837,731
		Ratio of women(%)	40.9	19.0	6.2	24.6	49.0	50.1
United Kingdom	1989	Men	322,600	63,000	63,700	4,500	17,700	173,700
		Women	289,900	34,100	8,800	3,300	26,200	217,500
		Total	612,500	97,100	72,500	7,800	43,900	391,200
		Ratio of women(%)	47.3	35.1	12.1	42.3	59.7	55.6
Former West Germany	1989	Men	929,394	163,852	280,503	20,657	59,685	404,697
		Women	575,169	69,102	39,386	13,862	50,463	402,356
		Total	1,504,563	232,954	319,889	34,519	110,148	807,053
		Ratio of women(%)	38.2	29.7	12.3	40.2	45.8	49.9

Note: Japan – Number of scholars in university departments, main junior college sections and fourth or fifth year of vocational high schools.
United Kingdom – Number of full-time scholars at the departmental level in universities (excluding public universities), polytechnic and higher education colleges.
Former West Germany – Number of students during winter term at universities and vocational high schools. In terms of departments outside of education and teacher's training, individuals aiming to obtain teacher certifications are included under each major.
Source: Ministry of Education "International Comparison on Educational Indicator".

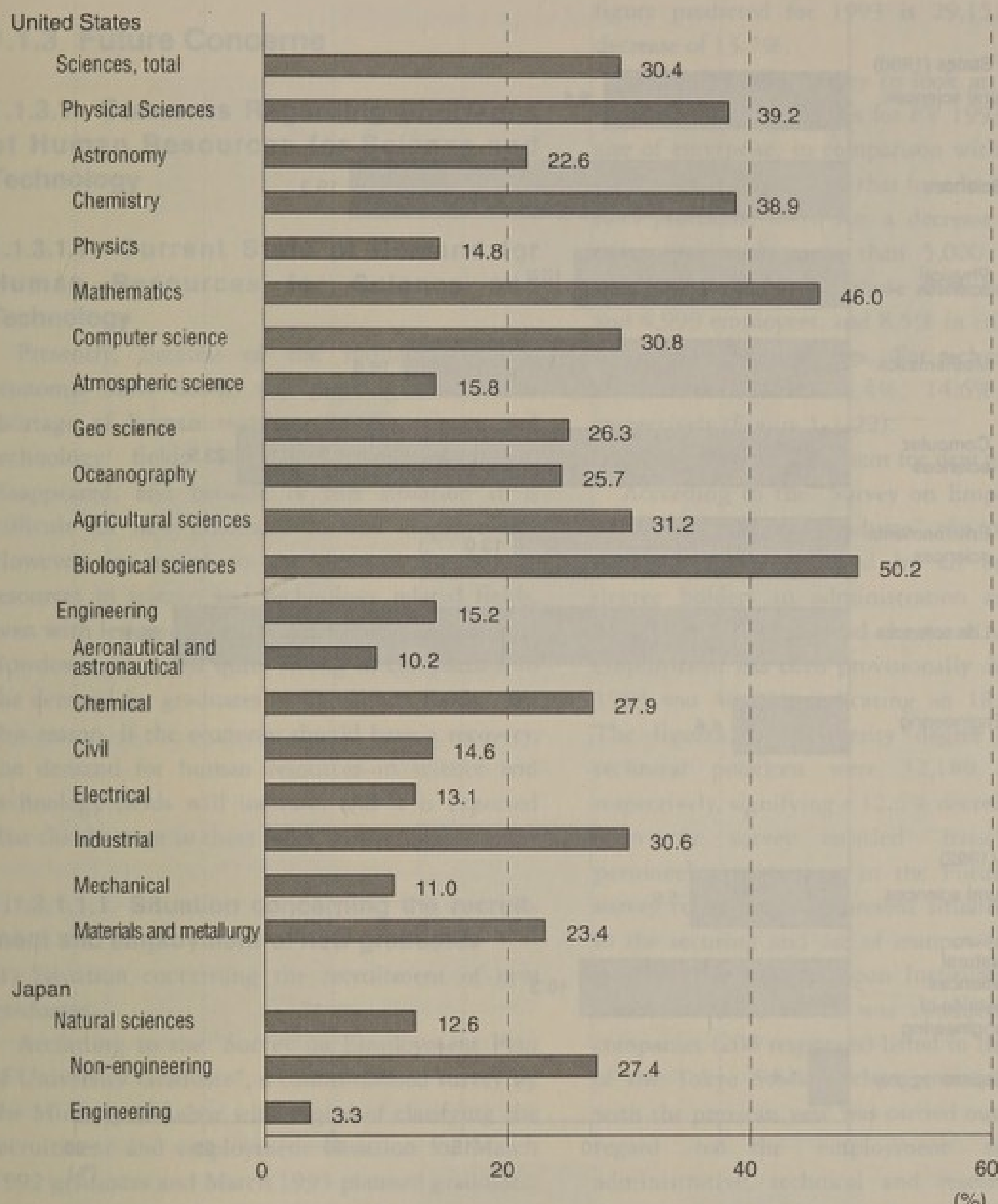


Figure 1-1-20 Comparison between Japan and the United States on proportion of women with bachelors degrees by major

Note: Does not include psychology and sociology.
Source: Science and Technology Agency, National Institute of Science and Technology Policy, "Female Researchers in Japan (FY 1993)".
Reference: Ministry of Education "Report on School Basic Survey" and U.S. National Science Foundation "Women and Minorities in S&E: 1992".

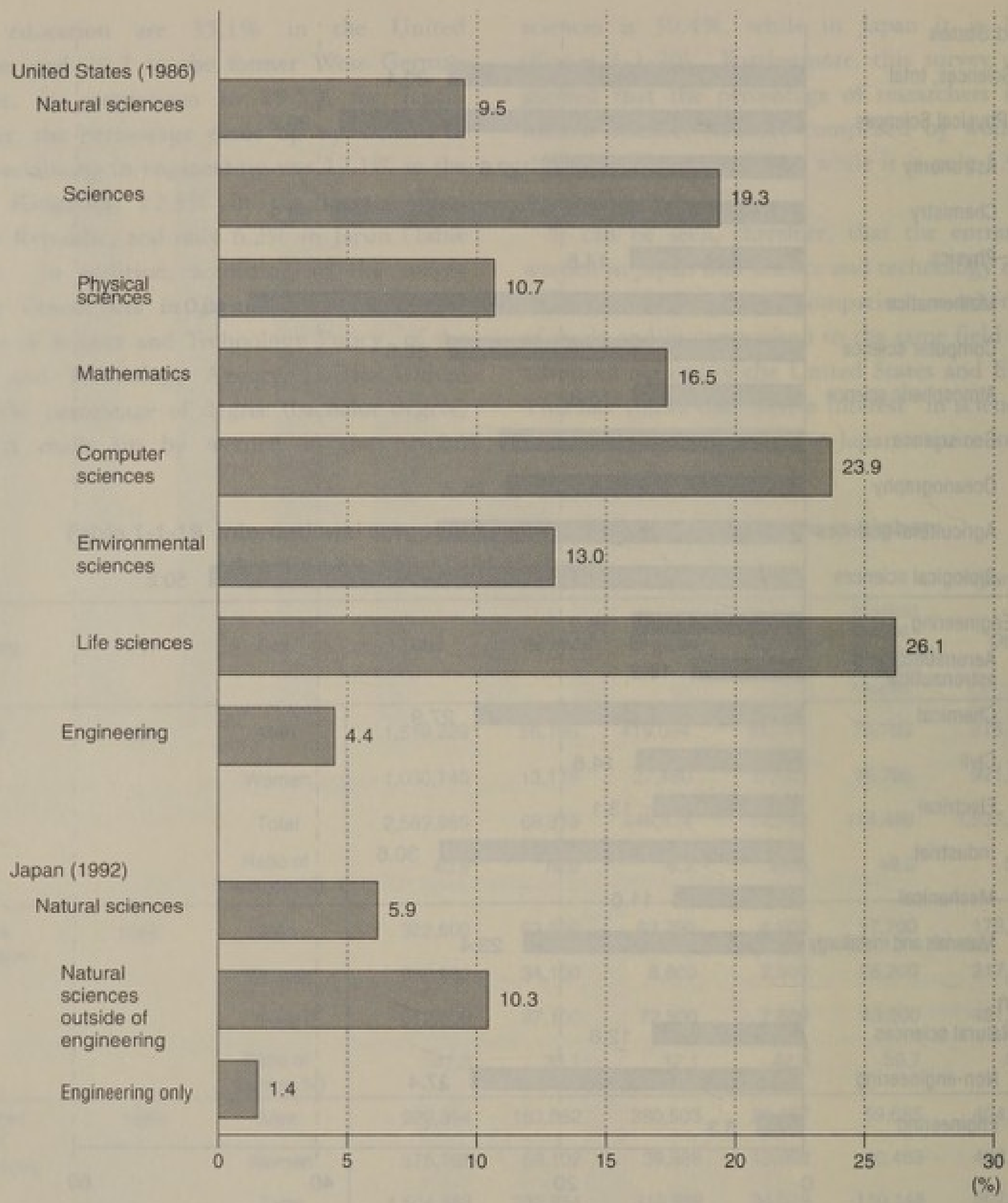


Figure 1-1-21 Comparison between Japan and the United States concerning the ratio of women among researchers according to field of study

Notes: 1. Does not include psychology and sociology.
2. The ratio of women among researchers was calculated with researchers defined as scientists and engineers involved in research and development according to content of work.

Source: Science and Technology Agency, National Institute of Science and Technology Policy, "Female Researchers in Japan(FY 1993) ".

Reference: Management and Coordination Agency, Statistic Bureau, "Survey of Research and Development". U.S. National Science Foundation, "Women and Minorities in S&E: 1992".

1.1.3 Future Concerns

1.1.3.1 Concerns Regarding Shortages of Human Resources for Science and Technology

1.1.3.1.1 Current State of Demand for Human Resources for Science and Technology

Presently, because of the influence of the economic slow down, the pressing sense of a shortage of human resources in the science and technology fields of several years ago has disappeared, and because of this situation it is difficult for new graduates to find employment. However, in regard to the demand for human resources in science and technology related fields, even with lessening in demand due to the economic slowdown, it is still quite strong in comparison to the demand for graduates in liberal arts fields. For this reason, if the economy should have a recovery, the demand for human resources in science and technology fields will increase, and it is expected that the shortage in these fields will return.

1.1.3.1.1.1 Situation concerning the recruitment and employment of new graduates

(1) Situation concerning the recruitment of new graduates

According to the "Survey on Employment Plan of University Graduate", a commissioned survey by the Ministry of Labor with a goal of clarifying the recruitment and employment situation for March 1992 graduates and March 1993 planned graduates, in regard to 2,310 companies (1,011 companies with valid responses) listed on the Tokyo, Osaka and Nagoya Stock Exchanges, in administration and sales positions for persons with at least a university degree, the total number of people recruited for employment in FY 1992 was 50,407, and the predicted recruitment for FY 1993 is 40,814, showing a decrease of 19.0%. In regard to university graduates in science and engineering, the total number of new graduates recruited for employment in FY 1992 was 33,779, and the figure predicted for 1993 is 29,151, showing a decrease of 13.7%.

Using the same survey to look at the predicted recruitment of employees for FY 1993 classified by size of enterprise, in comparison with the previous fiscal year, it can be seen that for administration and sales positions, there was a decrease of 24.7% in enterprises with more than 5,000 employees, a decrease of 13.7% for those with between 1,000 and 4,999 employees, and 8.5% in enterprises with less than 1000 employees. For technical positions, the decreases were 14.4%, 14.6%, and 2.8%, respectively (Figure 1-1-22).

(2) Situation of employment for new graduates

According to the "Survey on Employment Plan Survey of University Graduate", the total number of new graduates employed by all enterprises for degree holders in administration and sales was 49,604 in FY 1992, and the total number whose employment has been provisionally decided for FY 1993 was 40,294, indicating an 18.8% decrease. The figures for university degree graduates in technical positions were 32,189, and 28,125 respectively, signifying a 12.6% decrease.

In the survey entitled "Basic survey for personnel management in the Future (1992) –A survey concerning the present situation and future in the securing and use of manpower in an era of job mobility" of the Japan Institute of Personnel Administration, which was conducted for 1,019 companies (208 responses) listed in the first section of the Tokyo Stock Exchange, and a comparison with the previous year was carried out separately in regard to the employment situations in administrative, technical and research positions. According to this survey, in regard to the employment situation for university graduates in FY 1992, 32.6%, and 32.5% of those responded increased employment, in technical and research positions, respectively, with a decrease in employment of 19.1% in technical and research positions respectively and 10.4%. In contrast, the percentage of those increased employment in administration positions was 30.6%, while 27.1% decreased employment (Figure 1-1-23 (1)). In terms of planned hiring of graduates for FY 1993,

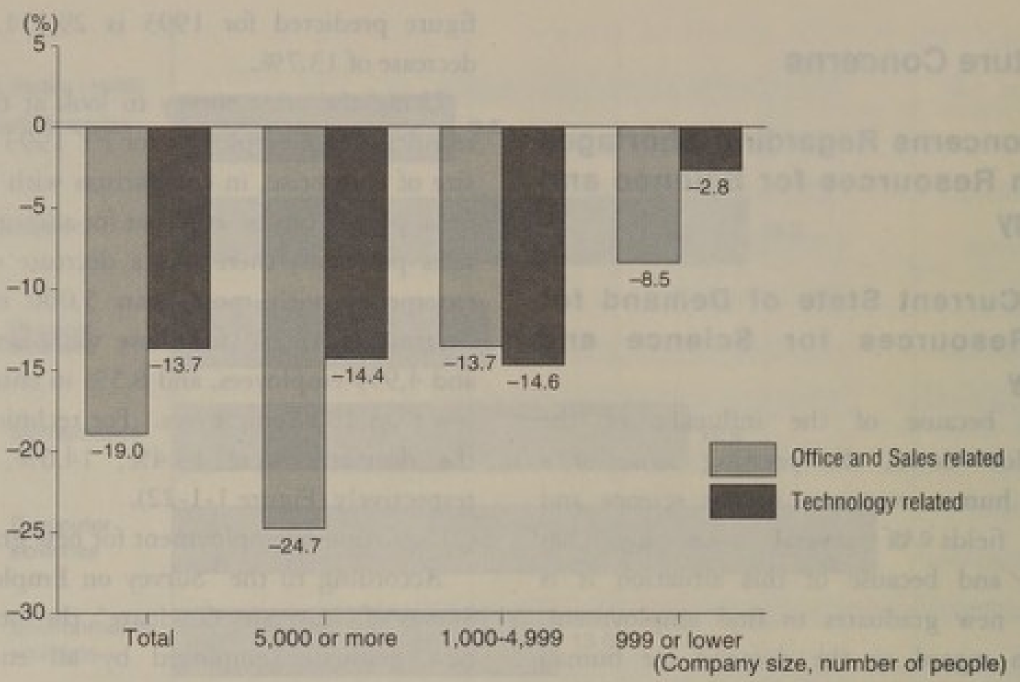


Figure 1-1-22 FY 1993 planned employment recruiting conditions — Comparison with previous year

Source: Japan Institute of Workers' Evolution, "Survey on Employment Plan of University Graduates(FY 1992)."

27.6% plan to increase employment, in technical positions and 21.4% in research positions while 31.1% and 30.2% plan to decrease employment, respectively. In contrast, of these, the percentage of companies planning to increase employment in administration positions was 14.9% while 45.5% plan to decrease employment (Figure 1-1-23 (2)).

Looking at the situation of employment for university degree holders in FY 1993 according to the scale of the individual enterprises using "Survey on Employment Plan of University Graduate", in comparison to the previous year, in administration and sales positions, there was a 26.5% decrease for companies with more than 5,000 employees, a 11.3% decrease for companies with 1,000-4,999 employees, and a 0.1% increase for companies with less than 1,000 employees. In technical positions, there was a 17.0% decrease, a 8.7% decrease, and a 12.0% increase for companies of the respective sizes (Figure 1-1-24).

The total number of university degree holders called for and actually recruited in FY 1993 decreased in administration, sales, and technical positions in comparison to the previous fiscal year; however, the percentage of decrease was smaller in the technical positions than for the two other positions. Furthermore, in technical, research, and administration positions in FY 1993, the percentage of companies planning to decrease employment of university graduates surpassed the percentage of companies planning to increase employment, but the percentage of those planning to decrease employment in administrative surpassed the percentage for technical and research positions. Moreover, the percentage of those planning to increase the employment of university graduates in administration was smaller than the percentage for employment for technical and research positions.

From these figures, it can be said that although there is an overall decrease in employment as a result of the economic slowdown, there is a general tendency to avoid reductions in the employment of science and technology.

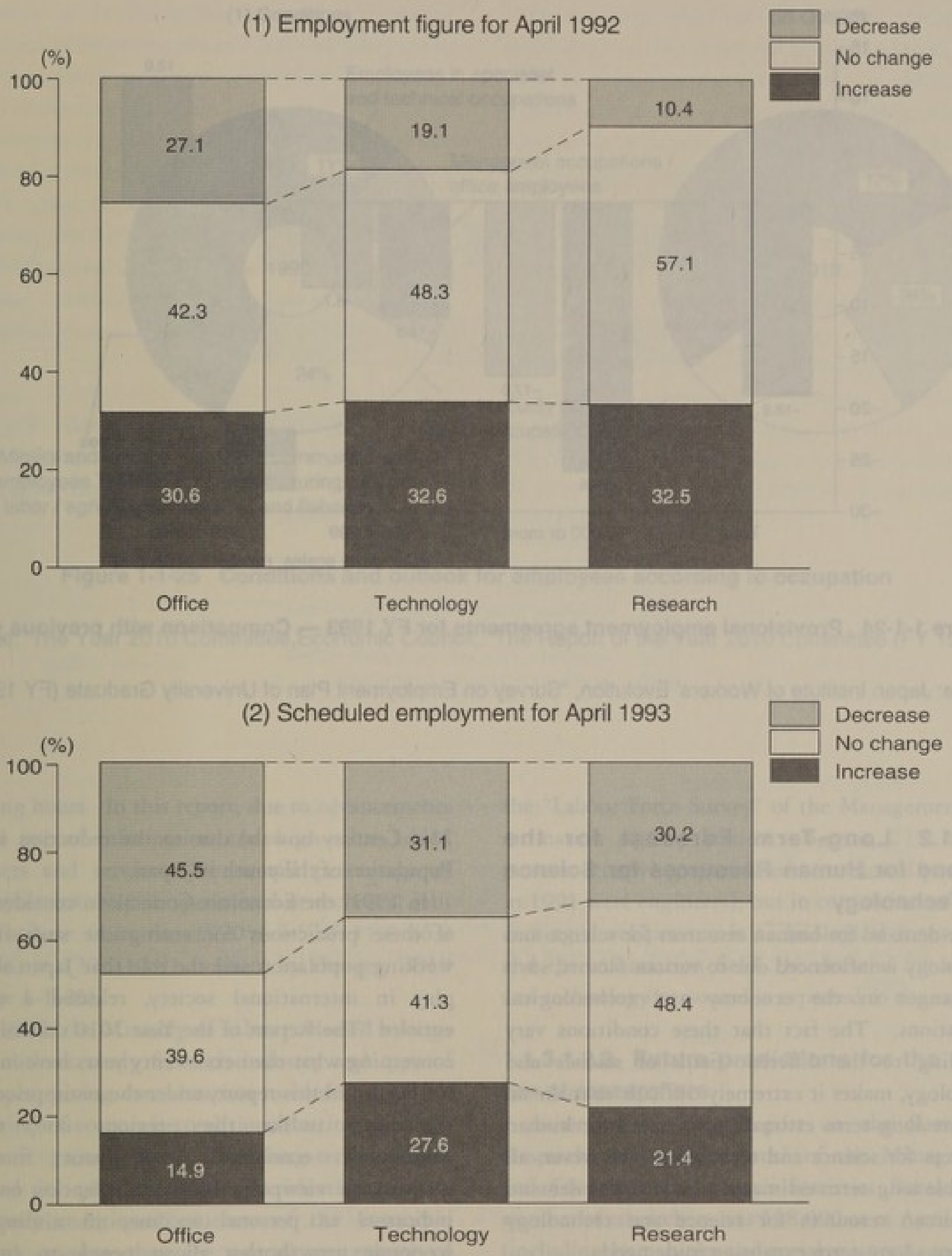


Figure 1-1-23 Number of new employees by occupation — Comparison with previous year

Source: Japan Institute of Personnel Administration "Basic Survey for Personnel Management in the Future (FY 1992)".

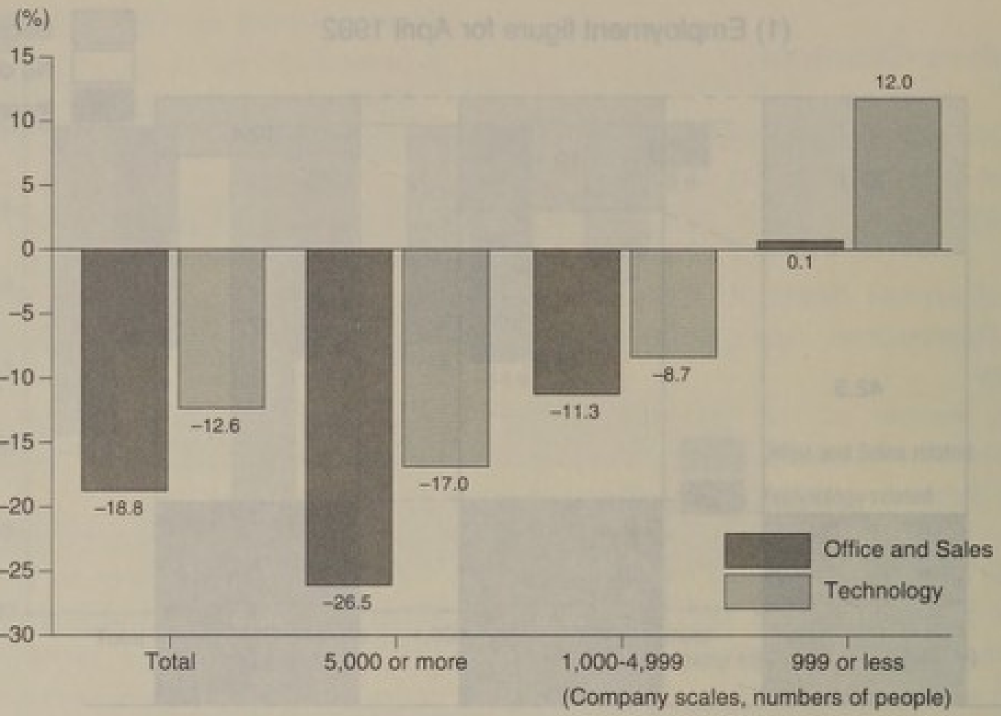


Figure 1-1-24 Provisional employment agreements for FY 1993 — Comparison with previous year

Source: Japan Institute of Workers' Evolution, "Survey on Employment Plan of University Graduate (FY 1992)".

1.1.3.1.2 Long-Term Forecast for the Demand for Human Resources for Science and Technology

The demand for human resources for science and technology is influenced due to various factors, such as changes in the economy and technological innovations. The fact that these conditions vary according to the different fields of science and technology, makes it extremely difficult to make an accurate long-term estimate of demand for human resources for science and technology. However, all available long-term estimates related to the demand for human resources for science and technology indicate a long-term expansion in demand.

1.1.3.1.2.1 Long-term employment structure

The average working population in Japan was 65.05 million in 1991 (a calculation based on those 15 years of age and above employed and fully unemployed), a slight decrease is predicted from the 21st Century onward due to the reduction in the Population of the youth in Japan.

In 1991, the Economic Council, in consideration of these predictions concerning the shift in the working population and the role that Japan should play in international society, released a report entitled "The Report of the Year 2010 committee", concerning what the next twenty years have in store for Japan. In this report, under the assumption that the next, unlike the previous one, which emphasized economic development from a quantitative viewpoint focussing attention on such indicators as personal income, in aiming for economic growth that allows people to enjoy a comfortable and rich lifestyle, a prediction was made for the industrial structure and employment structure for the year 2010, as a model of growth that optimizes the efficiency of each individual citizen in consideration of the limitations that exist in such areas as population, working population and

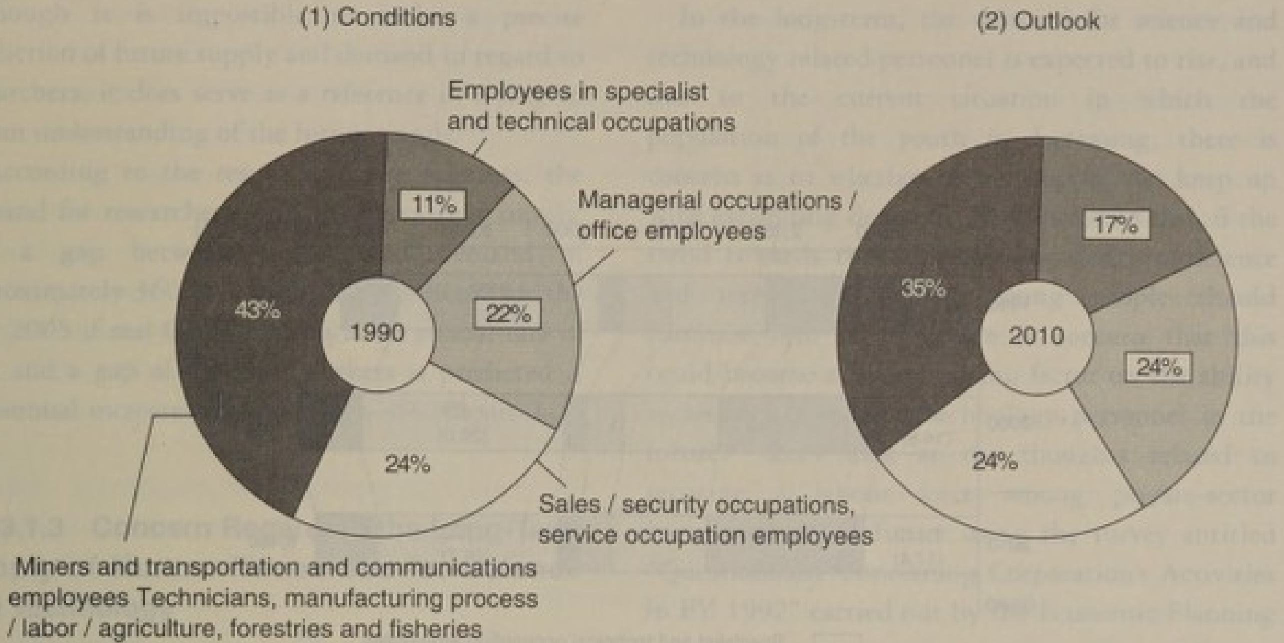


Figure 1-1-25 Conditions and outlook for employees according to occupation

Source: The Year 2010 Committee,Economic Council, "The Report of the Year 2010 Committee (FY 1991)".

working hours. In this report, due to advancements in the use of information and high-value added products and services, the overall percentage of employees involved in specialized or technical jobs will increase from the 1990 level of 11% (6.9 million) to 17% (10.91 million) by the year 2010 (Figure 1-1-25).

In 1992, the Ministry of Labour released a long-term outlook study for each industry and type of employee, giving consideration to conformity with each kind of economic condition, starting with the economic growth rate. This long-term outlook resulted in calculations almost identical to the previously mentioned estimate of the Economic Council, stating that the overall percentage of employees involved in specialized or technical jobs will increase from 11% (6.9 million) in 1990 to 17%(11.2 million) in 2010 (Figure 1-1-26).

All of the people involved in specialized or technical positions will not necessarily be human resources for science and technology (according to the "Labour Force Survey" of the Management and ordination Agency Statistics Bureau, 27% of the persons occupying specialized or technical positions in 1991 were engineers), but in consideration of the coming developments in technological innovations and the information field, the demand for science and technology personnel is expected to rise rapidly.

1.1.3.1.2.2 Future predictions for the number of researchers

According to the "Report on the Survey of Research and Development" of the Management and Coordination Agency's Statistics Bureau, the number of researchers was 598,000 as of April 1992 (including humanities and social sciences), and this is approximately 1.5 times the number ten years ago. The following is an investigation of the shifts in the demand and supply of researchers in the future.

In the report commissioned by the Science and Technology Agency entitled "Survey on R&D

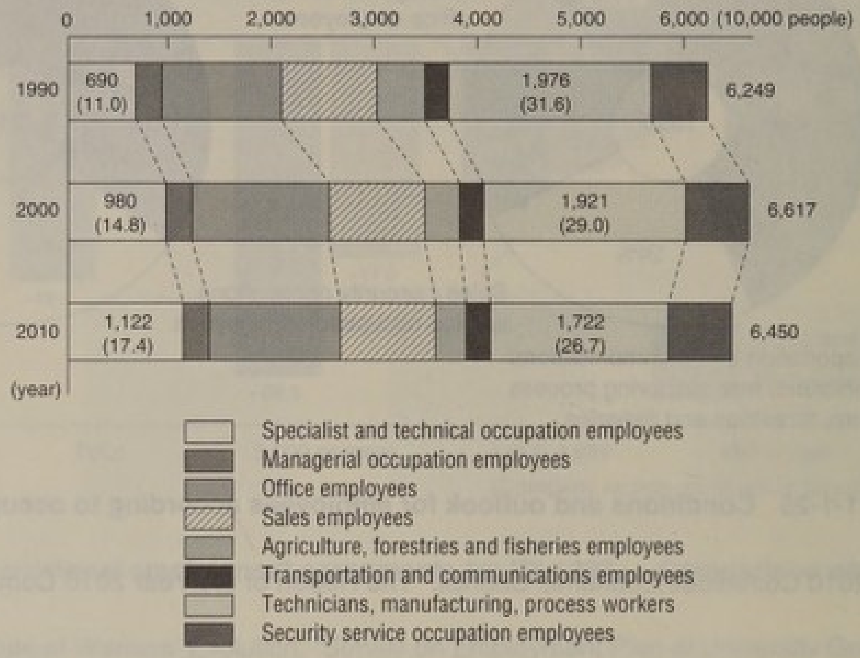


Figure 1-1-26 Outlook for employees by occupation

Notes : 1. Statistics of 1990 are according to the Labor Force Survey of Statistics Bureau, Management and Coordination Agency. Statistics on the year 2000 and 2010 are according to estimates by the Employment Security Bureau of the Ministry of Labour.

2. The figures in parentheses represent the proportion (%) of employees per occupation for each year.

Human Resources for Advanced Science and Technology", we can see a future estimate for the demand and supply of researchers based on an estimate of the demand and supply of researchers, including those in the fields of humanities and social sciences. In this survey research, the volume of supply and demand was predicted for researchers from 1990 and beyond, with the demand for researchers investigated through the use of a forecasting method assuming that the demand in a function of gross national product (GNP) and the number of university students. The supply of researchers was investigated using a forecasting method considering the function of population in productive age. The forecasting model used here is an extremely simplified one, and it seems that there are many factors, such as the research and development spending, that influence the supply and demand of researchers besides GNP, the number of university students and population.

Although it is impossible to make a precise prediction of future supply and demand in regard to researchers, it does serve as a reference in trying to get an understanding of the future trends.

According to the results of these forecasts, the demand for researchers will greatly surpass supply, and a gap between supply and demand of approximately 360,000 workers is predicted for the year 2005 if real GNP expands at an annual rate of 3%, and a gap of 480,000 workers is predicted if the annual increase of real GNP is 4% (Figure 1-1-27).

1.1.3.1.3 Concern Regarding the Long-Term Supply of Human Resources for Science and Technology

In the long-term, the demand for science and technology related personnel is expected to rise, and due to the current situation in which the population of the youth is decreasing, there is concern as to whether or not supply can keep up with expanding demand. In addition to this, if the trend towards the declining popularity of science and technology among young people should continue into future, there is concern that this could become a large limiting factor on the ability to secure science and technology personnel in the future. Let's look at the thoughts related to securing a labour force among private-sector companies in the future using the survey entitled "Questionnaire Concerning Corporation's Activities in FY 1992" carried out by the Economic Planning

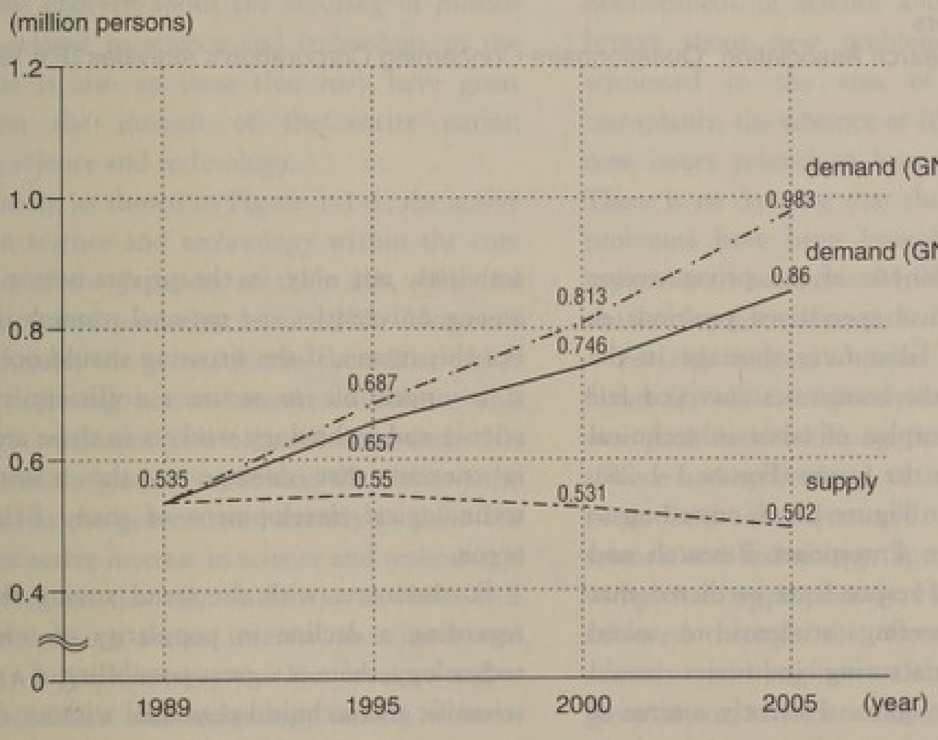


Figure 1-1-27 Forecast of the number of researchers in future

Source: The Institute for Future Technology, "Survey on R&D Human Resources for Advanced Science and Technology (FY1990) ".

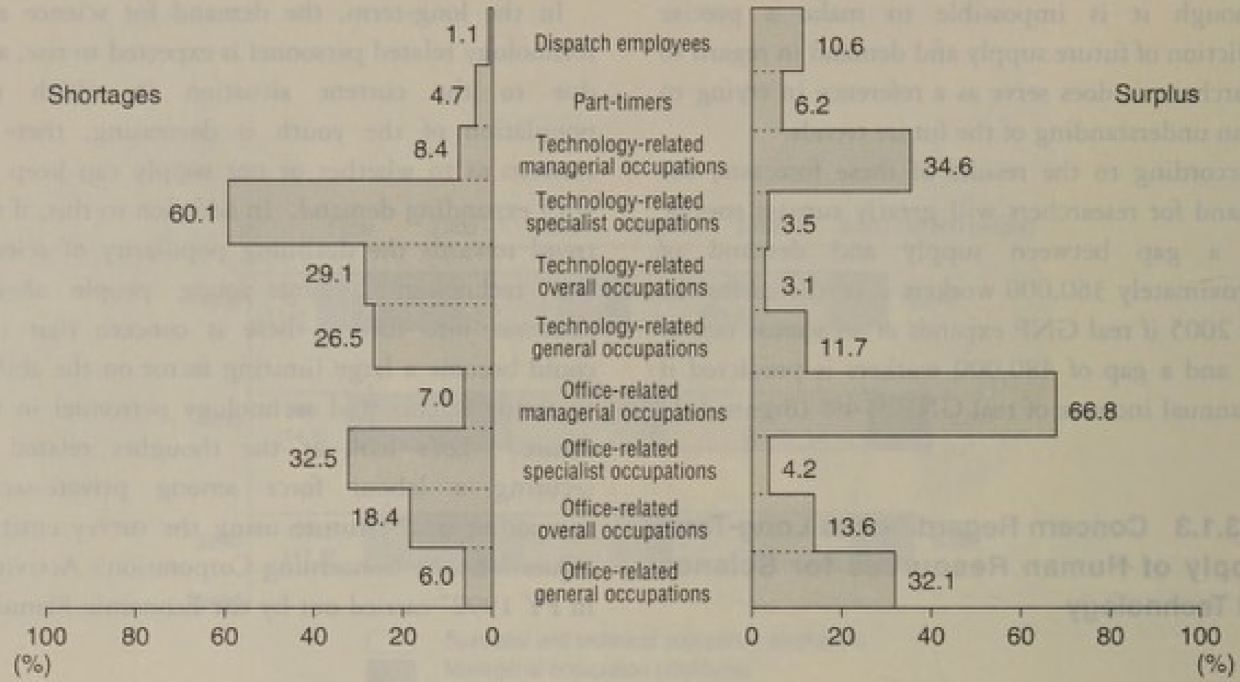


Figure 1-1-28 Future outlook on surpluses and shortages of personnel by occupation

Note: Multiple answers
Source: Economic Research Association "Questionnaire Concerning Corporation's Activities (FY 1992)".

Agency. A total of 60.1% of the private-sector companies cited technical specialized positions as most likely to have a labor force shortage in the future. Only 3.5 of the companies surveyed felt that there will be a surplus of labor in technical specialized positions in the future (Figure 1-1-28). In addition, as shown in Figure 1-1-7, according to the "Survey on Private Enterprises Research and Development", 61% of respondents predicted that the trend for engineering students to avoid employment in manufacturing industries would continue, or occur once again. Presently, a sense of over-employment is spreading throughout manufacturing industries, but these survey results show that concern over the future supply of human resources for science and technology are strongly rooted among private-sector companies.

Human resources for science and technology play an important role in research and development activities, not only in the private sector but also among universities and national research institutes. For this reason, if the situation should occur where it is impossible to secure a sufficient supply of science and technology workers in these areas, there is concern that damage to the scientific and technological development of many fields could occur.

Furthermore, with the trend among the young regarding a decline in popularity of science and technology, there is a great possibility of a supply of scientific and technical personnel without dreams or any stimulus concerning science and technology. In the past, the scientific and technological development of Japan was supported by science and technology personnel, in spite of lagging social conditions in comparison to the advanced countries of Europe and the United States and a relatively poor work environment. The fact that Japan was capable of producing such great accomplishments in the field of science and technology despite this harsh environment seems to be due to the dreams and passion of the Japanese science and technology personnel with regard to science and technology. In consideration of this, the trend towards the youth regarding the decline in popularity of science and technology causes great concern as to whether or not the dreams and passions concerning science and technology will continue to drive the science and technology personnel of the future.

1.1.3.2 Concern Regarding the Falling Interest in Science and Technology among the General Public

The declining popularity of science and technology among young people, or in other words, the decrease in active interest in science and technology on the part of the youth, has not only raised great concern about the securing of human resources related to science and technology in the future but is also an issue that may have great impact on the interest of the entire nation regarding science and technology.

Fortunately, as shown in Figure 1-1-1, the active interest in science and technology within the core generation of the Japanese in their 30s, 40s, and 50s has increased somewhat since 1981. However, if in the future, the generation in their 20s, which shows a declining active interest in science and technology maintains this attitude into their 30s and 40s, and the generation behind them shows the same trend as the generation currently in their 20s in terms of active interest in science and technology, there is concern that the nation as a whole will show a decreasing active interest in science and technology. Furthermore, the low level of active interest in science and technology among women, who account for over half of the population, is a matter which should be given great attention.

We have great hope for the future progress of science and technology in terms of resolving global environmental issues and other issues global in scale and in terms of attaining a peaceful, higher standard of living. For example, in light of forecasts for an explosive increase in the worlds population, especially in developing countries, in order to give consideration both to the demands of countries aiming to develop their domestic industries and increase their standard of living and to the conservation of the global environment, it is essential to introduce new measures for resolution based on the development of science and technology. On the domestic front, as the population become older, the development of science and technology will play an important role in building a society that can provide pleasant and valuable lives for Japanese of all ages ranging from the young to the elderly.

In planning for the development of science and technology in the future, there is a need to give sufficient consideration to the fact that the influence exerted on humans and society through the development of science and technology is not necessarily completely positive in nature. The development of science and technology can also brings about new problems. For example, as witnessed in the area of genetics and organ transplants, the advance of life sciences has brought new issues related to human dignity and ethics. There is no denying that the earth's environmental problems have been brought about through the expansion of human activities that has accompanied the development of science and technology.

For this reason, a major issue for Japan in the future is, while cautiously avoiding the creation of new problems stemming from the development of science and technology, to make an effort to meet needs both at home and abroad in developing science and technology, spreading the results and using them appropriately. However, this cannot be achieved through the efforts of the government, scientists and engineers alone. In addition to the government, scientists and engineers, the nation as a whole must play a major role in the area of science and technology where new ideas and products keep appearing, in terms of quickly understanding advanced results, studying them and quickly putting them to their maximum potential use. The nation as whole must also play a major role in appealing both directly and indirectly to the government, corporations and scientists and engineers to influence the direction and pace of development of science and technology.

People can, for example, raise issues which should be resolved in terms of the development of science and technology and clarify their needs. They can exert various effects regarding the activities of science and technology by evaluating, whether agreeing or disagreeing, on the efforts of scientists and engineers. Such efforts on the part of ordinary people may be an important factor in steering the development of science and technology down an appropriate path in the future. These efforts are also thought to be significant in the sense that scientists will feel the results of their work and be able to make further advancements in their work.

To adequately fulfill this role, the nation as a whole needs to avoid relying solely on the government and scientists and engineers to address issues related to science and technology. The nation needs to take a broader perspective toward the possibility of new problems stemming from the development of science and technology and have sufficient capacity to deal with them appropriately. To do this, it is necessary that society look at the role played by science and technology and the role that should be played by it as issues that effect them directly, take an interest in these issues and assume a positive attitude in addressing them.

In light of the outlook for the increasingly large role of advanced science and technology in future society, this approach is extremely important in the sense of providing a basic foundation for the people needed to participate in a society of advanced science and technology and provide for its sound management.

There is a need to focus attention in the future on the declining popularity of science and technology among the young people from the point of view that there is strong concern that this trend will lead to a decrease in interest of the nation as a whole in the science and technology that is so vital to Japan.

1.2 Background of the Declining Interest in Science and Technology

Various causes have been recently pointed out as forming the background of the declining popularity of science and technology among young people. "The Survey on High-Tech Researchers and Engineers" produced the following reasons which were pointed out by researchers who felt that there was a declining popularity of science and technology among young people: "Society holds scientists and engineers in low regard and does not give the status them deserve" (67.1%), "Young people are not interested in subjects like physics and chemistry because the emphasis is placed on examination techniques" (40.1%), "Schools are not passing on the enjoyment of studying science to the younger generation" (36.0%), "People who have scientific and engineering understanding capable to make their mark in fields other than science and technology" (32.6%) and "The way young people think has changed from logical thinking to a sensuous thinking" (31.8%) (Figure 1-2-1).

Also, the "Survey on Private Enterprises' Research and Development" revealed the following main items which were selected by private companies as the reasons for the declining popularity of the manufacturing industry among science and engineering graduates: "The difference in salaries with other jobs and industries" (66.0%), "Young people have a bad image of the working environment in manufacturing industries" (64.4%) and "Jobs and industries which require a special knowledge of science and engineering have expanded as far as the world of finance" (40.8%)(Figure 1-2-2).

The majority of young people who are involved in science and technology activities feel that the reason for the declining popularity of science and technology among young people and the declining popularity of the manufacturing industry among science and engineering graduates is related to the problems of how they are treated and their working environment. It seems that many people responding to these surveys see the declining

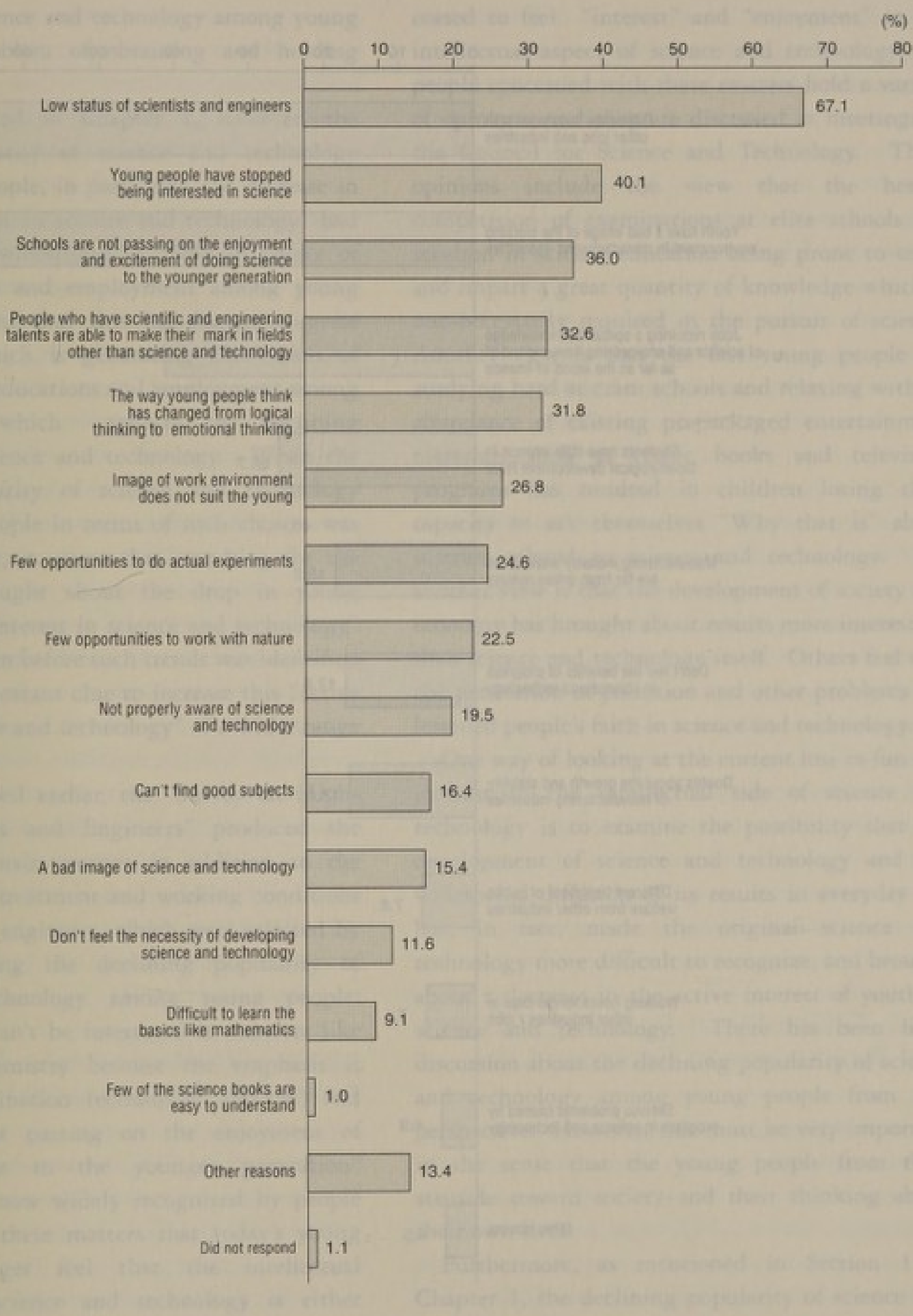


Figure 1-2-1 Factors considered by researchers as the causes of the declining popularity of science and technology among young people

Note: Multiple answers.
Source: Science and Technology Agency, "Survey on High-Tech Researchers and Engineers (1993)".

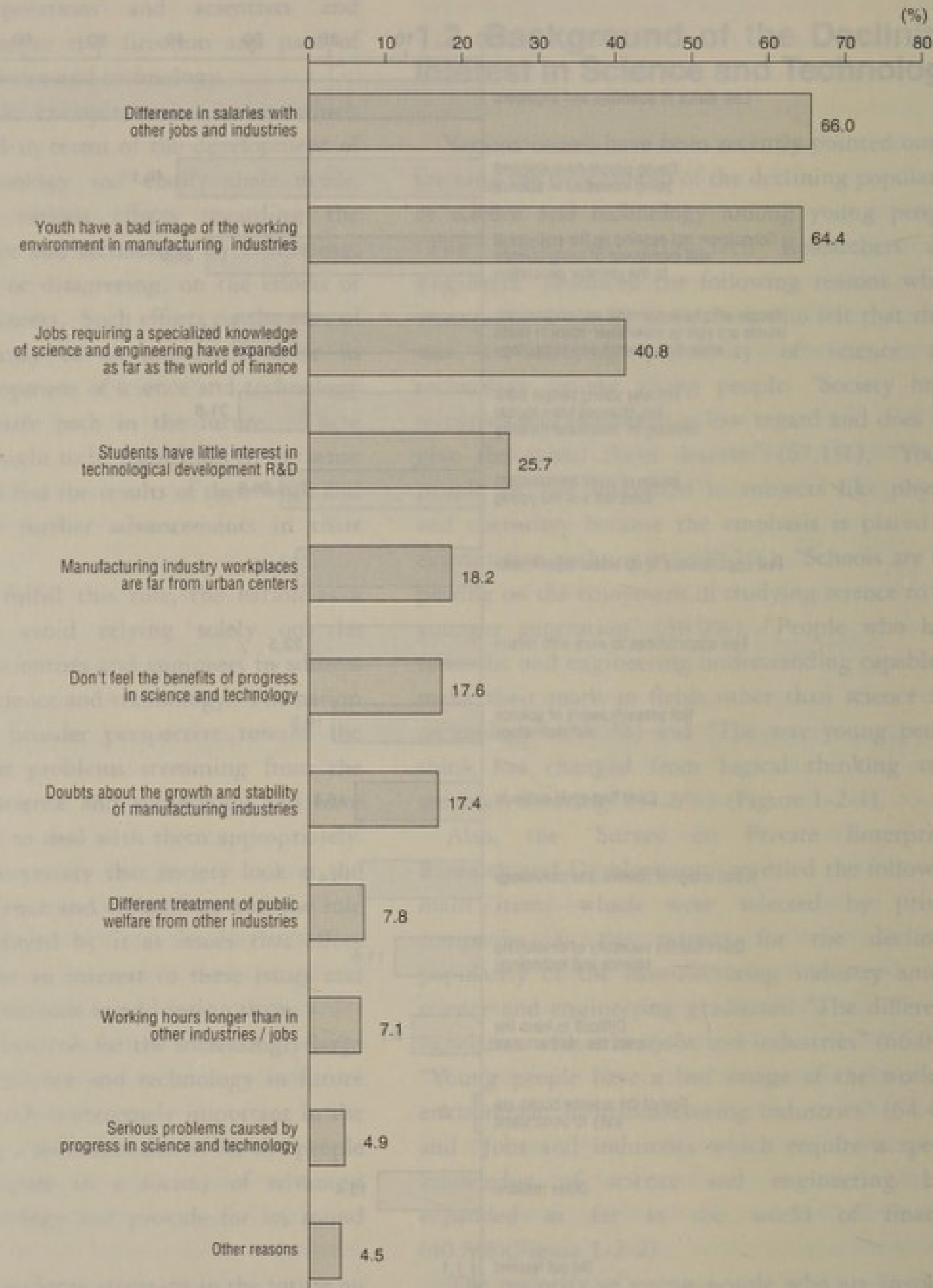


Figure 1-2-2 Factors considered by companies as the causes of the declining popularity of the manufacturing industry among science and engineering graduates

Note: Multiple answers.
Source: Science and Technology Agency, "Survey on Private Enterprises' Research(1993)".

popularity of science and technology among young people as a problem of obtaining and holding capable people.

As we analyzed in Chapter 1, however, the declining popularity of science and technology among young people, in particular, the decrease in "an active interest in science and technology" had already become widespread in 1988 in choice of higher education and employment among young people. It seems that this has formed a great undercurrent which is generating the trends of choice of higher educations and employment among young people which reflects the declining popularity of science and technology. When the declining popularity of science and technology among young people in terms of such choices was first pointed out, it seems that searching for the factors that brought about the drop in young people's "active interest in science and technology" that would be seen before such trends was identified would be an important clue to increase this "active interest in science and technology" of a wider range of young people.

As we described earlier, the "Survey on High-Tech Researchers and Engineers" produced the following two main reasons in addition to the problems of the treatment and working conditions of scientists and engineers, which were selected by people as causing the declining popularity of science and technology among young people: "Young people can't be interested in subjects like physics and chemistry because the emphasis is placed on examination techniques" (40.1%) and "Schools are not passing on the enjoyment of studying science to the younger generation" (36.0%). It is now widely recognized by people concerned with these matters that today's young people no longer feel that the intellectual component of science and technology is either "interesting" or "enjoyable". It seems that this change in attitude of young people has brought about the drop in their "active interest in science and technology" which occurred before the trend of the declining popularity of science and technology among young people was identified.

As regards the reasons that young people have ceased to feel "interest" and "enjoyment" in the intellectual aspect of science and technology, the people concerned with these matters hold a variety of opinions, and they are discussed at meetings of the Council for Science and Technology. These opinions include the view that the heated competition of examinations at elite schools has resulted in science education being prone to teach and impart a great quantity of knowledge which is not necessarily required in the pursuit of science. Another view is that the fact young people are studying hard at cram schools and relaxing with an abundance of existing prepackaged entertainment materials such as comic books and television programs has resulted in children losing their capacity to ask themselves "Why that is" about matters related to science and technology. Yet another view is that the development of society and economy has brought about results more interesting than science and technology itself. Others feel that the generation of pollution and other problems has lessened people's faith in science and technology.

One way of looking at the current loss in fun and interest in the intellectual side of science and technology is to examine the possibility that the development of science and technology and the widespread diffusion of its results in everyday life has, in fact, made the original science and technology more difficult to recognize, and brought about a decrease in the active interest of youth in science and technology. There has been little discussion about the declining popularity of science and technology among young people from this perspective. However, this must be very important in the sense that the young people from their attitude toward society and their thinking about their own lives.

Furthermore, as mentioned in Section 1 of Chapter 1, the declining popularity of science and technology among young people in terms of choices of higher education and employment is pointed out in the United States and the United Kingdom from the middle of the 1980s. There are major differences between the educational system of Japan and those of the United States and the United Kingdom. In terms of the development of science and technology and the widespread diffusion of its results into people's lives, however, there are many points in common. It could be said that the shift in the position of science and technology in people's lives forming the structural causes common to these countries in terms of the declining popularity of science and technology among young people.

Moreover, as indicated in Section 2 of Chapter 1, the recent decrease in the active interest of young people in science and technology seems to be a widely spread phenomenon occurring during the teens. This period seems to be the process when the way young people see things change from the curiosity and dreams of a child to mature perspective closer to adults based on the realities of life. This means that we cannot deny the possibility that the change in the position of science and technology in people's actual lives is a fundamental factor which influences young people during their growth into adulthood.

In the following section, we examined from this viewpoint the influence of the change in the position of science and technology that people's exert on the recognition and attitudes of young people toward science and technology. Then, we examine the declining popularity of science and technology among young people in terms of the impact exerted on choices of higher education and employment among young people.

1.2.1 Difficulty in Relating Science and Technology to Everyday Life

The way young people see things changes their growth from children into adults shifts from the curiosity and dreams of a child to a more mature perspective closer to adults based on the realities of life. To stimulate and raise an "active interest in science and technology" of young people, it is first of all important to make young people feel that science and technology is something they are familiar with in their everyday lives.

However, while the rapid advance of science and technology in recent years has made available advanced high-tech products with conveniences unimaginable only a decade ago, these advances have meant less opportunities to note such matters as the internal structures, operating principles and manufacturing processes of these products. As a result, although the products of science and technology has become familiar to everyone in their daily lives in as available convenient tools, this is commonly not recognized as a product brought about by "science and technology". People usually are not able to notice or recognize the knowledge of science and technology or the activities of scientists and engineers exist in the background. It seems that such state of things make young people difficult to feel familiar with science and technology compared with the times when the results of science and technology were widely used in people's daily lives.

This situation has brought about the following phenomenon which can be called the "black box syndrome of science and technology". Though the products of science and technology are recognized as convenient tools which can be used in people's everyday lives, the scientific and engineering knowledge and the activities of the scientists and engineers exist in the background are not really "visible" and people can see only the superficial characteristics of product such as the functions, design and brand names. In the following section, we will bring up some causes which seem to bring about this phenomenon in people's lives, and examine their influence.

1.2.1.1 Efforts to Make Science and Technology More Accessible

During the 1980s, semiconductor components become more integrated and low-priced, as a result a variety of high-tech products such as personal computers, word processors, facsimile machines, multi-function telephones and TV game devices, all of which possess high-level information processing functions, become available to the average household.

The high-tech products have widely diffused without people pay special attention to them. As a result, science and technology are not really felt to be surprising or exciting.

As a consequence, young people seems to regard these products merely as a convenience and lose any interest and curiosity in scientific and technological knowledge involved in such matters as an internal structure, operating principles and manufacturing processes of the product; however, such knowledge is the most advanced one.

In addition, these high-tech products have been designed to be easy-to-use, incorporating a variety of ideas and devices eliminating the need for the user to possess any special knowledge about science or technology. In many cases, we cannot understand the internal structure or operating principles of these products by merely looking at them from the outside, and there is not even any necessity at all to know such matters. Moreover, in the past it has been the normal practice to take apart clocks or electrical products to repair them; recently this is hardly ever done. If a product breaks down, we do not repair it but simply throw it away. Or, if we really want to repair the product, we merely replace one unit with a new one, just like inserting a cassette in a tape recorder. Therefore, the opportunity for people to come into contact with the internal structure or operating principles of industrial products become less and less.

This state of affairs has made it difficult for young people to experience first hand the fact that high-tech products are actually the results of "science and technology". Further more, there are lesser opportunities for young people of today to be challenged or startled into asking themselves various questions about these products. For example, how do they operate? In what way were they made? What kind of people made them? What kind of creative ideas have been incorporated in them? This seems to be one of the reasons why it has become difficult for young people to relate science and technology to everyday life.

Up to the present day, one of the major objectives, and dreams, of technological development has been to produce technology which requires no special prior knowledge, a technology which allows anyone to enjoy its benefits, and to make available as much as possible a variety of easy-to-use and low-cost products. However, we must also add that it would be ironic indeed if the results of this progress made by many engineers to achieve this objective has been to create the current declining popularity of science and technology among young people.

1.2.1.2 The Technical Advancement and Specialization of Science and Technology

As science and technology has been developed rapidly in recent years, industrial products have spread to people's daily lives, driven forward by advanced technology. However, they have also become products that people cannot at all understand the internal structures, operating principles or manufacturing processes except for those specializing in them. To the average citizen, these aspects of products cannot even be imagined; it seems as if these products have arrived from some distant planet.

Now, knowledge about the basic principles and laws in the science system are taught in school, but knowledge about the internal structures, operating principles and manufacturing processes of these advanced industrial products which are widely spread throughout our everyday lives, are almost never made so that we can easily understand them. Companies advertise and provide information about the superficial features of their products such as their functions, design and brand names, but it seems that they do not provide the consumer with information about the internal structures, operating principles and manufacturing processes in a way that the average person can understand them.

As an end result, young people have an insufficient opportunity to have their curiosity aroused concerning the internal structures, operating principles and manufacturing processes of these products. Moreover, there are less and less opportunities for them to become aware of the existence of the places where research and manufacturing are conducted.

This state of affairs has resulted in the fact that it is only the superficial features of these products which link together the average citizen and the research and manufacturing locations. It seems that the average citizen scarcely recognize the existence of knowledge of the science and technology in the background, and the activities of the scientists and engineers, who developed these products.

1.2.1.3 The Increased Role of Large Organizations in Scientific and Technological Activity

The advancement and complexity of science and technology in recent years has resulted in an increasingly strong tendency for scientific and technological activities to be carried out not by an individual but by large organizations. As a consequence, it is now a normal practice for today's outstanding new products to be developed within large organizations. It is extremely difficult to link the results with any particular individual. It seems to be more significant that we speak about an organization such as a company as the entity which carries out the technological activities to develop a new product which raises our interest and influences our daily lives. On the other hand, the activities of scientists and engineers become more difficult to be spoken about.

In addition, the distance between the places where scientific and technological activities are conducted and the places where we conduct our daily lives becomes more physically separated as places where scientific and technological activities are moving from small-scale manufacturing plants in the centers of towns and cities to large-size plants in the suburbs where they are unnoticed by ordinary people. As a result, places where scientific and technological activities are becoming increasingly difficult to be recognized by people not directly involved in the activities.

As a general rule, it seems that scientists and engineers are not good at communicating with other people, and also they sometimes do not effectively pass on their information to society as a whole. These impressions are supported by the results of a survey which revealed the tendency of those students wishing to enter science and engineering faculties at colleges, students with a relatively high possibility to become scientists and engineers in the future. The results of the survey revealed that such students are more negative than students wishing to enter other fields about aspects related to communication such as "Socializing with other people" and "Reading and writing" (Figure 1-2-3). In this manner, the tendency of scientists and engineers not to be good at communicating make it difficult for ordinary people to understand and imagine the scientific and technological activities that are contributing to society.

This tendencies has made the research and manufacturing locations, and the scientists and engineers working at them difficult for the young people.

1.2.1.4 The Widespread Satisfaction with Material Prosperity

Scientific and technological development in recent years has contributed to the expansion of the Japanese economy and the realization of material wealth for the people. We would now like to analyze how these developments have been recognized by young people.

Youth Affairs Administration of the Management and Coordination Agency carried out a series of surveys targeting young people (between 15 and 23 on April 1st of the year of the survey entitled "The Survey on Consciousness of Solidarity of Youth". These surveys reveal the thing Japan can be proud of its position in the world as the percentage of people who replied that "People's lives are prosperous" rose from 8.2% in 1970 to the highest figure of 36.3% in 1990 (Figure 1-2-4). People were also asked whether or not they were satisfied with their lives at present. The percentage of people who replied that they were "Satisfied" or "Fairly satisfied" has been increasing from 67.1% in 1967 to 82.2% in 1990. Conversely, the percentage of those who replied that they were "Unsatisfied" or "Somewhat unsatisfied" has been decreasing from 32.5% in 1970 to 16.9% in 1990 (Figure 1-2-5). These figures show that not only do young people feel proud of their prosperity but also that they themselves are satisfied with their own lives.

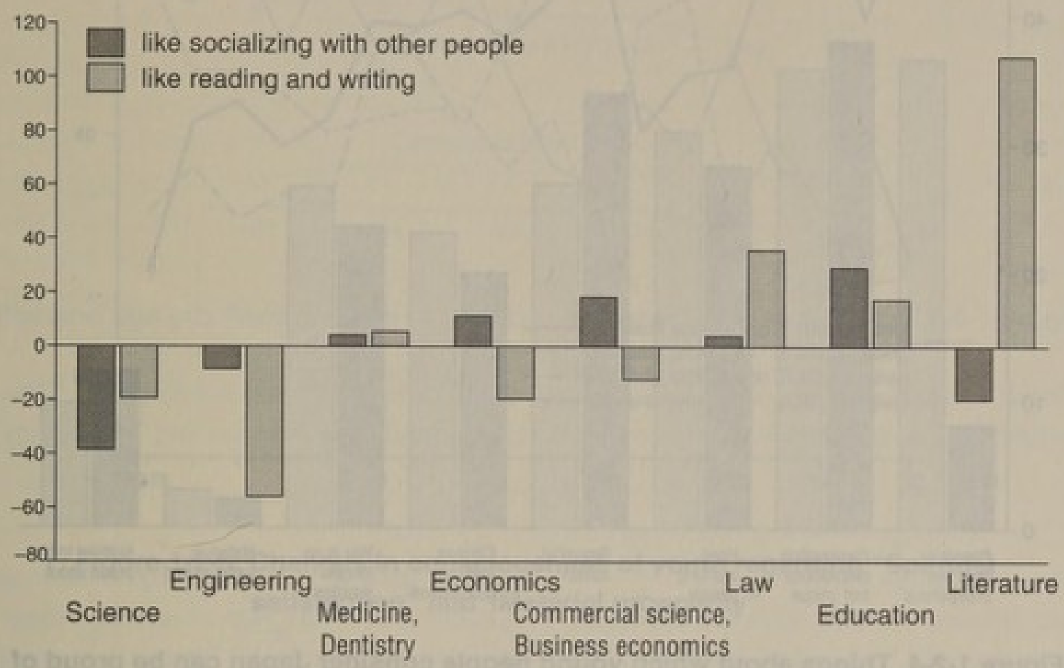


Figure 1-2-3 Self-image of university applicants about communication by faculty of their choice

Notes: 1. This figure represents points of self-image about each tendency plus difference from the average point of the whole. "like very much" counts for +200, "like" for +100, "do not like very much" for –100, "do not like at all" for –200.

2. Survey target: third-year students who wish to enter a university or a colledge
Survey period: November 1989 –January 1990.

Source: Science and Technology Agency, National Institute of Science and Technology Policy, "How the Information on Science and Technology Activities Should Be Sent to Younger Generation (FY 1992)".

The Prime Minister's Office has produced "Public Opinion Survey Concerning People's Lifestyles". This survey revealed that there has been an increase since the beginning of the 1980s in the percentage of young people in their early and late twenties who attach importance to "A spiritual happiness". At the same time, the percentage of those who attach importance to "Material prosperity" has declined. This seems to reflect the fact that because there has been an increase in the diffusion of durable goods brought about by higher levels of income, the demand for material prosperity has been fairly well satisfied. Therefore, it seems people are increasingly demanding lifestyles which are prosperous as regards their spiritual or psychological dimensions as the next stage (Figure 1-2-6). In this manner, as a result of attaining a material prosperity in people's lives, young people are demanding a spiritual or psychological prosperity in the form of leisure, release from

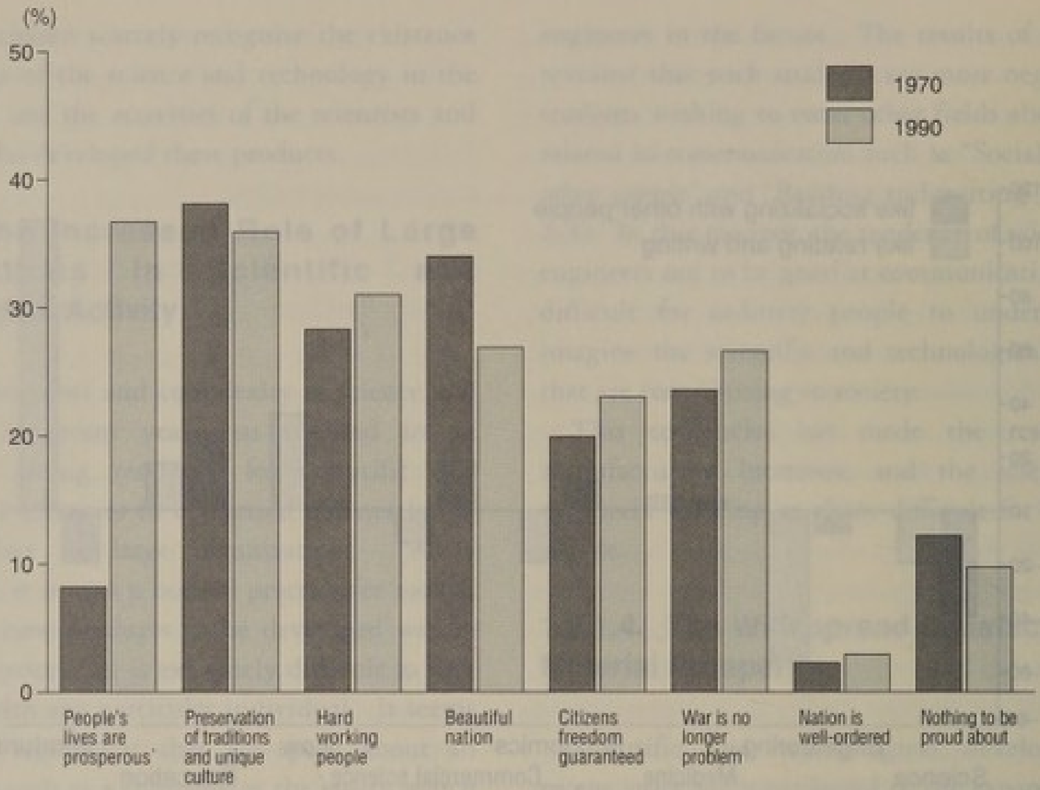


Figure 1-2-4 Things about which young people consider Japan can be proud of

Note: Survey target: Youth aged between 15 and 23 on April 1st of the survey year.
Source: Youth Affairs Administration, Management and Coordination Agency, "Survey on Consciousness of Solidarity of Youth (1991)".

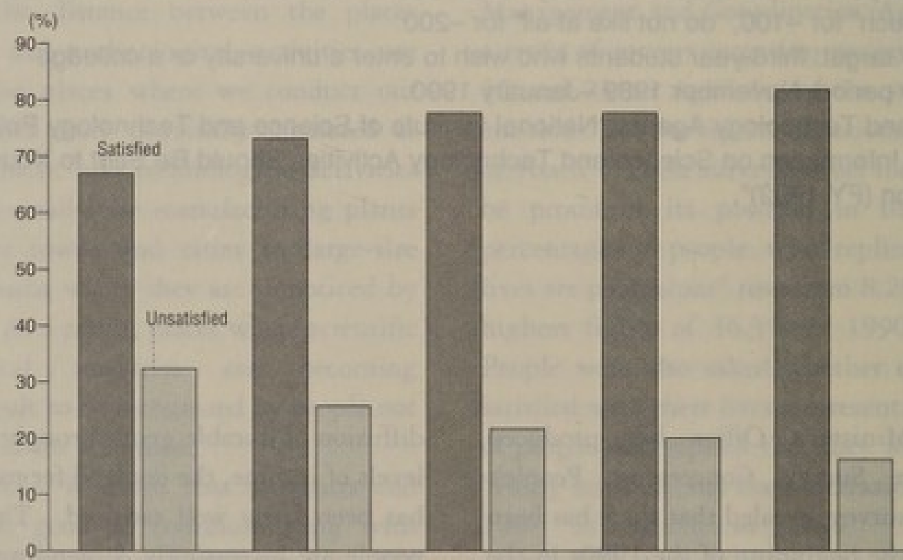


Figure 1-2-5 Degree of satisfaction about life of youth

Notes: 1. "Satisfied" is the total of "I am satisfied" and "I am somewhat satisfied" replies.
"Unsatisfied" is the total of "I am unsatisfied" and "I am somewhat unsatisfied" replies.
2. Survey target: Youth aged between 15 and 23 on April 1st of the survey year.
Source: Youth Affairs Administration, Management and Coordination Agency, "Survey on Consciousness of Solidarity of Youth (1991)".

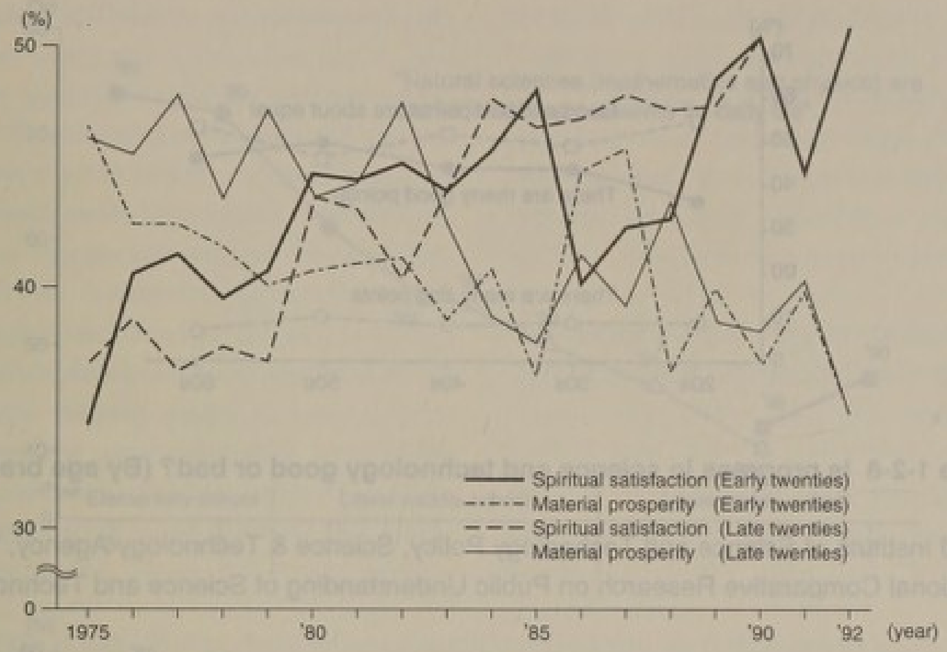


Figure 1-2-6 Changes in consciousness of youth regarding "Spiritual satisfaction" and "Material prosperity"

Source: Prime Minister's Office, Public Relations Office, "Survey on Japanese Lifestyle".

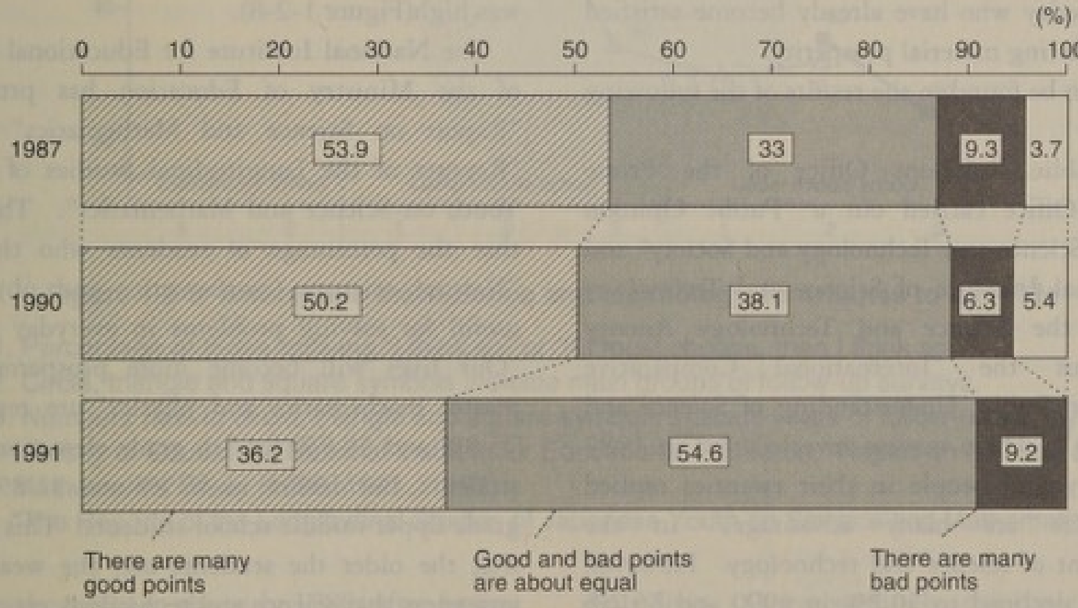


Figure 1-2-7 Is progress in science and technology good or bad?

Note: This graph shows replies from people in their twenties.

Sources: Science & Technology Agency, National Institute of Science and Technology Policy, "The International Comparative Research on Public Understanding of Science and Technology (1991)".
Prime Minister's Office, Public Relations Office, "Public Opinion Survey on Science, Technology and Society (1987, 1990)".

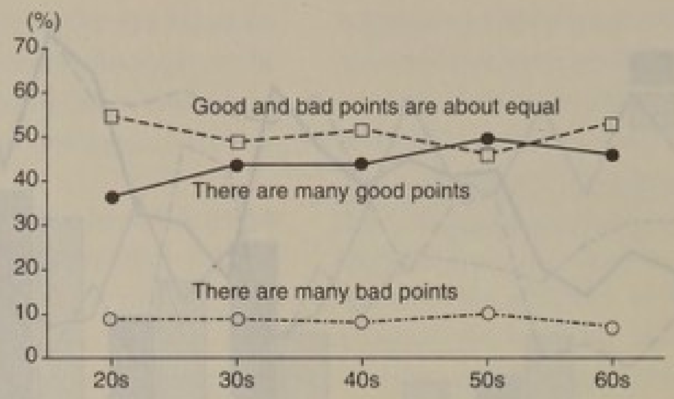


Figure 1-2-8 Is progress in science and technology good or bad? (By age bracket)

Source: National Institute of Science and Technology Policy, Science & Technology Agency, "The International Comparative Research on Public Understanding of Science and Technology (1991)".

pressure and comfort more than ever before.

In the past, Japanese young people had hoped for material prosperity and had great expectation for developments in science and technology. It seems that this had not been passed on to the young people of today who have already become satisfied with the existing material prosperity.

These can be found in the results of the following surveys.

The Public Relations Office of the Prime Minister's Office carried out a "Public Opinion Survey on Science and Technology and Society" and the National Institute of Science and Technology Policy of the Science and Technology Agency carried out the "International Comparative Research on Public Understanding of Science and Technology". These surveys revealed that in 1987 53.9% of young people in their twenties replied that "There are many advantages" in the development of science and technology. However, this figure declined to 50.2% in 1990 and 36.2% in 1991. At the same time, the percentage of those who replied that "There are many disadvantages" fluctuated between 9.3% in 1987, 6.3% in 1990 and 9.2% in 1991. On the other hand, the percentage of those who replied that "Advantages and disadvantages are about equal" increased from 33.0% in 1987, 38.1% in 1990 to 54.6% in 1991(Figure 1-2-7). Looking at each age bracket, unlike the other age brackets, those in their twenties who replied " There are many advantages" was low and the percentage who replied "Advantages and disadvantages are about equal" was high(Figure 1-2-8).

The National Institute for Educational Research of the Ministry of Education has produced a "Report on Science and Mathematics" and the "Reports of the Longitudinal Studies of Japanese Youth on Science and Mathematics". These show that the percentage of students who think that "Natural sciences (mathematics and physics) are useful for solving problems in everyday life" and "Our lives will become more prosperous if we master mathematics and physics" are respectively 73.8% and 58.8% for 5th grade elementary school students, but decline to 46.5% and 31.8% for 3rd grade upper middle school students. This indicates that the older the students are, the weaker their awareness that science and technology contribute to daily life is (Figure 1-2-9).

These results reveal that young people do not particularly feel that developing and acquiring knowledge about science and technology will solve problems of everyday life or will make their lives more prosperous.

Japan became one of the leading economic

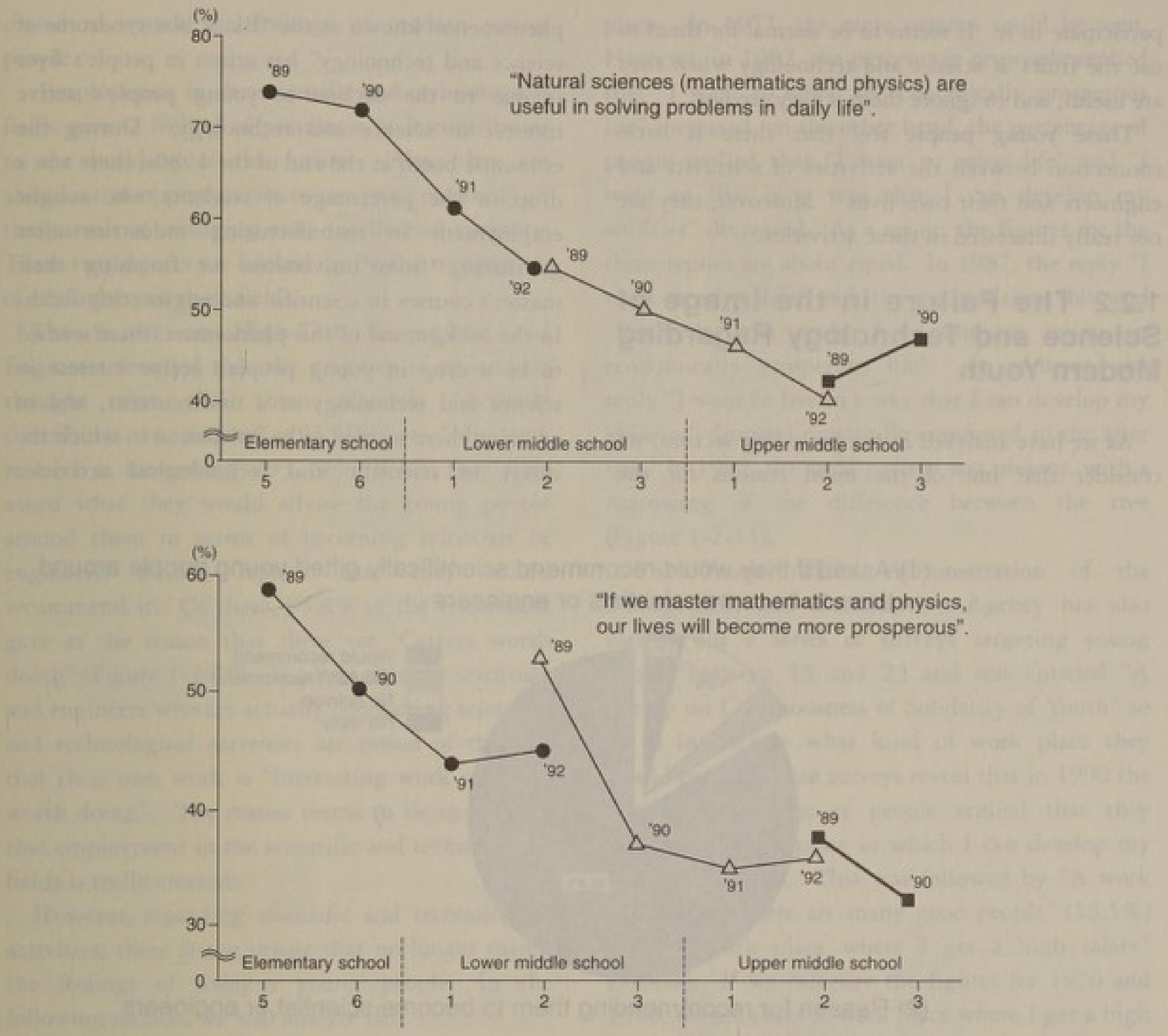


Figure 1-2-9 Awareness that science and technology contributes to daily life

Notes: 1. Percentage of those replying "I think so" or "If I must choose, then I think so."
2. Circle, triangle and square symbols indicate main groups of follow-up surveys.
3. Numbers next to circle, triangle and square symbols indicate years of follow-up surveys.

Sources: Ministry of Education, National Institute for Educational Research, "Report on Science and Mathematics Study (1990, 1991, 1993).
"The Reports of the Longitudinal Studies of Japanese Youth on Science and Mathematics (1992)".

powers in the world in the early 1980s after having weathered the oil crisis in the 1970s. As a result, young people recognize Japan as a prosperous country, and feel less dissatisfaction about their lives. Since the 1980s, there have been very few opportunities for young people to actually experience the inconvenience resulting from the insufficient development of technology in their daily lives. Correspondingly, the consciousness to realize prosperity and solve inconveniences in daily life through science and technology has become uncommon.

Under this circumstance, young people accept the present situation of science and technology as a given one, rather than strongly feel the necessity to develop science and technology and actively participate in it. It seems to be normal for them to use the fruits of science and technology when they are useful, and to ignore them if they are not.

These young people feel that there is little connection between the activities of scientists and engineers and their own lives. Moreover, they are not really interested in these activities.

1.2.2 The Failure in the Image of Science and Technology Regarding Modern Youth

As we have analyzed in the preceding section, we consider that one of the main reasons for the phenomenon known as the "Black box syndrome of science and technology" has arisen in people's lives is due to the decline in young people's active interest in science and technology. During the economic boom at the end of the 1980s, there was a drop in the percentage of students who sought employment in manufacturing industries after graduating from universities or finishing their master's courses in scientific and engineering fields. In the background of this phenomena, there seemed to be a drop in young people's active interest in science and technology as a undercurrent, and in addition there seemed to be a situation in which the image of scientific and technological activities

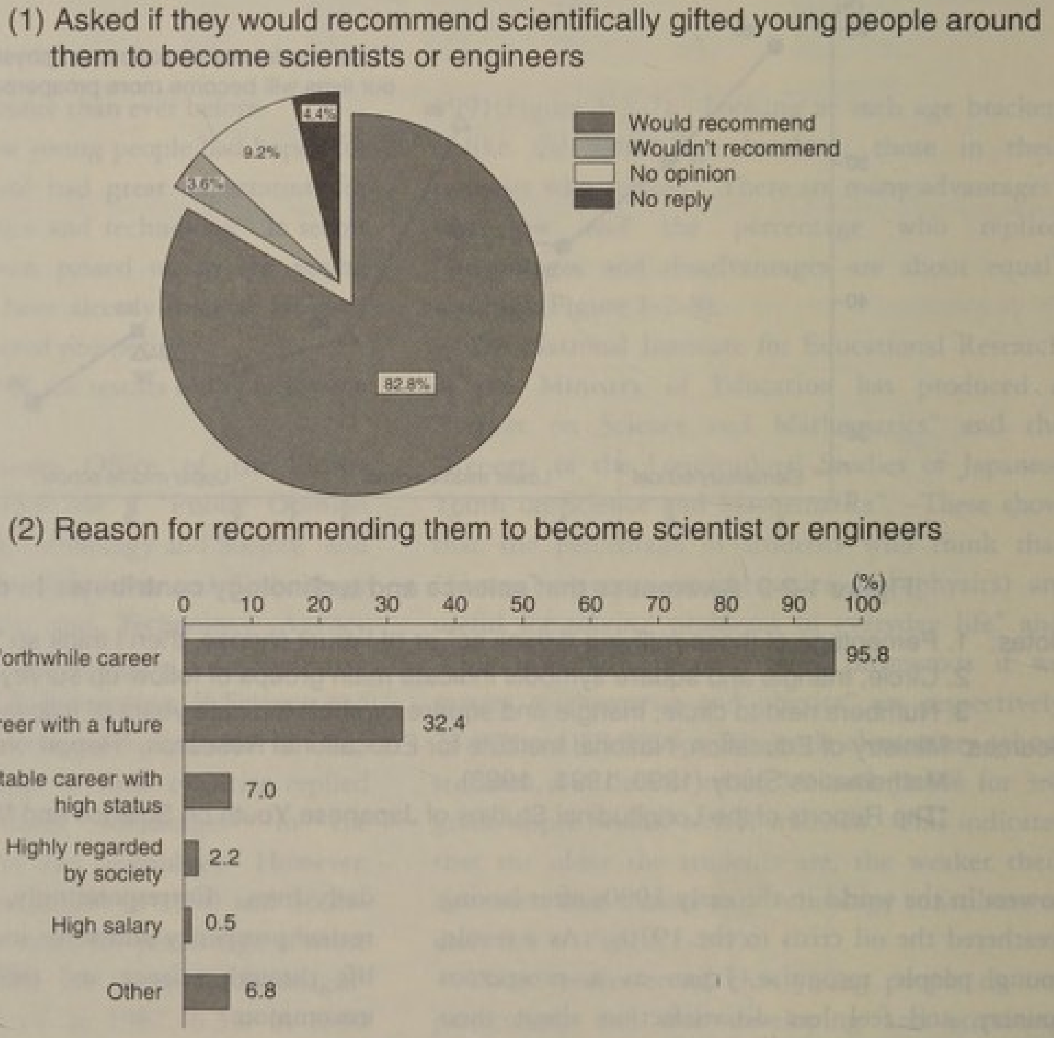


Figure 1-2-10 Opinions of scientists and engineers

Source: Science and Technology Agency, "Survey on High-Tech Researchers and Engineers (1993)".

ceased to match the feelings of modern young people.

Employment in the scientific and technological fields gives a feeling of proudness as it contributes to the building of the future. Also, they are abundant in opportunities to use one's creativity in the pursuit of satisfying one's intellectual curiosity. These two aspects are backed up by the recognition of researchers in these fields.

The Survey on High-Tech Researchers and Engineers revealed that the majority of researchers thought that their own research "Actually contributes to society" (93.4%) or "My own research is interesting" (93.2%). When they were asked what they would advise the young people around them in terms of becoming scientists or engineers, 82.8% replied that they would recommend it. Of these, 95.8% of the researchers gave as the reason that these are "Careers worth doing" (Figure 1-2-10). It seems that the scientists and engineers who are actually conducting scientific and technological activities are proud of the fact that their own work is "Interesting work which is worth doing". The reason seems to lie in the fact that employment in the scientific and technological fields is really creative.

However, regarding scientific and technological activities, there is the image that no longer match the feelings of today's young people. In the following section, we will analyze this.

1.2.2.1 The Changing Disposition of Young People

The Japan Productivity Center and the Junior Executive Council of Japan have jointly been carrying out a series of "Survey on Consciousness about Working" which target new company employees in order to investigate their consciousness of new male and female company employees regarding work. These surveys show that in 1972 the highest percentage of people replied that "I want to live in a way that I can develop my abilities". This reply was followed by "I want to enjoy life" and "I want to enjoy an economically prosperous life" in second and third place. In 1977, the same pattern could be seen. However, in 1982, the percentage of people replied that "I want to enjoy an economically prosperous life" increased, on the other hand, the percentage of people replied that "I want to enjoy life" and "I want to live in a way that I can develop my abilities" decreased. As a result, the figures for the three replies are about equal. In 1987, the reply "I want to enjoy life" took the top position, followed closely by the reply " I want to enjoy an economically prosperous life". In contrast, the reply "I want to live in a way that I can develop my abilities" dropped drastically composed to the after two. In 1992, the same pattern was present, with a narrowing of the difference between the tree (Figure 1-2-11).

The Youth Affairs Administration of the Management and Coordination Agency has also carried out a series of surveys targeting young people between 15 and 23 and was entitled "A Survey on Consciousness of Solidarity of Youth" so as to investigate what kind of work place they would prefer. These surveys reveal that in 1990 the highest percentage of people replied that they wanted "A work place in which I can develop my talents" (62.7%). This was followed by "A work place where there are many good people" (56.5%) and "A work place where I get a high salary" (51.4%). If we compare the figures for 1970 and 1990, we see that "A work place where I get a high salary moved from 36.2% to 51.4% and "A work place where I can take vacations and there is little overtime" moved from 16.6% to 37.9%. All in all, there is a strong tendency to place importance on the tangible advantages offered by the work place (Figure 1-2-12).

The series of "Survey on Consciousness about Working" questioned whether young people felt that they must face hardship when they make progress. There was a drop in the number of those who replied "We should expect to face hardships when we make progress" from 61% in 1969 to 40% in 1992. This reveals that there is a trend for young people to abandon the belief of former generations that it is acceptable/natural to experience hardship while they are young (Figure 1-2-13).

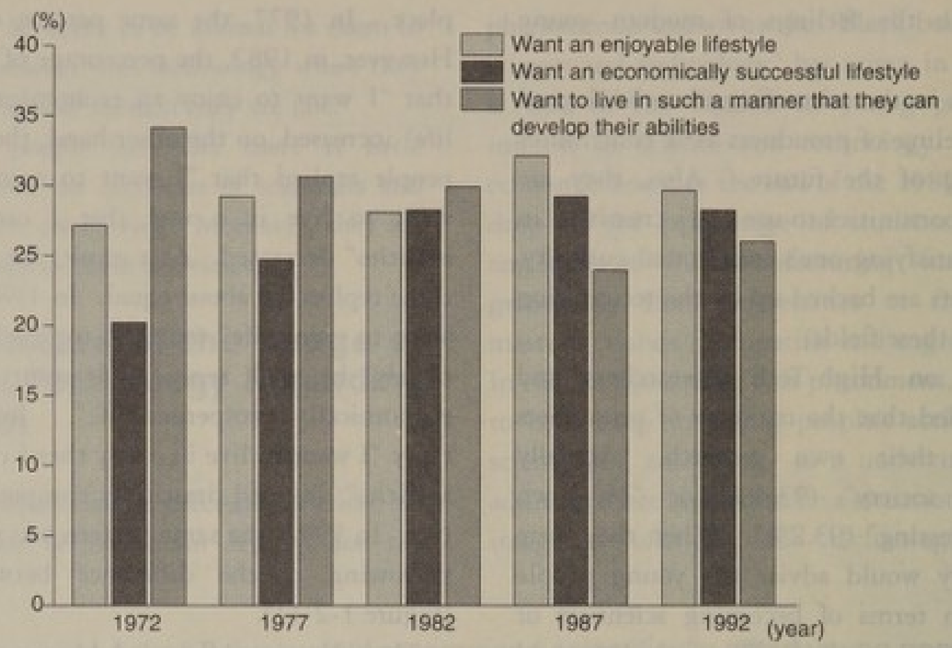


Figure 1-2-11 Changes in work aims of new male company employees

Source: Japan Productivity Center and The Junior Executive Council of Japan, "Survey on Consciousness about Working".

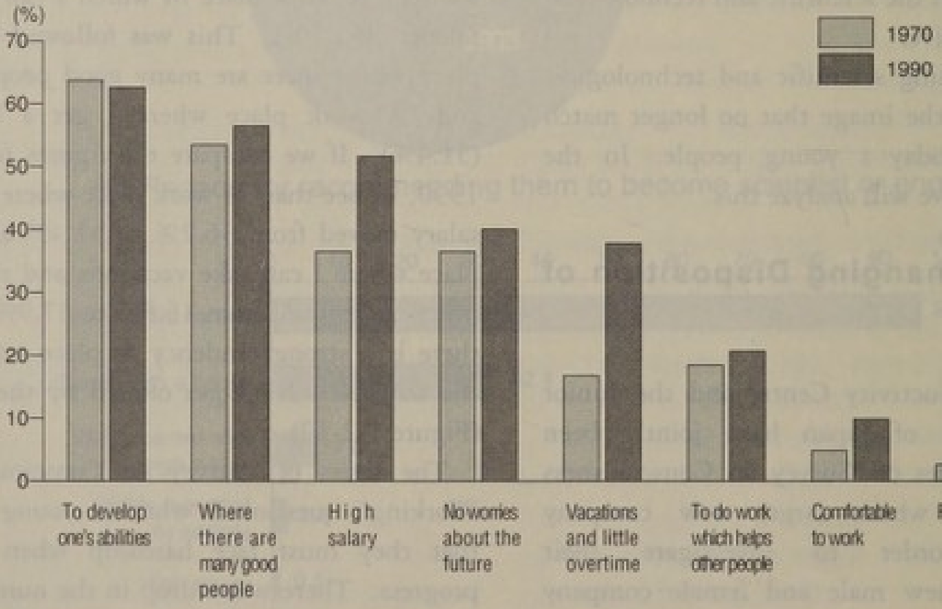


Figure 1-2-12 What youth desire in workplaces

Note: Survey target: Youth between 15 and 23 on April 1st of survey year.
Source: Management and Coordination Agency, Youth Affairs Administration, "Survey on Consciousness of Solidarity of Youth (1991)".

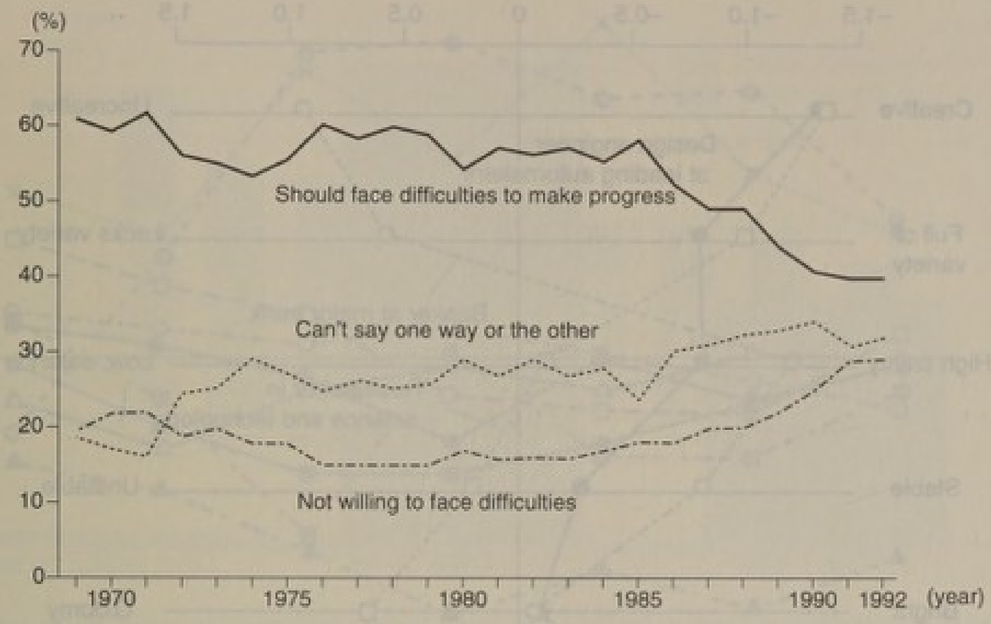


Figure 1-2-13 Changes in awareness of difficulties among new company employees

Source: Japan Productivity Center and The Junior Executive Council of Japan, "Survey on Consciousness about Working".

As the foregoing shows, recently young people are oriented toward "An enjoyable and economically prosperous life" and "A work place which provides high income with only limited restrictions on one's time". As for "The hardships of youth", a strong tendency has emerged for them to attach importance to the tangible advantages available and the avoidance of hardships.

1.2.2.2 The Image of Lifestyle of Science and Engineering Students in Universities

The National Institute of Science and Technology Policy of the Science and Technology Agency carried out a survey which investigated the images held by 3rd grade upper middle school students concerning the lives of science and engineering students in university. Eighty-seven percent of the upper middle school students thought that science and engineering students in university spent their time studying. On the other hand, only 15.7% of the students thought that arts students in university are busy with studying. Also, the upper middle school students were asked if they thought that a university student's life holds promise for the future, is advantageous for obtaining employment, is serious, is full of interesting changes and is stylish. In the case of science and engineering students in university, the affirmative replies were 75.3%, 71.9%, 67.5%, 56.5% and 37.5%, respectively. In the case of arts students in university, the corresponding affirmative replies were 25.2%, 24.3%, 14.5%, 36.2% and 24.2%, respectively. It is clear from these results that upper middle school students tend to hold an image that science and engineering students in university are busy studying.

1.2.2.3 The Image of Occupations in the Fields of Science and Technology

It appears that young people regard employment related to science and technology, namely, working as a scientist or engineer, rather negatively with a utilitarian image in comparison with other types of employment. In this context, let's look at the

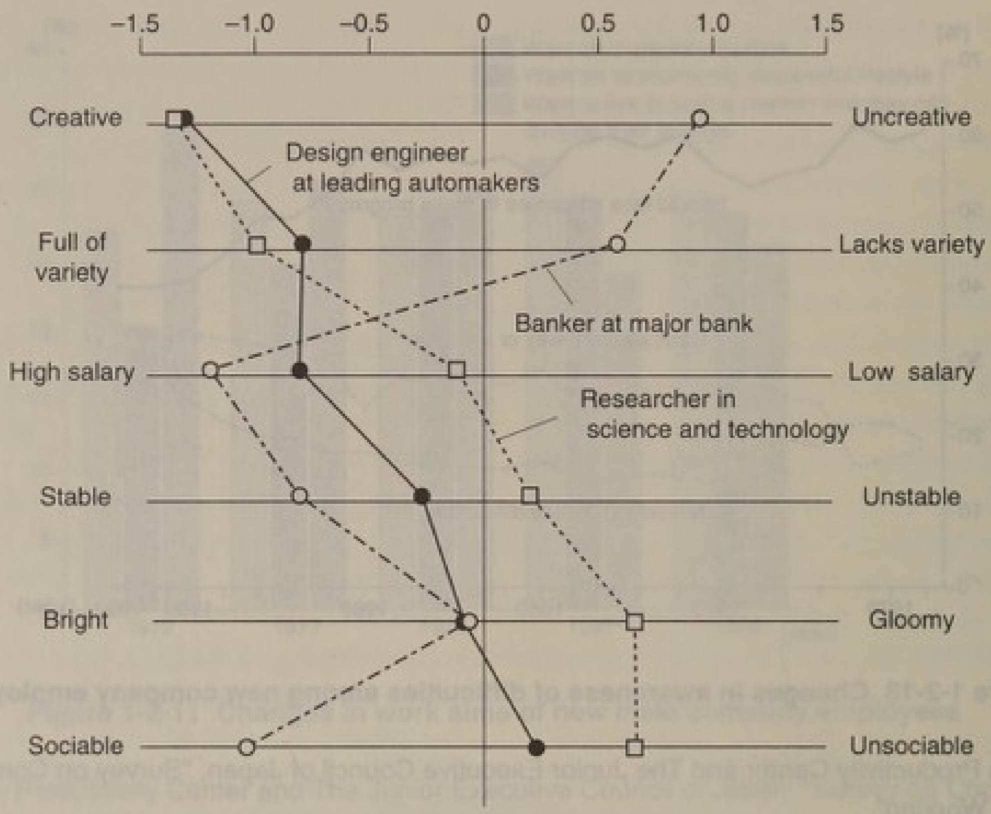


Figure 1-2-14 Images of selected occupations among upper middle school students

Notes: 1. Respondents were asked to give one of five evaluations for each item, with "very" given ± 2 points, "slightly" ±1 point and "neither" 0 points. Figures shown represent the mean scores for each item.

2. The survey was carried out between October and November 1992.

Source: From the research by Science and Technology Agency, National Institute of Science and Technology Policy.

images of various jobs held by high school students.

The survey by the National Institute of Science and Technology Policy of the Science and Technology Agency offered two examples of a "Design engineer in a major automaker" and a "Researcher in the science or technology fields" as science-related jobs, and a "Banker in a major bank" as an arts-related job.

The survey then investigated the images held by high school students of these three different jobs by means of comparing the average scores awarded to such polarities as "Bright-gloomy". The results revealed that the arts-related job of an "Banker in a major bank" was regarded as having a negative image of being "Uncreative" and "Having no variety". However, at the same time this job held a positive image for the utilitarian aspects of possessing a "High salary" and "Stability". On the other hand, the science-related jobs of "Design engineer in a major automaker" and a "Researcher in the science or technology fields" held a positive image of being "Creative" and "Full of variety". However, their image as regards the utilitarian aspects of "High salary" and "Stability" was not as favorable as that of the "Banker in a major bank". This tendency was particularly noticeable in the case of a "Researcher in the science or technology fields" (Figure 1-2-14).

It seems, therefore, that young people hold a negative and utilitarian image about jobs related to science and technology in comparison with jobs in other fields such as that of a banker. Let's now

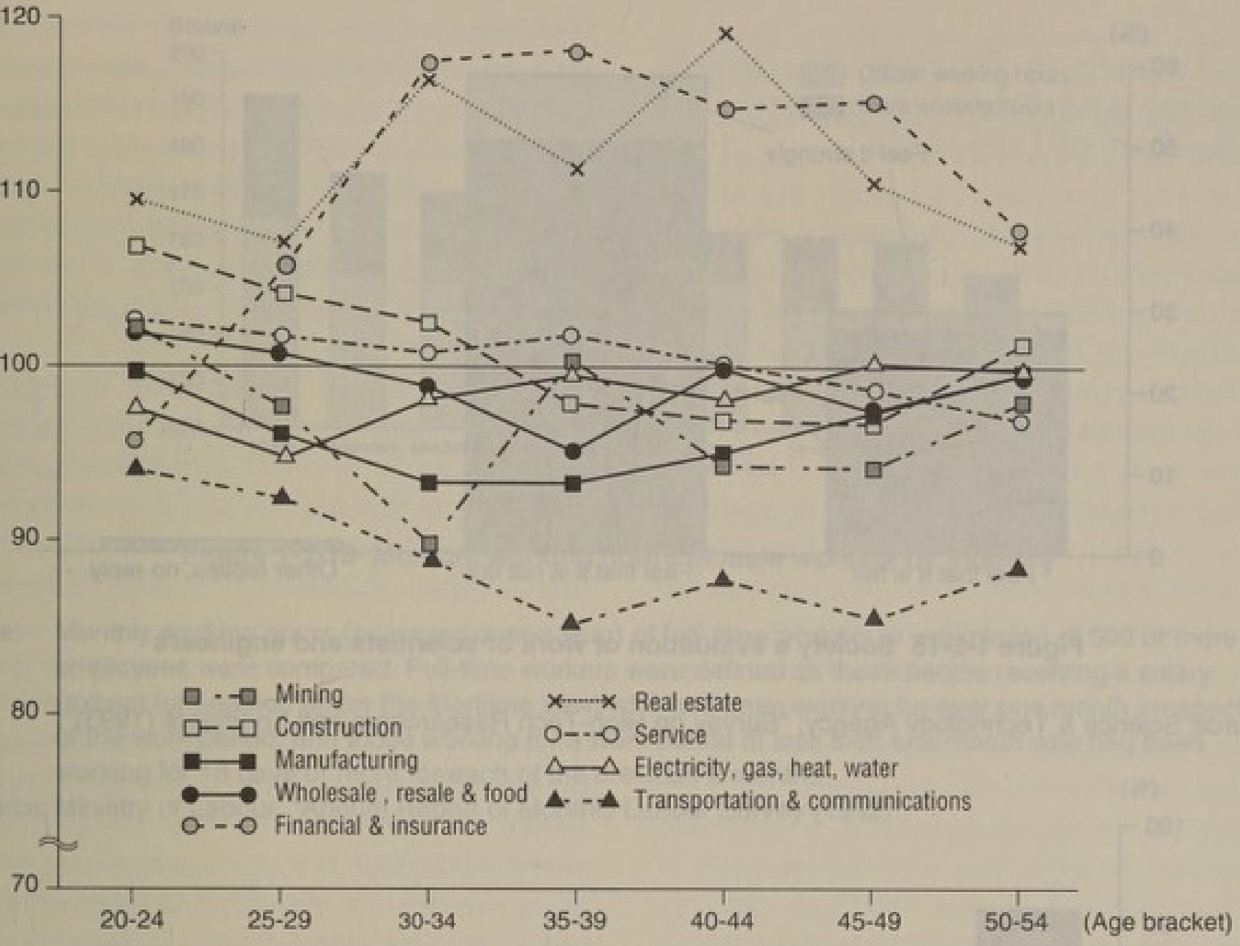


Figure 1-2-15 Levels of official salaries by industry of male workers (Average for all industries = 100)

Note: Levels of official salaries by industry for June 1991 based on a level of 100 for the average of all industries were compared for university-graduate male workers in companies with 1,000 or more employees. Official salaries were divided into "administrative, clerical or technical male workers" in production industries, and "male workers" in non-production industries.

Source: Ministry of Labour, "Basic Survey on Wage Structure (1992)".

examine whether or not this image is reflected in the salaries that are paid. The Ministry of Labour has conducted a "Basic Survey on Wage Structure". If we look at male workers in large companies with a workforce of over 1,000 who are university graduates, we can compare the different levels of salaries in different industries taking the figure of 100 as the figure for an official salary for June 1991 averaged over all industries. In the manufacturing industries, the salaries at all ages ranging from the 20-24 age bracket up to the 50-54 age bracket do not exceed the average industry salary. However, in the financial and insurance industries, the salary for the 20-24 age bracket falls short of the average industry figure at 95.8. However, for the other ages from the 25-29 age bracket up to the 50-54 age bracket the salaries greatly exceed the average industry figure, falling in the 105-118 range (Figure 1-2-15).

The situation as regards salaries is also evident in the perceptions of researchers and engineers. "The Survey on High-Tech Researchers and Engineers"

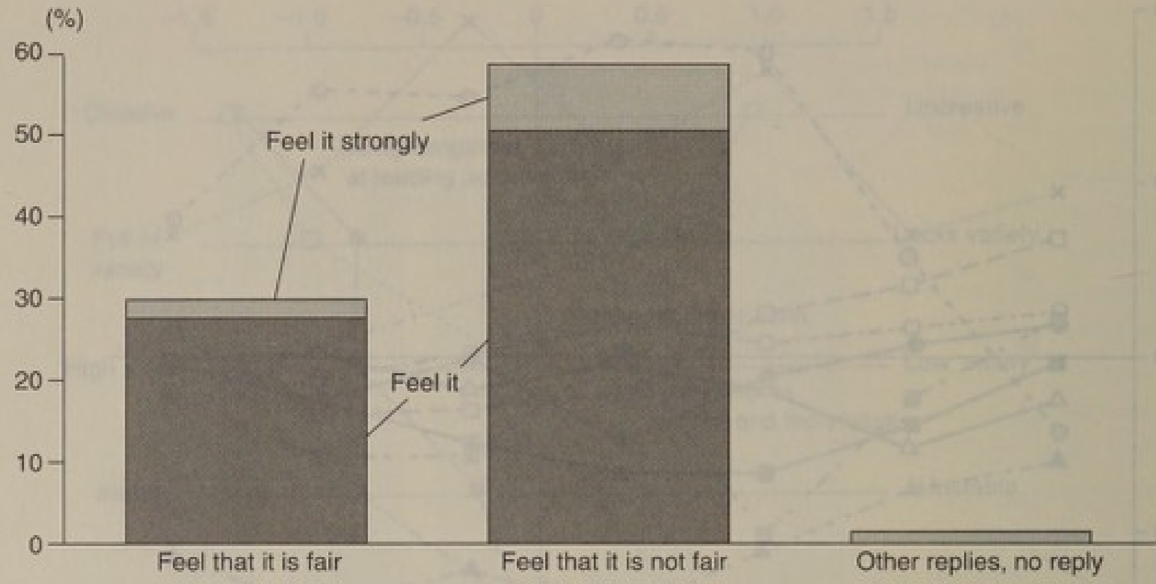


Figure 1-2-16 Society's evaluation of work of scientists and engineers

Source: Science & Technology Agency, "Survey on High-Tech Researchers and Engineers (1993)".

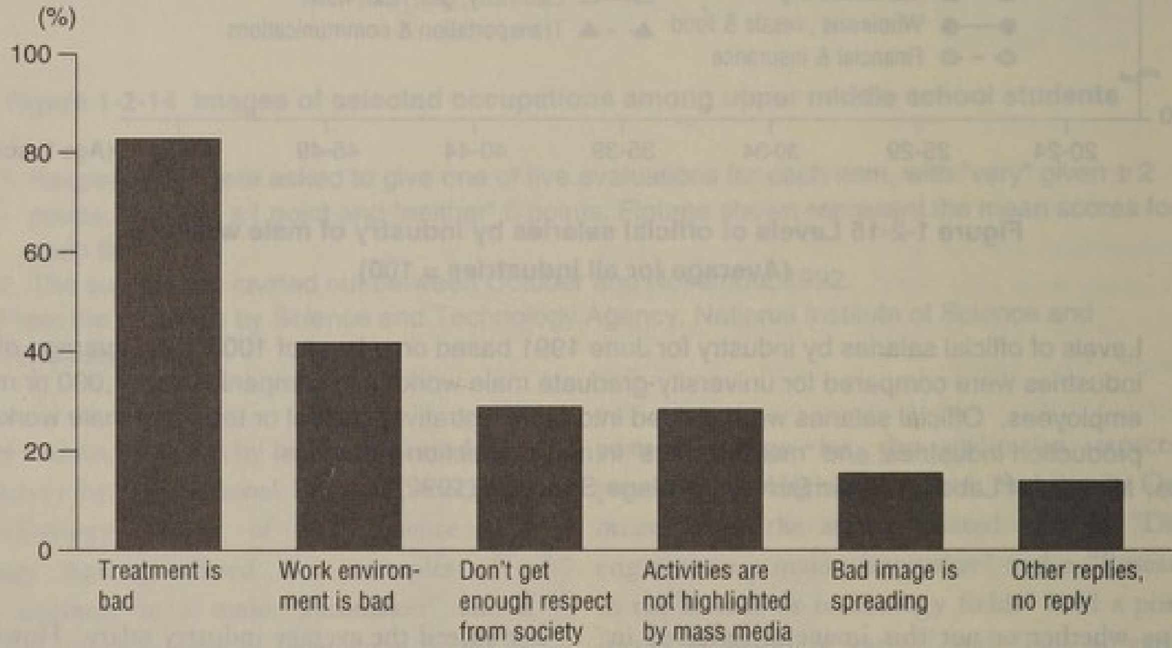


Figure 1-2-17 Reasons why scientists and engineers feel they are not fairly evaluated

Source: Science & Technology Agency, "Survey on High-Tech Researchers and Engineers (1993)".

reveals that over half of the researchers, 56.8%, feel that society does not properly regard the work done by scientists and engineers. At the same time, no more than 29.4% of the researchers feel that their work is correctly evaluated (Figure 1-2-16). Moreover, of those researchers who feel that the work of scientists and engineers is unfairly recognized, 81.7% feel that the reason is that "Scientists and engineers are treated badly"(Figure 1-2-17). It seems likely that these perceptions for

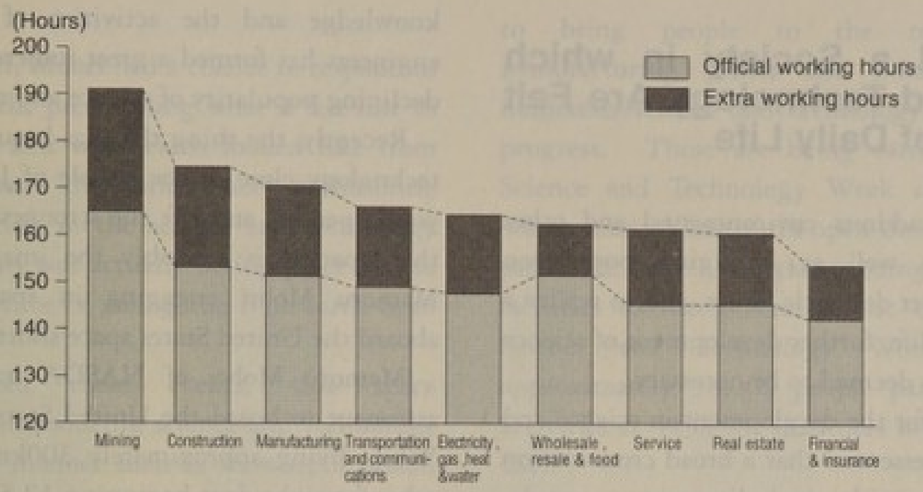


Figure 1-2-18 Monthly working hours of male workers by industry

Note: Monthly working hours (averaged over a year) of full- time workers in workplaces of 500 or more employees were compared. Full-time workers were defined as those people receiving a salary (except for seamen under the Maritime Law) who had been working for over one month irrespective of the work period, and those working for a work period of less than one month who had been working for 18 days or more for each of the previous 2 months.

Source: Ministry of Labour, "Annual Report of Monthly Labour Survey (1992)".

scientists and engineers are passed on to young people, resulting in a downgrading of the image they hold of jobs related to science and technology.

As described earlier, there is a strong tendency for today's young people to desire "A work place where I can take vacations and there is little overtime work". The Ministry of Labour's "Annual Report of Monthly Labour Survey" has compared the working hours of employees in manufacturing and non-manufacturing industries. This survey revealed that the long average monthly working hours in 1992 of full-time male employees in workplaces with 500 or more employees was 171.0 hours in the manufacturing industries, 190.7 hours in the mining industry and 174.6 hours in the construction industry. The industry covered by the survey with the shortest hours was the financial and insurance industry at 155.9 hours. This reveals that the monthly working hours in the manufacturing industries are on the average 15.1 hours longer than those in the financial and insurance industry (Figure 1-2-18).

Therefore, it seems that the image of researchers and engineers in the typical occupations concerned with science and technology enduring difficult working conditions is based on reality. In addition, technological development has resulted in technological products being spread throughout society, and specialist's knowledge and abilities about science and technology have been applied to a wide range of industries, transcending the narrow sense of scientific and technological activities. It seems that many factors such as the dramatic increase in the employment of engineers even in the financial and insurance industry, which hold a utilitarian image in the late 1980s, have directly influenced the selection of academic courses by young people. This in turn entails that we should further examine ways of improving the status and work environment for jobs in the science and technology fields in order to secure scientific and technical personnel.

1.3 Toward a Society in which Science and Technology Are Felt to Be Part of Daily Life

For Japan to address environmental and other global issues as well as its aging population structure and other domestic issues, and to realize a better quality of life, further development of science and technology is deemed to be necessary.

In the future, for the development in science and technology, it is essential that a broad cross-section of the Japanese people, including young people, take a positive attitude and join scientists and engineers in considering science and technology and grapple with the necessary development in this area. The declining popularity of science and technology among young people is of great concern to the future of Japan in the sense that it threatens the formation of these social conditions.

Thus far, the declining popularity of science and technology has only been discussed in terms of young people, but if this trend continues, the impact may extend throughout the entire nation. Looked at in this light, one of the basic ways to address the problems of declining popularity of science and technology among young people would be to create a society in which everyone has more familiarity with scientific and technical knowledge as well as the activities of scientists and engineers. This assumes that the problem is largely due to the development of the black-box syndrome of science and technology in daily life.

This chapter confronts these very problems to create a society as mentioned above and considers them as one source to achieve a broader discussion.

1.3.1 Providing More Opportunities to Become Familiar with Scientists and Engineers

In light of the analysis presented in Section 1 of Chapter 2, there is a possibility that the development of the black-box syndrome of science and technology in our daily lives which lessen the opportunities to feel close to scientific and technical knowledge and the activities of scientists and engineers has formed a great undercurrent, causing declining popularity of science and technology.

Recently, the thing that has brought science and technology close to the people of Japan, including young people, and left the strongest impression on the Japanese is probably the image of astronaut Mamoru Mohri engaging in space experiments aboard the United States space shuttle.

Mamoru Mohri of NASDA was Japan's first astronaut to board the United States space shuttle. While flying approximately 300km in the earth's orbit for eight days beginning 12 September 1992, Mohri conducted Japan's first real space experiment (First Material Processing Test (FMPT)"Fuwatto '92").

For the Fuwatto '92 space experiment, experimental devices developed by Japan were installed in the Space Lab built in the cargo bay of the Space Shuttle Endeavor. Using the micro-gravity of space, material experiments and life science experiments were conducted with the aim of producing materials of difficult-to-obtain levels of purity and high homogeneity. In addition, this space experiment had great significance for science and technology in Japan. Since it helped Japan to obtain the technology for manned space flight and other endeavors in the future. Furthermore, the fact that a Japanese astronaut participated in space flight and carried out a space experiment as a scientist and engineer aboard the space shuttle for the first time was very meaningful. The large coverage together with the increased national interest still remains mid in our minds.

The fact that the nation was able to see newspaper photographs and television images of Mohri participating in space experiments aboard the space shuttle is thought to have had an enormous impact by enabling the Japanese to share this scientific and technological dream. In addition, Mohri took some time out from his experiment to speak from orbit to the elementary school children on earth. He conducted an experiment introducing the world of microgravity by using a more paper plane and an apple to quiz and teach children about the special circumstance of space.

While in orbit, Mohri had a chance to respond to questions from the press asking what it felt like to step into space and what earth looked like from space. This made the nation more enthusiastic about participating in the science and technology projects since this was actually taking place and to share the experience of seeing the blue earth from space.

Judging from these events, this space experiment, by introducing science and technology in a convincing manner such as showing a person actually participating in research at the most advanced research location, can be seen as a successful example of bringing science and technology closer to more Japanese, especially young people.

This case shows that providing the people of Japan with an opportunity to directly or indirectly experience the activities of scientists and engineers or to come into contact with the actual scientists and engineers themselves is an extremely effective way of bringing science and technology close to the nation, including young people. This is an area where increased efforts can be expected.

A variety of ways exist to give a nation the opportunity to come in contact with the human side of scientists and engineers including more opportunities for ordinary citizens to visit the research centers, factories and other locations where scientists and engineers are working and the sending of researchers and engineers to conferences as lecturers.

The following are some examples of efforts which are expected to greatly contribute to the expansion of opportunities for Japanese people to be in closer contact with scientists and engineers. These will be seriously promoted in the future. Each of these approaches will be thoroughly examined from various angles.

1.3.1.1 Making Research Facilities and Factories More Accessible to the General Public

A wide range of experiments is being conducted to bring people to the research centers, manufacturing plants and other places where numerous science and technology activities are in progress. These are being carried out through Science and Technology Week and other events where research institutes open their facilities to the public at large. At the opening of the research facilities to the general public during the 1993 Science and Technology Week, a total of approximately 38,000 people participated in the activities at 44 of the institutes in Tsukuba Science City.

As regards the private sector, efforts have already been made to construct a research facility which ordinary citizens can have access to and meet with researchers so as to make science and technology more available closer to a greater number of people. One of the goals of these facilities is to give people a real sense of the activities of researchers and to show the human side of researchers by making research sites more accessible to ordinary people. By designing in an exhibition facility and other facilities into the research facilities at the conceptual stage, these facilities embody a unique conception not seen in the past.

Even at the factories, one of the major sites for the activities of science and technology, they are making ordinary people feel more familiar with the factories and also are providing a more pleasant working environment for the employees by putting in gardens and making the factories more accessible to the public.

Making sites for the activities of science and technology more accessible to ordinary people also brings about administrative problems and a new burden for the scientists and engineers working there. Therefore, it is not easy in terms of the operation of these facilities. However, we must recognize the importance of having the general public become more familiar with the activities of scientists and engineers. With the above examples as well as the utilization of various other approaches, more research and manufacturing institutions must initiate necessary steps not only to allow but also to encourage the general public to visit their workplaces.

1.3.1.2 Efforts by Scientists and Engineers to Speak Enter into Dialogue with the Public

Efforts by scientists and engineers to convey actively to people their thoughts on the importance and intellectual excitement of their activities and on their contribution to society could expand the opportunities for people to come into contact with the human side of scientists and engineers and greatly contribute to bring the activities of scientists and engineers closer to people.

According to the "Survey on High-Tech Researchers and Engineers", almost all researchers (97.0%) believe there is a need to advance the science and technology in Japan beyond its current level. Of these, over half (72.4%) cited the reason "if the progress of science and technology stops, the existence of mankind will be in danger due to global environmental problems, population explosion, energy problems and others".

Figure 1-3-1 shows that most scientists and engineers are deeply concerned about the future of mankind and feel a pressing need to further advance science and technology. Efforts by scientists and engineers to directly express their thoughts to society and share their thoughts with people are expected not only to provide an opportunity for people, including young people, to think more seriously about science and technology but also to bring the activities of scientists and engineers much closer to the average person.

This survey also revealed that most researchers find their research interesting (93.2%) and think that it contributes to society (93.4%) (Figure 1-3-2). It is expected that efforts by scientists and engineers to accurately convey to society, particularly young people, their thoughts on the intellectual excitement of their activities and their contribution to society will greatly contribute to stimulate an active interest in science and technology.

According to this survey, the percentage of researchers, who believe the interest of their research should be understood by ordinary people and the percentage who believe the contribution of their research to society should be understood by ordinary people are 54.4 and 65.7%, respectively. However, of these researchers, 35.6% of them think that while researchers should make efforts to convey their ideas to ordinary people about their interest in research, they are actually unable to do due to a lack of time and due to other reasons. The same response was given by 36.0% of them with regard to conveying to the people in general about the contribution of their research to society. As a result, the percentages of researchers actually making efforts to speak on or write about research or the contribution of it to society are only 29.2% and 32.7%, respectively.

In light of these conditions, there is thought to be plenty of room for scientists and engineers to make more efforts to show others what is so interesting in their activities.

Accordingly, organizations in the fields of science and technology should become more aware of the importance of the role of the activities of scientists and engineers in supplying the public information and ideas regarding the enjoyment and excitement of their work. Due consideration should be given to encouraging and supporting such activities by providing reading material especially directed to the general public, promoting lecture meetings and other means.

1.3.1.3 Use of On-going Scientific and Technological Projects

As noted above, the image of astronaut Mamoru Mohri engaging in space experiment aboard the space shuttle during the Fuwatto '92 space experiment in September 1992, was shown to the nation and was thought to be very effective in terms of bringing science and technology closer to the Japanese people. This example testifies to how convincing and impressive it can be to see the image of a real human participating in a science and research project that is actually in progress. To bring science and technology closer to the daily lives of the Japanese people, especially young people, it is thought to be effective to use the power of real things and take every opportunity to convey

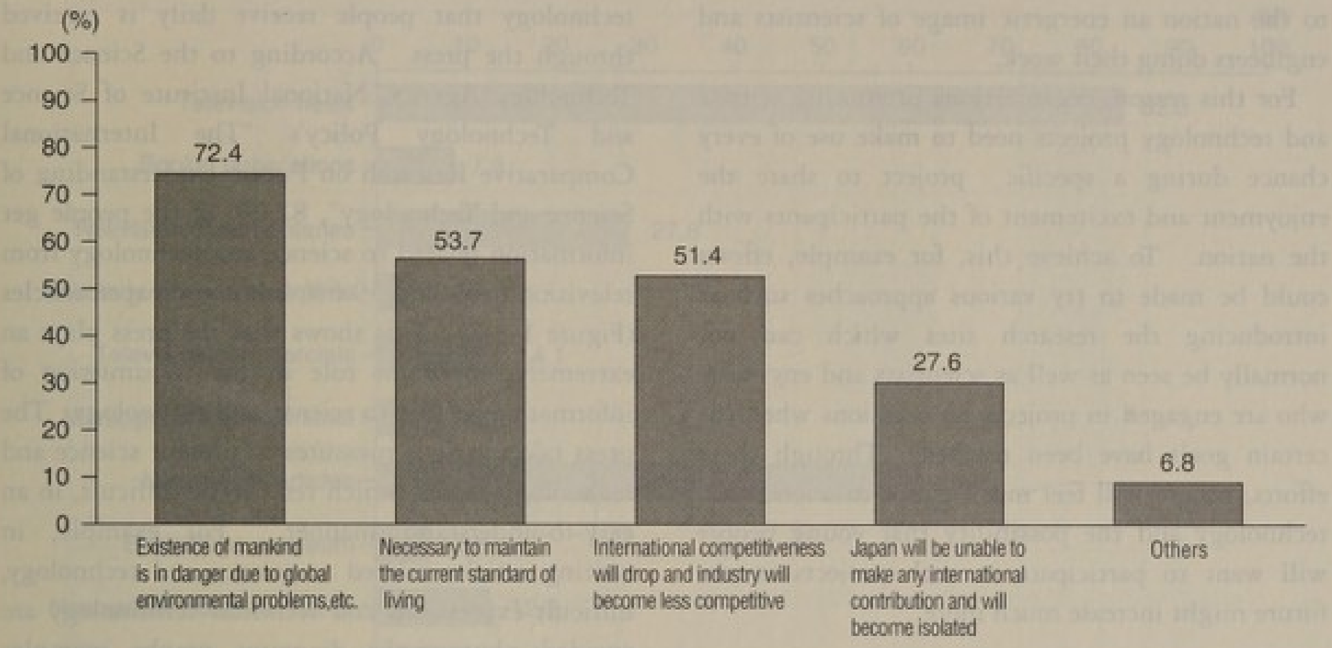


Figure 1-3-1 Reasons for promoting science and technology

Note: Multiple responses
Source: Science and Technology Agency, "Survey on High-Tech Researchers and Engineers (FY 1993)".

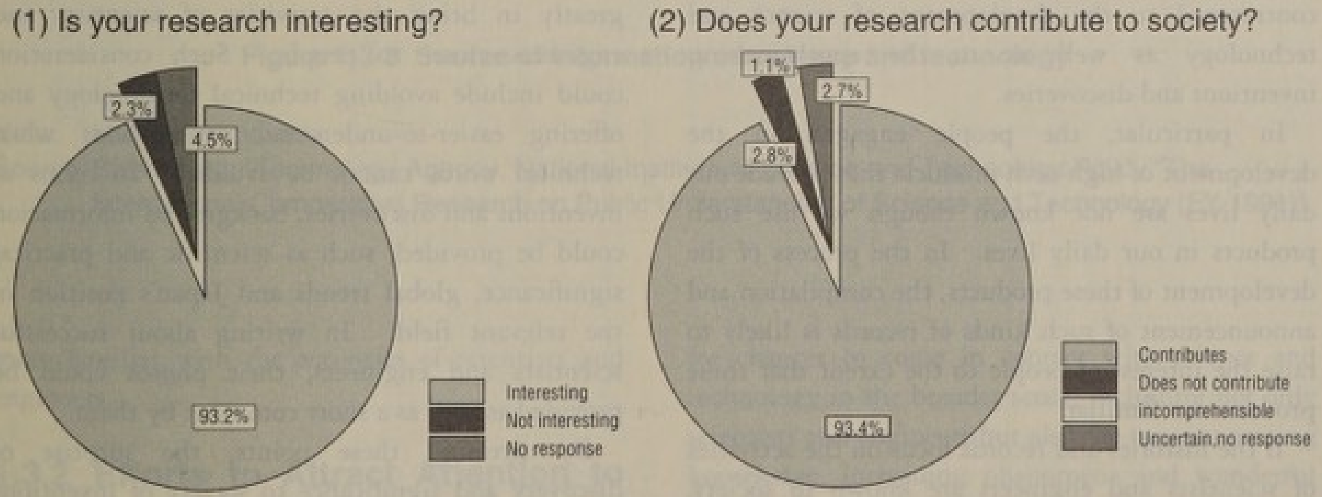


Figure 1-3-2 Views of scientists and engineers regarding their research

Source: Science and Technology Agency, "Survey on High-Tech Researchers and Engineers (FY 1993)".

to the nation an energetic image of scientists and engineers doing their work.

For this reason, organizations promoting science and technology projects need to make use of every chance during a specific project to share the enjoyment and excitement of the participants with the nation. To achieve this, for example, efforts could be made to try various approaches such as introducing the research sites which can not normally be seen as well as scientists and engineers who are engaged in projects on occasions when the certain goals have been reached. Through these efforts, people will feel much closer to science and technology and the possibility that young people will want to participate in such projects in the future might increase much more.

1.3.1.4 Records of Achievement of Scientists and Engineers

Another effective method for increasing the opportunities for people to come into closer contact with the actual circumstances of scientists and engineers might be to compile and announce or publish histories and records that focus on the human side of each scientist and engineer who has contributed to the development of science and technology as well as to the epoch-making inventions and discoveries.

In particular, the people engaged in the development of high-tech products that pervade our daily lives are not known though we use such products in our daily lives. In the process of the development of these products, the compilation and announcement of such kinds of records is likely to raise the interest of people to the extent that these products are familiar.

If the histories and records focus on the activities of scientists and engineers are known to society, many people, including young people, would feel familiarity with the activities of the scientists and engineers.

1.3.1.5 Publicize Activities through Media

Most of information about science and technology that people receive daily is received through the press. According to the Science and Technology Agency, National Institute of Science and Technology Policy's "The International Comparative Research on Public Understanding of Science and Technology", 82.0% of the people get information related to science and technology from television news and 59.6% from newspaper articles (Figure 1-3-3). This shows that the press plays an extremely important role in the transmission of information related to science and technology. The press takes various measures to present science and technology topics, which tend to be difficult, in an easy-to-understand manner. For example, in writing articles related to science and technology, difficult expressions and technical terminology are avoided; photographs, diagrams, graphs, examples and other easy-to-understand devices are employed; relationships to society and daily life are explained; Japan's position in the world is clarified and other measures are taken so as to improve reader comprehension.

In addition to efforts on the side of the press, efforts by organizations in the field of science and technology to always give sufficient consideration to reader comprehension is thought to contribute greatly in bring the activities of scientists and engineers closer to people. Such consideration could include avoiding technical terminology and offering easier-to-understand explanations when technical words cannot be avoided. In terms of inventions and discoveries, background information could be provided, such as scientific and practical significance, global trends and Japan's position in the relevant field. In writing about successful scientists and engineers, their photos could be provided as well as a short comment by them.

By stressing these points, the surprise of discovery and significance to society of inventions could be conveyed in an easy-to-understand manner and the excitement and dreams of the researchers engaged in the research could be conveyed to society in an effective, exciting manner.

Efforts from the side of those supplying information regarding science and technology are expected to greatly contribute to make people feel

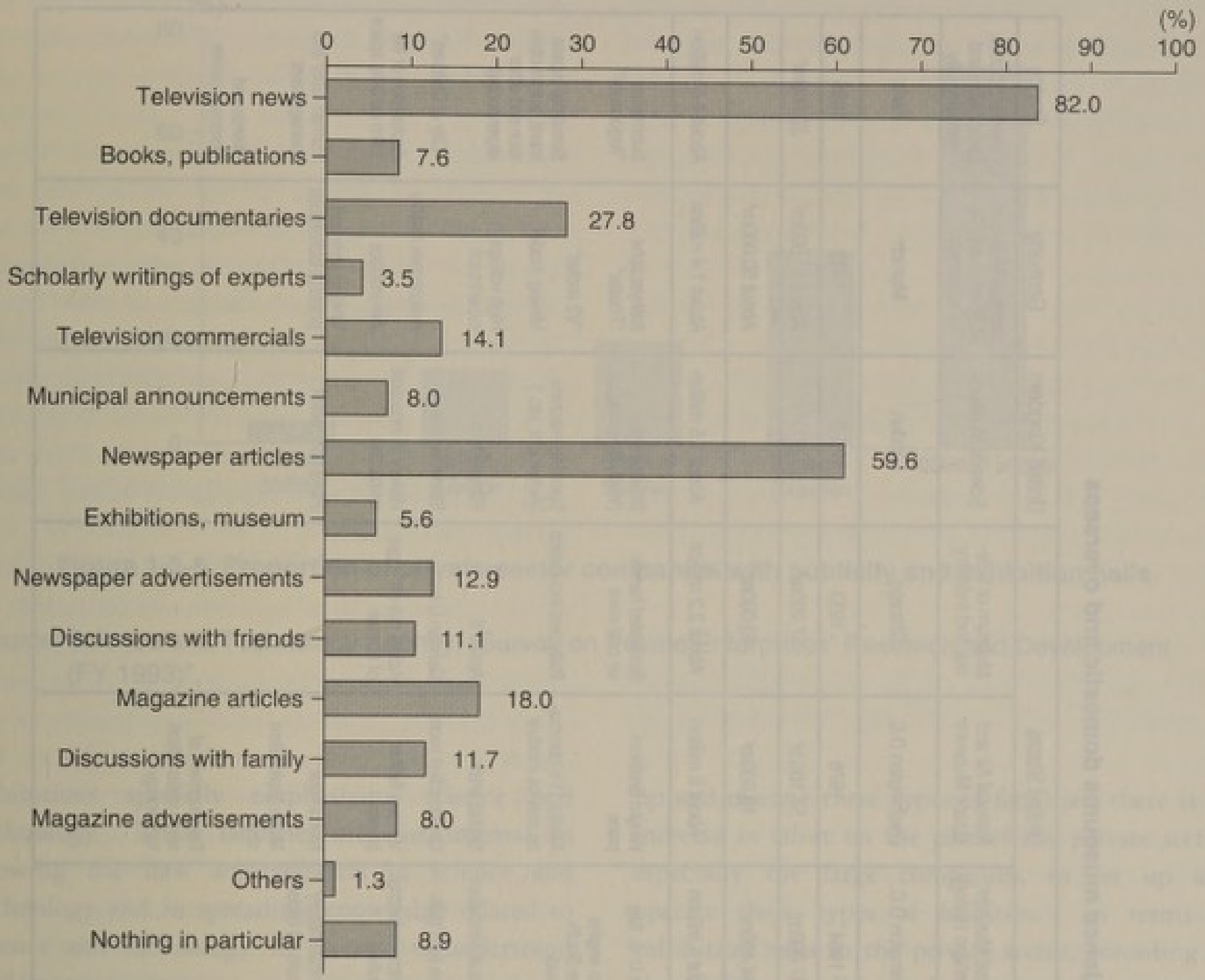


Figure 1-3-3 Source of information on science and technology

Note: Multiple responses
Source: Science and Technology Agency, National Institute of Science and Technology Policy "The International Comparative Research on Public Understanding of Science and Technology (FY 1991)".

more familiar with the activities of scientists and engineers.

1.3.2 Efforts to Attract Attention to Science and Technology

The previous section dealt with the possibility of expanding opportunities for people to have contact with scientists and engineers. This section considers the possibility of making people feel much closer to science and technology by allowing for chances to come in contact with science and technology in the broader sense, including not only scientists and engineers but also the new innovating knowledge, intriguing phenomena and wonderful results related to science and technology.

In the past, numerous ways were devised to increase interest in science and technology by providing opportunities the people to contact with the great breakthroughs that were occurring in this area.

Many places exists for these activities, especially

Table 1-3-4 Major Science museums domestic and overseas

	Japan			United States			United Kingdom	Germany	France
Name	National Science Museum	Science Museum (Tokyo)	Tsukuba Expo Center	National Museum of American History	National Air and Space Museum	Museum of Science and Industry	Science Museum	German Museum of Science and Technology	La Villette Science, Technology and Industry City
Location	Tokyo, Ueno Park	Tokyo, Kitanomaru Park	Tsukuba, Ibaraki Prefecture	Washington D.C.	Washington D.C.	Chicago	London	Munich	Paris
Establishment	1877	1964	1986	1964	1976	1933	1928	1932	1986
Floor space	48,000m²	25,000m²	10,000m²	37,000m²	51,100m²	57,000m²	27,900m²	About 40,000m²	30,000m²
Exhibition floor space	16,500m²	9,000m²	1,500m²	34,400m²	18,000m²	40,000m²		About 50,000m²	
Number of visitors a year	1.1 million	530,000	230,000	About 5 million	About 8 million	About 2.2 million	About 1.5 million	About 1.4 million	About 4-5 million
Main exhibition equipment	Mecatrosaurus Entire structure of dinosaur Maiasaura Zero fighter planes Japanese watch Lambda rocket Moon rock South pole rock Japanese animals and plants Japanese tools	Nuclear World Explorer Axion Multimedia experiment Spaceship earth and space generator powered by Solar sells Simulation MTB simulator Japanese space development New energy Computer art gallery Rainbow piano	Spaceship "Atom" Astro Camp Steam cultivation tomato H-II rocket model Techno Tsukumaru Robot Body exploration Heavy particle ray gun Medical equipment model 3-D Hi-Vision theater Tsukuba Expo '85 Memorial corner	Large U. S. flag Steam engine for the South Railroad Foucault pendulum Edison light bulb American industrial revolution American history and cultural history	Wright Brothers plane Apollo 11's command service module Skylab orbit Construction room Various fighter planes Moon rock Moon exploration ship Development of earth observation technology	Simulated hands-on coal mine Baby bird incubation Apollo 8 German U boat Actual cut-off finger of human	Steam engine (Watt, Newmekon) Spinning machine (Aukwright, etc.) Planetarium Steam vehicle History of industrial revolution Plane and rocket	Bathyscaphe "Trieste" "V2 rocket" Mining model High voltage experiment Automobile history Aeronautics Writing style and printing techniques	Submarine "Argonaute" Simulator (space travel, automobile race and other experiences) "City of Children" Exploration of life from earth to space Human labor and management Words and communication

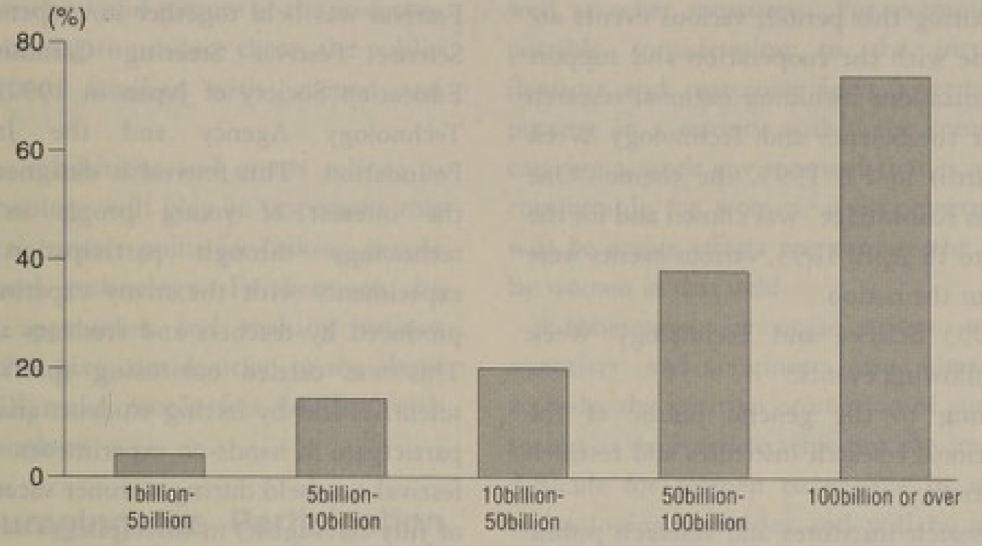


Figure 1-3-5 Proportion of private-sector companies with publicity and exhibition halls

Source: Science and Technology Agency, "Survey on Private Enterprises' Research and Development (FY 1993)".

exhibitions specially emphasizing science and technology. These facilities are instrumental in showing the new achievements in science and technology and in spreading knowledge related to science and technology in an easy-to-understand and impressive matter.

Furthermore, these facilities play an important role in increasing the interest of people in science and technology by allowing them experience the dreams and sense the importance and interest of science and technology.

According to a study by the Japanese Council of Science Museums, the number of facilities that carried out exhibitions concerning science in Japan numbered 1,613 as of September 1992. These facilities include the National Science Museum of the Ministry of Education (opened in Tokyo in 1877), Science Museums (opened in 1964 in Tokyo and 1963 in Osaka) and the Tsukuba Expo Center (opened in 1986 in Tsukuba City) operated by foundations . They, however, do not measure up to the famous facilities in the advanced countries of Europe and the United States in terms of scale, such as exhibition space (Table 1-3-4). Recently, in addition to efforts made by local governments to set up and operate these types of facilities, there is an increase in effort on the part of the private sector, especially the large companies, to set up and operate these types of facilities. In terms of exhibition halls in the private sector, according to the "Survey on Private Enterprises' Research and Development", the proportion of companies that have set up publicity halls and exhibition halls to open up their operations to the public on a wide scale amounts to only 18.5% on the whole, but the percent of companies with capital of over 100 billion yen almost to 72.7% (Figure 1-3-5).

In addition, efforts to increase people's interest in science and technology through various events and activities is continuing.

A well-known example of this is Science and Technology Week, established under the approval by the Cabinet of the Government in 1960. In addition to deepening the people's understanding regarding science and technology, this event is designed to make young people on whose shoulders rests our destiny, aware of the importance of science and technology and stimulate their interest in science. This event is held yearly during the week beginning on Monday that includes Invention Day

(April 18). During this period, various events are held nationwide with the cooperation and support of related organizations including national research institutes. For the Science and Technology Week (the thirty-fourth) in FY 1993, the theme "One Earth, Limitless Knowledge" was chosen and for the week from 12 to 18 April 1993, various events were held throughout the nation.

The FY 1993 Science and Technology Week included the following events:

(1) The opening to the general public of the facilities of national research institutes and research public corporations.

National research institutes and research public corporations opened their facilities to the general public and events such as the model rocket contest were held (NASDA).

(2) SCIENCE NOW '93

This event was held at the Tokyo International Trade Center under the theme of "Technology Forecast — How will our future change?" The current state and future outlook of research and development was introduced.

(3) Third Science Museum Rally

A map was distributed to young people to find their way to 22 different science museums in Tokyo, Saitama and Ibaraki and the ones who made it to five or more of these received a prize.

In addition, on Atomic Day (approved by Cabinet in 1964), October 26, and Space Day, September 12, events and activities are held to deepen understanding of the people and increase interest in people in science and technology related to atomic energy and space.

Recently, in light of the increased sense of danger with respect to declining popularity of science and technology, academic circles also recognizing the importance of making more opportunities for people, especially the young people, to come in contact with science and technology. Those associated with academic circles have taken the lead in trying new ways directly and indirectly to get the young people of Japan more interested in science and technology.

For example, in 1992, through the efforts of those in the field of physics, the Youngster's Science Festival was held together in cooperation with the Science Festival Steering Committee (Physics Education Society of Japan in 1992), Science and Technology Agency and the Japan Science Foundation. This festival is designed to stimulate the interest of young people in science and technology through participation in science experiments with the many experimental devices produced by teachers and students all over Japan. This was carried out using special lectures by scientists and by letting students and their parents participate in hands-on experiments. In 1993, this festival was held during summer vacation (from end of July to August) in three places — Tokyo, Sendai and Sapporo.

In addition to these, various other efforts were being made to increase opportunities for people to become more familiar with knowledge related to science and technology. In light of the concern about the danger of the declining popularity of science and technology among young people, the trend toward strengthening these efforts is increasing among those directly related to the field of science and technology.

Exhibitions, events and other activities related to science and technology have played and will hopefully continue to play an important role in bringing people more in touch with science and technology. As considered in Section 1 of Chapter 2, if it is true that one of the basic causes for the declining popularity of science and technology is black box syndrome of science and technology in the daily lives of the people, one of the things that is expected when holding events and activities related to science and technology, more than ever before is that they come up with measures to address the black box syndrome of science and technology.

The results of scientific and technological activities have been overlooked as a result of their particular diffusion within modern society. To prevent the black box syndrome from increasing further, the public must be fully aware of the role science and technology has played in producing modern products. If the public is able to form a positive image of the science and technology due to these products, with a vivid picture of the scientists and engineers working to produce them, the public will become more familiar with science and technology.

In the future, exhibitions and events related to science and technology will play an important role in serving a vital contact point for linking people with science and technology. Furthermore, by taking various approaches and making various improvements that give consideration to the above points, they will make people feel familiar with science and technology.

1.3.3 Encouraging the Participation of Women in Scientific and Technological Activities

As pointed out in Section 2 of Chapter 1, woman's little presence in science and technology-related occupations such as scientists and engineers. It is possible to interpret this, in the opposite sense, as indicating that there is great room for an increase of women in participation related to science and technology through future efforts.

As woman's impact on society continues to increase, the continued low level of active interest in science and technology of women who account for about half of the population is a matter which should be given the utmost concern. Woman's participation in occupations related to science and technology, including scientists and engineers, is important both in terms of spreading the activities of women in society and in terms of securing human resources related to science and technology. This is also important in terms of making women, who do not directly participate in scientific and technological activities, feel closer to scientists and engineers and in terms of increasing the level of active interest in science and technology among women as a whole.

In promoting Woman's participation in scientific and technological activities, there is a need for organizations related to science and technology to continue supportive activities of women in the field of science and technology through diversification in the form of work during child birth and rearing as well as other measures. For example, by giving possible consideration to the introduction of flextime and maternity leave systems as well as putting in a nursery within the company and by creating a work environment that is attractive and comfortable for women, it is expected that there will be active efforts to promote the participation by women in this field.

Furthermore, in organizations where female scientists and engineers are already working actively, the positive promotion of such women to society is expected to wipe out the image that it is difficult for women to engage in scientific and technological activities and will be a tremendous boost to bring science and technology closer to women.

1.3.4 Creating an Atmosphere in which Science and Technology Can Be Discussed as Everyday Subjects

So as to further develop science and technology with the aim of creating a better future for both Japan and the global community and soundly managing a society which uses advanced science and technology, it is extremely important that the people which constitute such society have a correct understanding of science and technology. In this light, there is a need to pay closer attention to trends in the active interest in science and technology of the nation as a whole, particularly the young people.

The thing we need to recognize ourselves is that the attitude of the young people toward science and technology reflects the attitude of society as a whole toward science and technology. As science and technology developed and its products permeated our daily lives in a form that could be easily used by anyone, science and technology become difficult for people to "see". In addition, if society as a whole has promoted such a tendency, this is an issue that cannot be overlooked.

On the international level, Japan is facing dangers such as global environment issues in light of the limitations of the earth.

Domestically, Japan being pressed to find solutions to its aging population structure and other issues effecting the realization of a better quality of life. Japan has great hope in the development of science and technology in terms of overcoming these difficulties and continuing to secure peace and prosperity.

Unless we ourselves renew our recognition and make regular efforts to speak to young people on whose shoulders rests our destiny, it will be difficult for them to "see" science and technology because they are very content with their current lifestyle.

Young people will become more interested in science and technology if they feel close to it and if society earnestly supports it. For this reason, creating an atmosphere in which people can actively discuss what science and technology should be and the direction of its development, as familiar and their own problem is important. And efforts in this direction should be considered the responsibility of the Government and the nation as a whole for the next generation.

Conclusion:

Part 1 of this White Paper addresses the relationship between the young people and science and technology, considering ways to deal with the declining popularity of science and technology among young people. In terms of the points considered here, unless a certain level of effort is made by society, no visible results will be obtained.

Accordingly, efforts to deal with the declining popularity of science and technology among the young people may be too late if people wait until the problems become more serious. There is a need to take a long-term perspective and deal with the issue immediately. Even if no immediate visible results are achieved, we need to recognize that it is important to continue making strategic and energetic efforts over the long term.

At the Council for Science and Technology, a discussion of the issues related to the declining popularity of science and technology among young people are being conducted from the perspective of securing human resources in this area. This White Paper is provides a useful discussion of this problem. As a result of deliberations at the council, in addition to serious recognition of these issues by people in industry, academia and the Government, including scientists and engineers, it is expected that these issues can be addressed early due to the mutual understanding and communication of all of those involved.

The problem of the declining popularity of science and technology among young people should be addressed by all of us. Both policy makers and those involved directly in the fields of science and technology must be more directly involved. It is hoped that the public will consider and seek solutions to the problem directly related to their own future through various measures. These include entering into a dialogue with the young people concerning scientific and technological issues.

Part 2
The Current Status of Science and Technology in Japan and Other Nations

Governments of major countries are actively promoting their own science and technology policy to challenge the limits of human capabilities; to provide solutions to worldwide concerns such as the global environment, natural resources and energy; and to add to the strengthening of competitive industrial power. Industries in the world are increasing investments in research and development (R&D) to cope with competition in product development and the trend toward high-tech products.

Japan, including its industries and other sectors, has been actively investing in R&D, and the level of science and technology is considered to be rising steadily. Its R&D activities need to be strengthened and expanded further in order to adjust its base for development; to bring material wealth to the people and to accomplish stable economic growth.

Part 2 describes Japan's characteristics in science and technology, as well as Japan's research activities[1]. This is done by comparing data on R&D expenditures, number of researchers, and other activities for selected countries.

2.1 R&D Expenditures

2.1.1 Total R&D Expenditures

2.1.1.1 Trends in R&D Expenditures

When a country examines its R&D expenditures[2], its contents and approach may differ from other nations. As a result, a simple comparison of R&D expenditures among countries may not present compatible data, although it gives a general idea as to a country's attitude toward science and technology. In terms of R&D expenditures, the United States spends the most followed by Japan and Germany[3] (Figure 2-1-1).

2.1.1.2 Increase of R&D Expenditures in Real Terms

R&D expenditures in real terms for Japan, the United States, Germany, France and the United Kingdom are calculated using the amount in 1985 as the basis of comparison. According to this data, Japan has the highest growth rate among these nations (Figure 2-1-2).

1) In this paper, "research activities" apply only to natural sciences and not to social sciences and humanities. Classification of natural sciences as distinct from social sciences and humanities is based on the individual research institute or university and college department concerned.

2) R&D expenditures are the funds spent by research institutions themselves for research. There are two methods of estimating R&D expenditures: disbursement and cost. This paper considers R&D expenditures to be disbursements. Disbursement includes expenditures on labor, materials, tangible fixed assets, and so on. In case of cost, it is computed by adding the depreciation of tangible fixed asset, instead of expenditure on the tangible fixed assets.
Japanese R&D expenditures are calculated for Japan's fiscal year, which begins in April.

3) The date for Germany in Chapter 1 and 2 cover Western Germany only, until 1990, and Unified Germany from 1991.

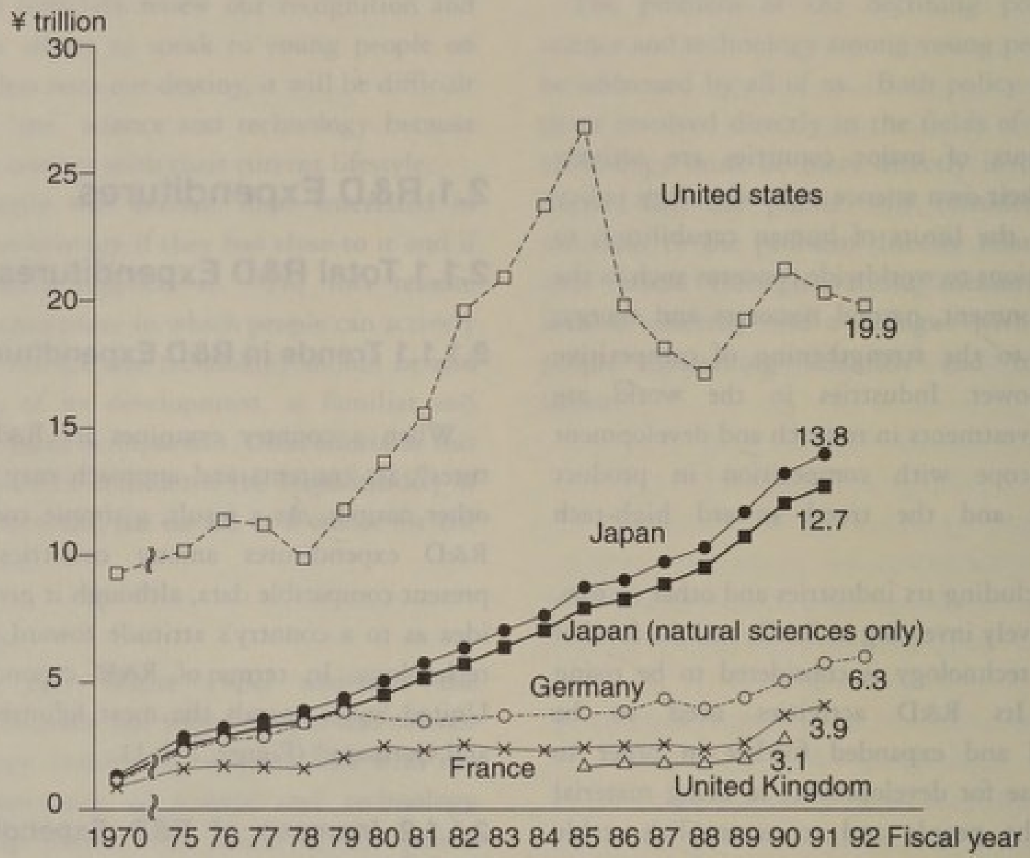


Figure 2-1-1(1) Trends in R&D expenditures of selected countries - IMF exchange rate conversion

2.1.1.3 R&D Expenditures as a Percentage of Gross National Product (GNP)

R&D expenditures as a percentage of GNP show the level of research investment. During the 1970s, this percentage decreased or remained level in major countries. It began to increase in 1978, but, has decreased or remained level in major countries with the exception of Japan and France in recent years. Although R&D expenditures in Japan grew steadily until FY 1990, decreased research investment by the private sector led to a flattening out in growth in FY 1991 (Figure 2-1-3).

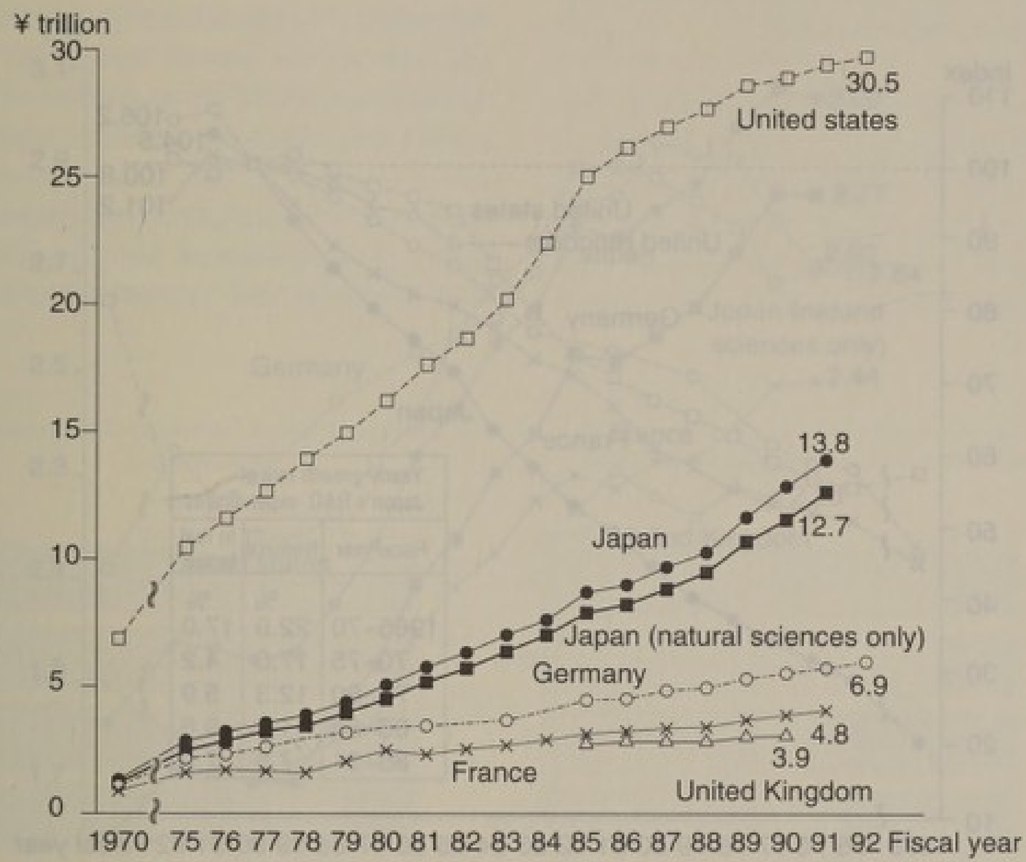
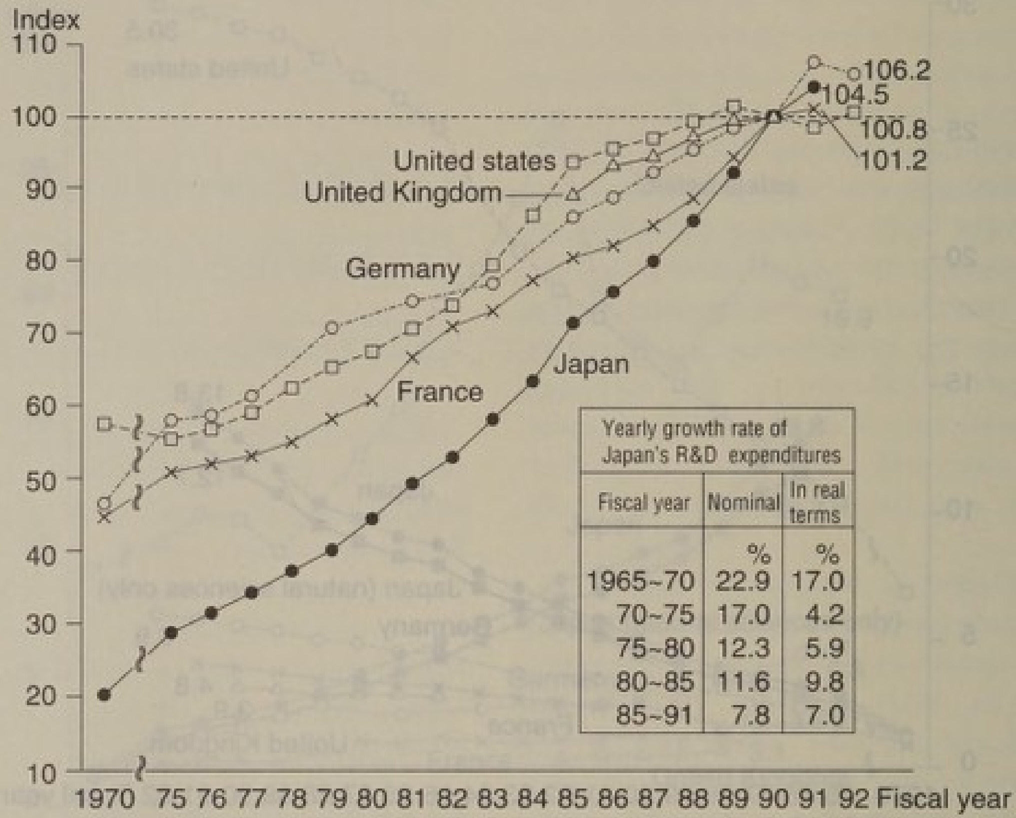


Figure 2-1-1(2) Trends in R&D expenditures of selected countries - OECD purchasing power parity

Notes: 1. For comparison, statistics for all countries include research in social science and humanities. The figure for Japan shows also the amount for natural sciences only.
2. Only the figure for Japan are not on full-time equivalent basis.
3. The 1991 data for the US are provisional and the 1992 data are estimates.
4. Germany: the years for which data are not available are indicated on a straight line.
5. The 1991 data for France are provisional.

Sources: Japan — Report on Survey of Research and Development by Statistics Bureau, Management and Coordination Agency
United States — National Patterns of R&D Resources 1992 by National Science Foundation(NSF)
Germany — "Bundesbericht Forschung" , "Faktenbericht zum Bundesbericht Forschung" by Federal Ministry for Research and Technology (BMFT)
France — Projet de Loi de Finance — Rapport annexe sur l' Etat de la Recherche et du Developpement Technologique.
United Kingdom — "Annual Report of Government Funded R&D 1992" by Cabinet Office

(See Appendix 1)



Yearly growth rate of Japan's R&D expenditures

Fiscal year	Nominal	In real terms
	%	%
1965~70	22.9	17.0
70~75	17.0	4.2
75~80	12.3	5.9
80~85	11.6	9.8
85~91	7.8	7.0

Figure 2-1-2 Growth of R&D expenditures (in real terms) in selected countries

Notes: 1. For comparison, statistics for all countries include research in social sciences and humanities. The table in the figure on Yearly Growth Rate of Japanese R&D expenditures represents only that for natural sciences.

2. The 1990 index is set at 100.
3. The 1991 data for the US are provisional, the 1992 data are estimated.
4. Germany: the years for which data are not available are indicated on a straight line.
5. The 1991 data for France are provisional.

Source: Same as in Figure 2-1-1.
(See Appendix 1,15)

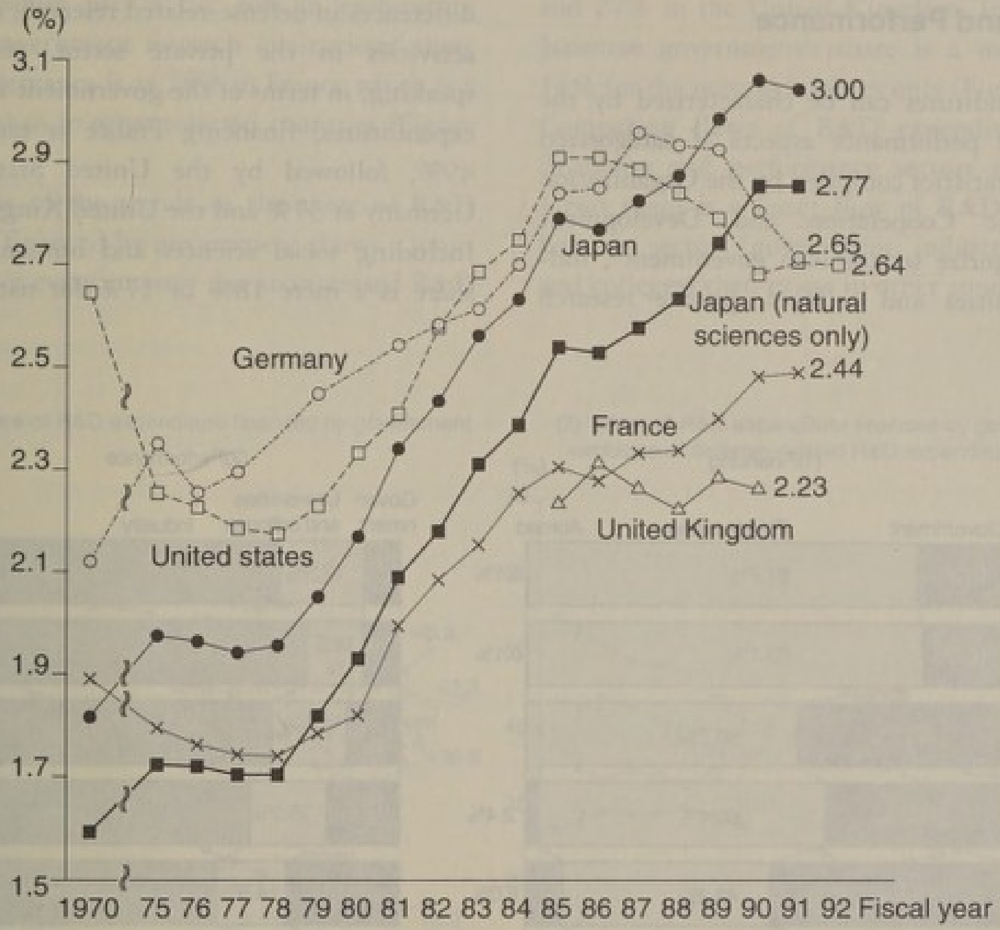


Figure 2-1-3 Growth of R&D expenditures (in real terms) in selected countries

Notes: 1. For comparison, statistics for all countries include research in social sciences and humanities. The figures for Japan show also the amount for natural sciences only.
2. Only the figures for Japan are not on a full-time equivalent basis.
3. The 1991 data for the US are provisional and the 1992 data are estimated.
4. Germany: the years for which data are is not available are indicated on a straight line.
5. The 1991 data for France are provisional.

Source: Same as in Figure 2-1-1.
(See Appendix 1)

2.1.2 R&D Expenditures by Financing and Performance Sector

2.1.2.1 Share of R&D Expenditures by Financing and Performance

R&D expenditures can be characterized by the financing and performance aspects of categorized sectors. The statistics compiled by the Organization for Economic Cooperation and Development (OECD) categorize sectors into government[4], industry, universities and colleges, private research institutions, and abroad. Shares of R&D expenditures by financing and performance in selected countries are compared by OECD - categorized sectors.

The government R&D expenditures percentage may differ from country to country due to differences in defense-related research, tax structure, activities in the private sector, etc. Generally speaking, in terms of the government share of R&D expenditures, financing France is ranked first at 49%, followed by the United States at 43%, Germany at 37% and the United Kingdom at 36%. Including social sciences and humanities, Japan's share is a mere 18% or 17% for natural sciences

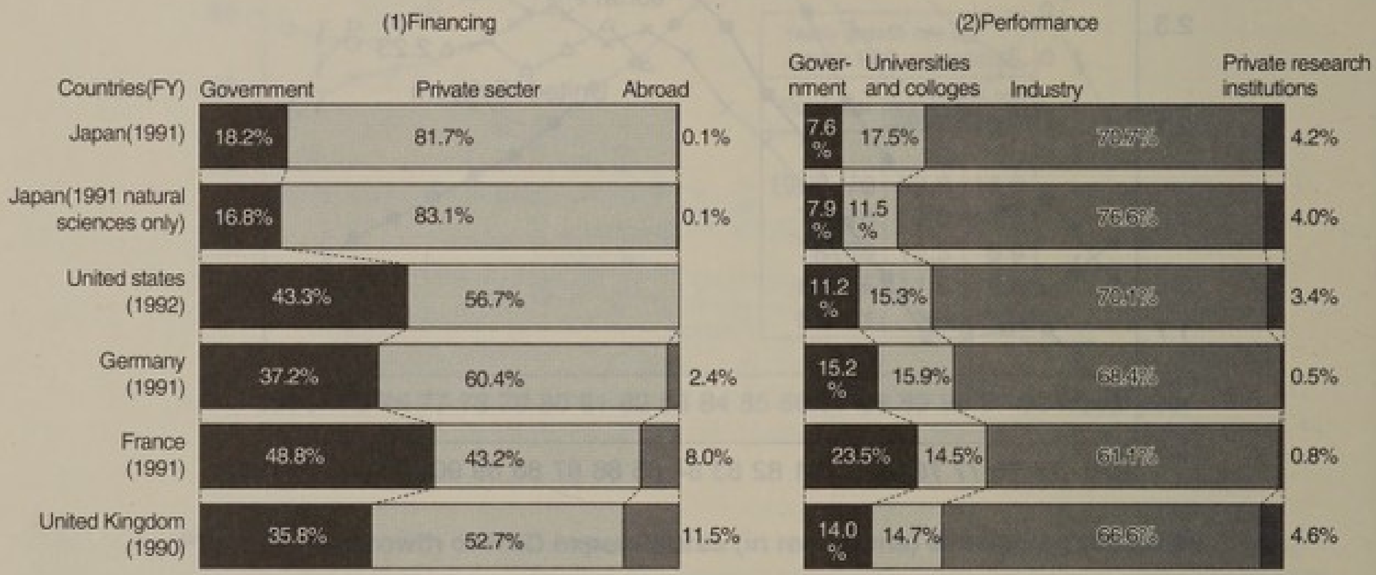


Figure 2-1-4 Share of R&D expenditures financing and performance sector in selected countries

Notes: 1. For comparison, statistics for all countries include research in social sciences and humanities.
The figure for Japan shows the amount for natural sciences only.
2. (1) In the financing column, the private sector includes any sector other than the government and abroad.
3. The figures for the United States and for Germany is an estimate. The figures are provisional.

Sources: Japan, US and United Kingdom — Same as in Figure 2-1-1.
Germany and France — OECD statistics.

(See Appendix 2)

4) In this paper, whenever R&D expenditures and number of researchers are discussed, they refer to both national government and local government.

only. In Japan, the private sector finances a great deal of R&D expenditures (Figure 2-1-4(1)).

Looking at R&D performance, industry spends approximately two-thirds of the total R&D expenditures in selected countries. This means that private companies play a big role in performing R&D. The government research institutions' share of R&D performance is at 24% in France which is a higher ratio than in other selected countries (Figure 2-1-4(2)).

An analysis of the trends in the share of R&D expenditures financed by government shows a long-term decline in every country due to increased R&D activities by industry and its increased relative importance in every country. Excluding the defense-related R&D budget including social sciences and humanities, the government shares of R&D financing were 36% in France, 34% in Germany and 22% in the United Kingdom. In contrast, the Japanese government's share is a mere 17% and 16% for the natural Sciences only (Figure 2-1-5).

Comparing flows of R&D expenditures between financing and performance sectors shows that in Japan there is a lesser flow of R&D expenditures between sectors (government, industry, universities and colleges) than exists in other countries and that

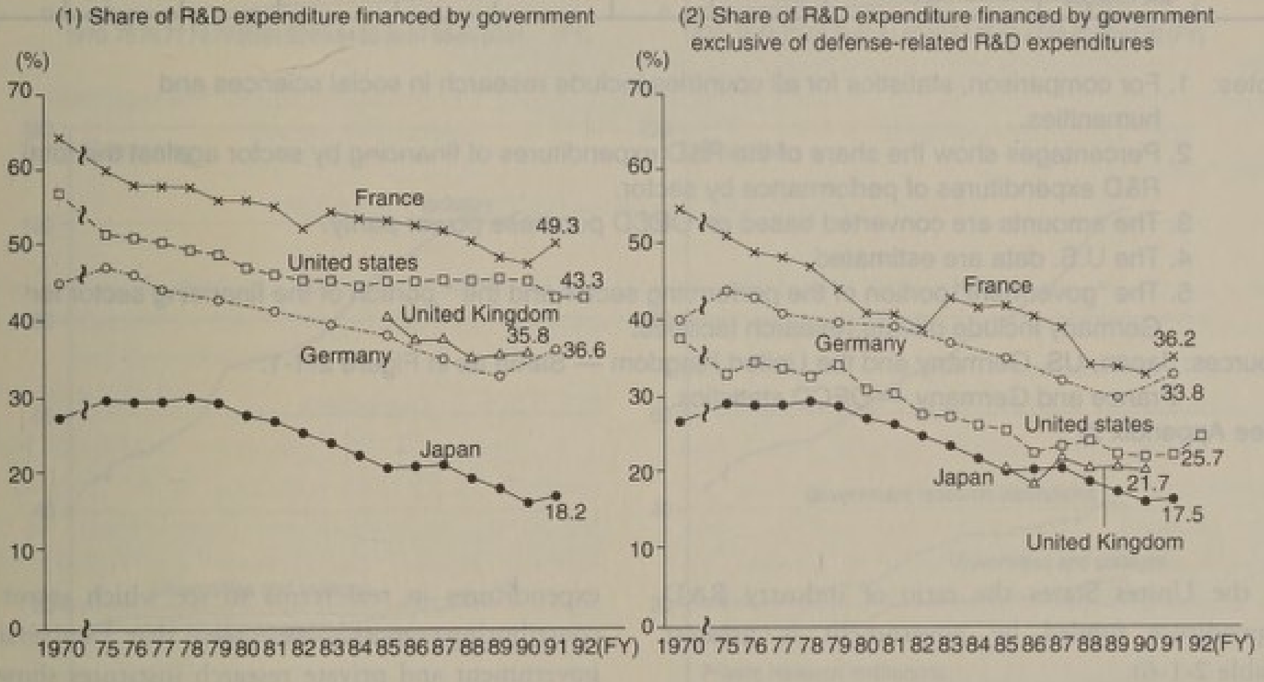


Figure 2-1-5 Trends in government-financed for R&D expenditures in selected countries

Notes: 1. For comparison, statistics for all countries include research in social sciences and humanities.
2. Government percentages exclusive of defense-related research expenditures are calculated by the following equation.

$$\frac{\text{(Government financed R\&D expenditures)} - \text{(Defense - related R\&D expenditures)}}{\text{(R\&D expenditures)} - \text{(Defense - related R\&D expenditures)}} \times 100(\%)$$

3. The 1991 data for the U.S. are provisional and 1992 data are estimated.
4. Germany: the years for which data are not available are indicated on a straight line.
5. The 1991 data for France are provisional.

Sources: Japan, U.S., Germany and France – same as in Figure 2-1-1.
United Kingdom – "Annual Review of Government Funded R&D" by the Cabinet Office.
(See Appendix 1)

Table 2-1-6 The flows of R&D funds between industry, universities and colleges, and government sectors in selected countries

Financing sector	Performing sector	Japan (1991) Amount unit ¥100mill	Japan (1991) Share %	United States (1992) Amount unit ¥100mill	United States (1992) Share %	Germany (1991) Amount unit ¥100mill	Germany (1991) Share %	France (1988) Amount unit ¥100mill	France (1988) Share %	United Kingdom (1990) Amount unit ¥100mill	United Kingdom (1990) Share %
Government	Government	10,236	97.8	33,440	100.0	9,972	95.5	9,202	93.3	4,684	85.0
Industry	Government	232	2.2	0	0	*352	3.4	386	3.9	546	9.9
Government	Industry	1,335	1.4	59,470	28.4	5,045	10.8	4,899	20.8	4,381	16.7
Industry	Industry	95,893	98.4	150,100	71.6	40,253	85.8	16,463	69.9	17,748	67.8
Government	Universities and colleges	11,909	49.5	30,400	66.4	9,926	92.3	5,505	94.3	4,188	72.2
Industry	Universities and colleges	570	2.4	2,565	5.6	823	7.7	235	4.0	460	7.9

Notes: 1. For comparison, statistics for all countries include research in social sciences and humanities.
2. Percentages show the share of the R&D expenditures of financing by sector against the total R&D expenditures of performance by sector.
3. The amounts are converted based on OECD purchase power parity.
4. The U.S. data are estimated.
5. The "goverment" portion of the performing sector and the * portion of the financing sector for Germany include private research facilities.

Sources: Japan, US, Germany and the United Kingdom — Same as in Figure 2-1-1.
France and Germany — OECD statistics.

(See Appendix 2)

in the Unites States the ratio of industry R&D expenditure funded by government is greatest (Table 2-1-6).

In Japan, industry performs little of government-financed R&D. This is because, in Japan, each sector has been rather independent from one another, and has had little interaction. Furthermore, Japan's private sector is quite active in R&D. Another reason is, for example, in the United States, the flow of defense-related R&D expenditures between sectors is very high.

2.1.2.2 R&D Expenditures by Sector

R&D expenditures are increasing in major countries. Examining the growth rate in R&D expenditures in real terms to see which sector is contributing most, we see that university, government and private research institutes showed no or only slight increase, while the industrial sector, with the exception of United States, has the significant growth rate. This proves that R&D activities by the industrial sector have been increasing in recent years. The rate of increase is especially high in Japan (Figure 2-1-7).

Industry bas a great influence on growth of R&D expenditures. Particularly in Japan, the growth of R&D expenditures has been influenced by trends in R&D expenditures by companies. Examining changes in the contribution by sectors to the annual increases of Japan's R&D expenditures in real terms, R&D expenditures in the industrial

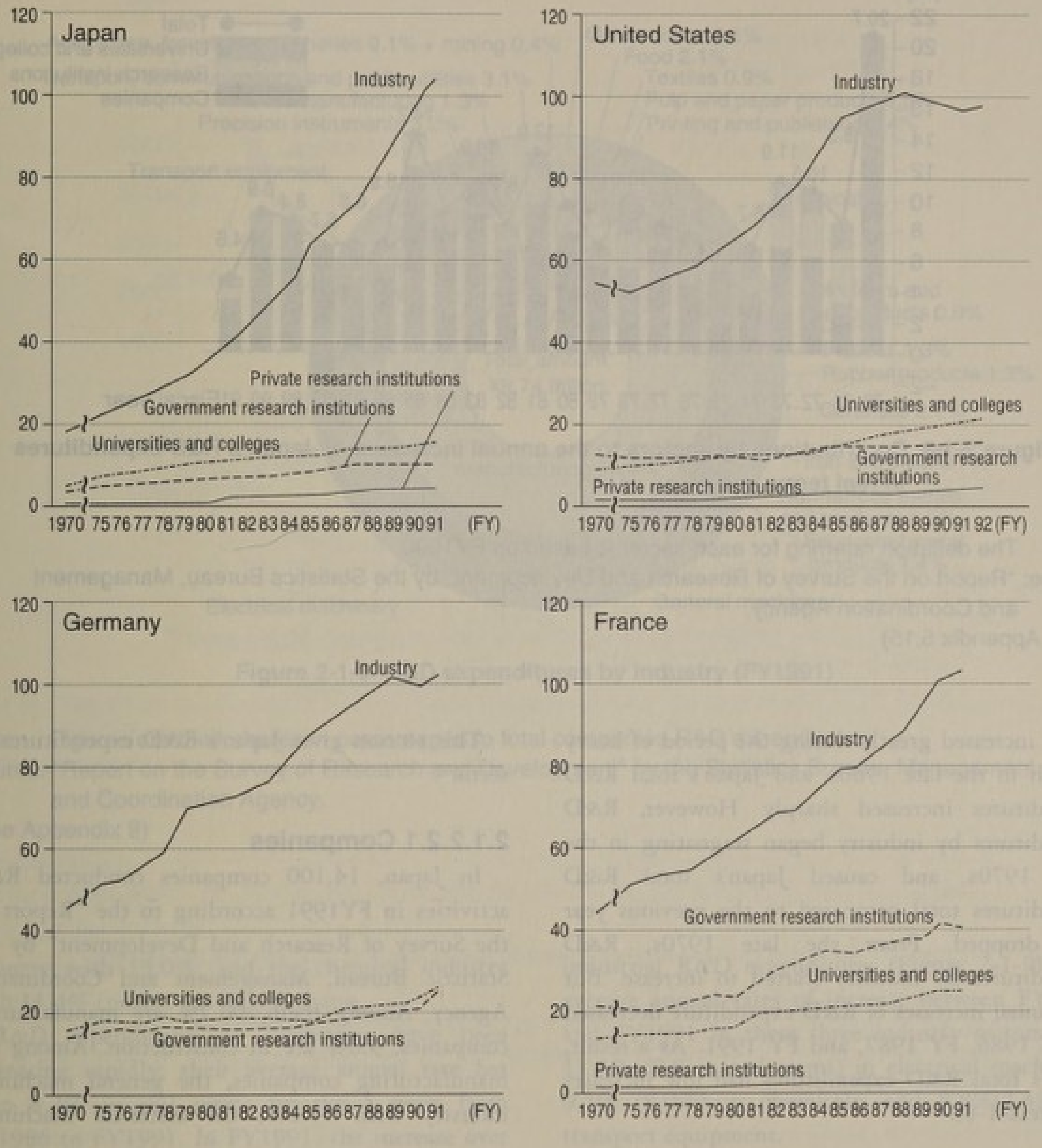


Figure 2-1-7 R&D expenditure growth (in real terms) by sector in selected countries

Notes: 1. The index in FY1990 is set at 100 in each country. This is equivalent to R&D expenditures (in real terms) by industry in that year.
2.All countries except Japan include social sciences and humanities.
3.The 1991 data for the US are provisional and the 1991 data are an estimate.
4.The 1990 and 1991 data for Germany are an estimate.
5.Germany: the years for which data are not available are indicated by a straight line.
6.The 1991 data for France are provisional.
Germany and France — OECD statistics.

(See Appendix 15)

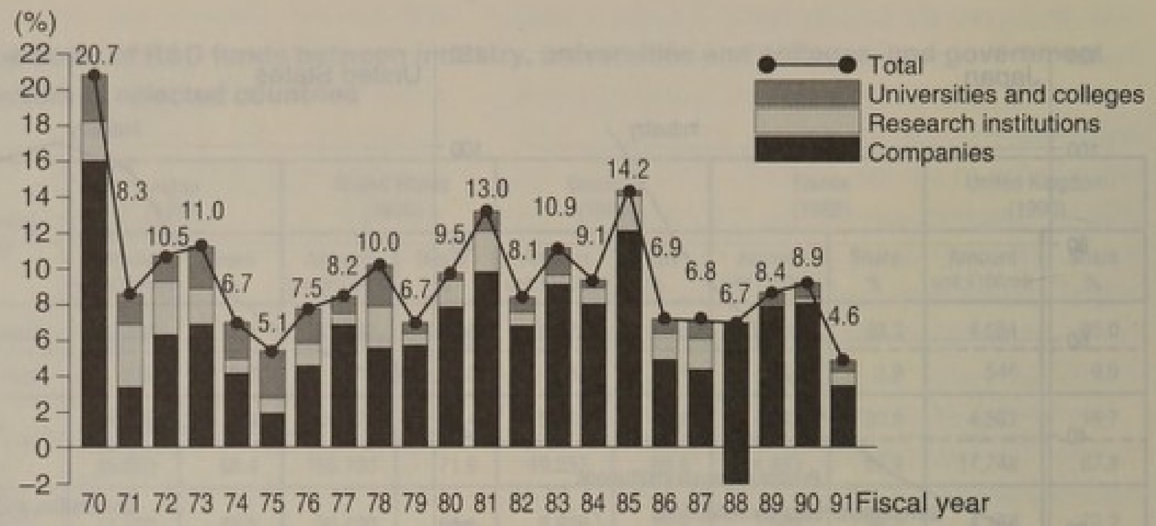


Figure 2-1-8 Contributions by sectors to the annual increases of Japan's R&D expenditures in real terms

Note: The deflation raterring for each sector is based on FY1990.
Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 5,15)

sector increased greatly during the period of heavy growth in the late 1960s, and Japan's total R&D expenditures increased sharply. However, R&D expenditures by industry began stagnating in the early 1970s, and caused Japan's total R&D expenditures total compared to the previous year also dropped. From the late 1970s, R&D expenditures by industry started to increase. But the annual increases of R&D expenditure decreased in FY 1986, FY 1987, and FY 1991. As a result, Japan's total R&D expenditures had low increases (Figure 2-1-8).

This section gives Japan's R&D expenditures by sector[5].

2.1.2.2.1 Companies

In Japan, 14,100 companies conducted R&D activities in FY1991 according to the "Report on the Survey of Research and Development" by the Statistic Bureau, Management and Coordination Agency. Among them, 90.2% are manufacturing companies; 9.0% are in construction. Among the manufacturing companies, the general machinery industry with 15.2%, the electrical machinery

5) Research activities in Japan in this paper are provided by companies, research institution, and universities and colleges. These classifications are based on the "Report on the Survey of Research and Development" compiled by the Statistics Bureau, Management, and Coordination Agency. The Following defines some of these organizations.

- Companies–Corporate companies (Capital: 1 million yen or more (FY1974 or before), Capital: 300 million yen or more (between FY1975 and FY1978), Capital: 5 million yen or more (FY1979 or after), and profit-oriented public corporations (such as NHK (the Japan Broadcasting Corporation), and the Japan Highway Public Corporation).
- Research institutions-National, local government-owned and private (such as foundations) research institutions and research corporations. Research-centered public corporations are, for example, the National Space Development Agency of Japan, the Power Reactor and Nuclear Fuel Development Corporation, the Japan Atomic Research Energy Institute, and the Institute of Physical and Chemical Research. According to the OECD definition, government research institutions include national and local government-owned research institutions and research-centered corporations.
- Universities and colleges-departments of universities and colleges (including graduate schools), junior colleges, colleges of technology, research institutions attached to the universities and colleges and inter-university research institutes, and national institution for academic degrees.

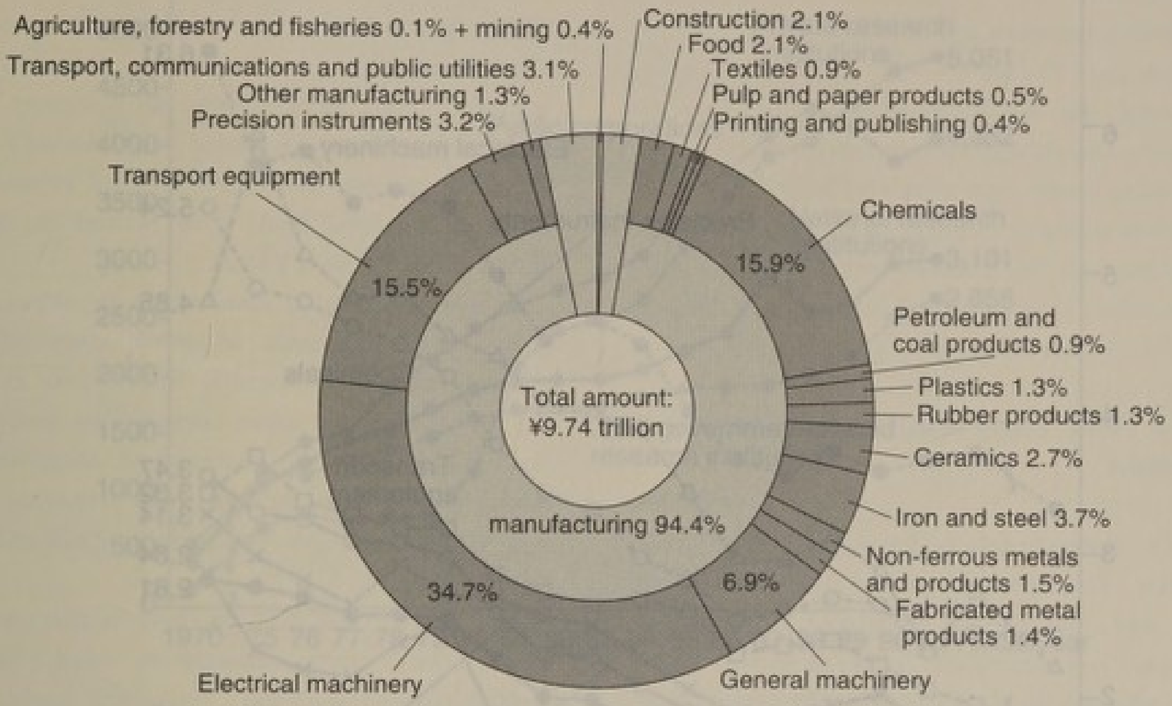


Figure 2-1-9 R&D expenditures by industry (FY1991)

Note: Figures are their shares in percentages to total companies R&D expenditures.
Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 9)

industry with 15.0%, and the chemical industry with 11.4% contain the largest shares.

R&D expenditures by companies have been increasing rapidly; their average annual rate has been 8.2% in real terms for the 5 years from FY1986 to FY1991. In FY1991, the increase over the previous year was 5.1%(4.5% in real terms). R&D expenditures then totaled 9,743.0 billion yen, 76.6% of the total R&D expenditures in Japan.

R&D expenditures by industry type show manufacturing at 94.4% followed by transportation/communication/public utilities companies at 3.1%. In the manufacturing category, the electric machinery industry accounts for 34.7%, chemicals for 15.9% and the transport equipment for 15.5% of the total industrial R&D expenditures. These three types of industries perform 66.1% of the total industrial R&D expenditures (Figure 2-1-9). The average annual rates of increase between FY1986 and FY1991 in these three industry sectors were 11.3% (9.8 in real terms) in electrical machinery, 9.5% (8.0%) in chemicals, and 8.8%(7.3%) in transport equipment.

Adopting the ratio of R&D expenditures against total sales as the index that indicates a company's awareness of the importance of R&D, the ratio for all industry reached 2.78% in FY1990, the highest level ever. This indicates that the relative importance of R&D is increasing in companies along with the trend toward high-tech products, etc. Principal industries with a high R&D to sales ratio are electrical machinery (6.31%), chemicals (5.24%) and precision instruments (4.85%) (Figure 2-1-10).

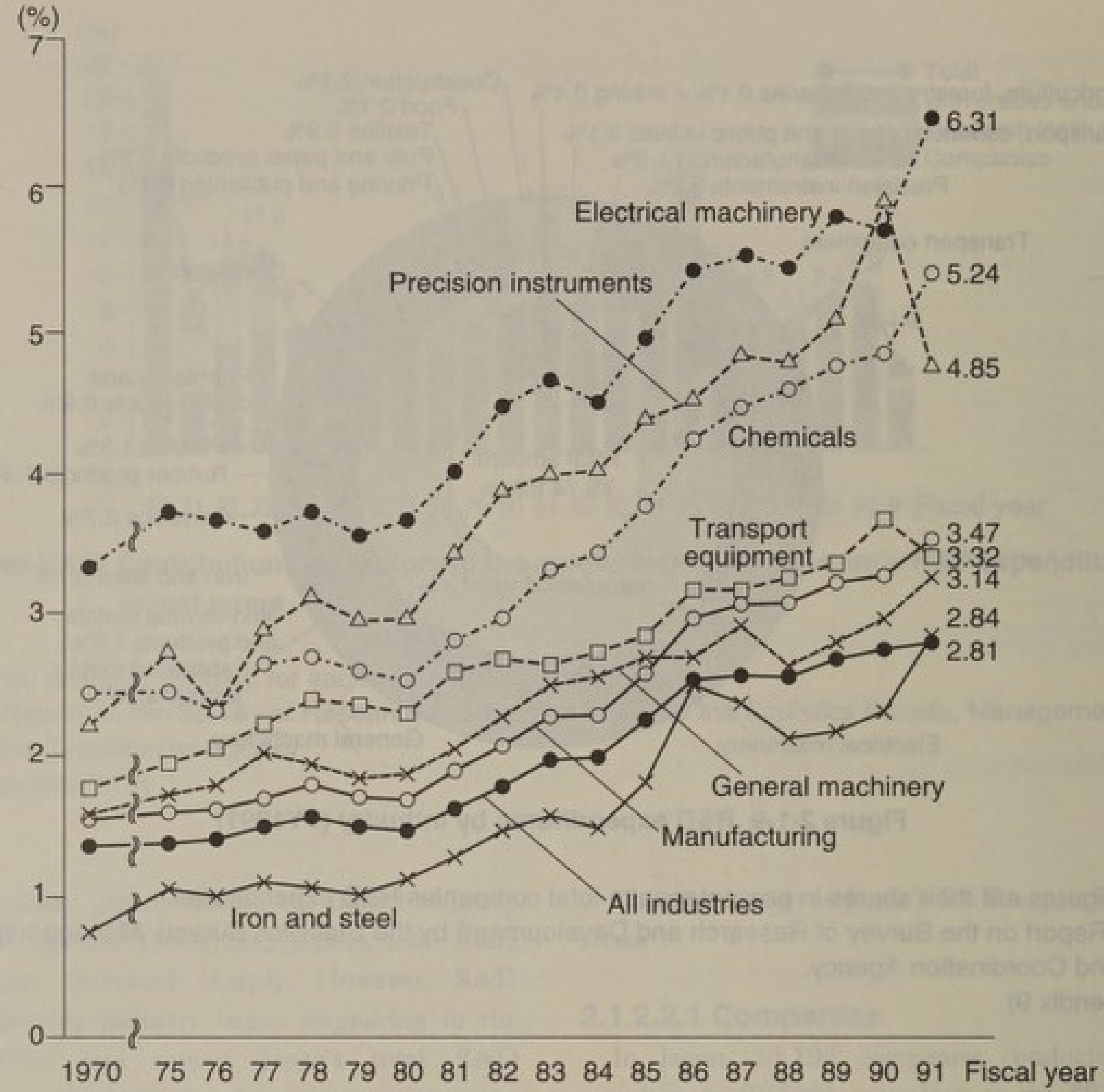


Figure 2-1-10 Ratio of R&D expenditures to sales figures in selected industries

Note: Figures are for private companies only. Public corporations are not included.
Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 10)

2.1.2.2.2 Research Institutions

Research institutions in Japan may be classified as national, local government-owned, private including nonprofit organizations such as foundations, and research-centered public corporations. National and local government-owned research institutions and public corporations are conducting research necessary to implement policies in the following fields.

- Basic and leading research
- Large-scale research such as nuclear energy development and space development
- Research to secure resources such as food and energy
- Research to support small-to-medium-sized enterprises
- Research to promote significant local industries for the development of the local economy
- Research that is beyond the capabilities of the

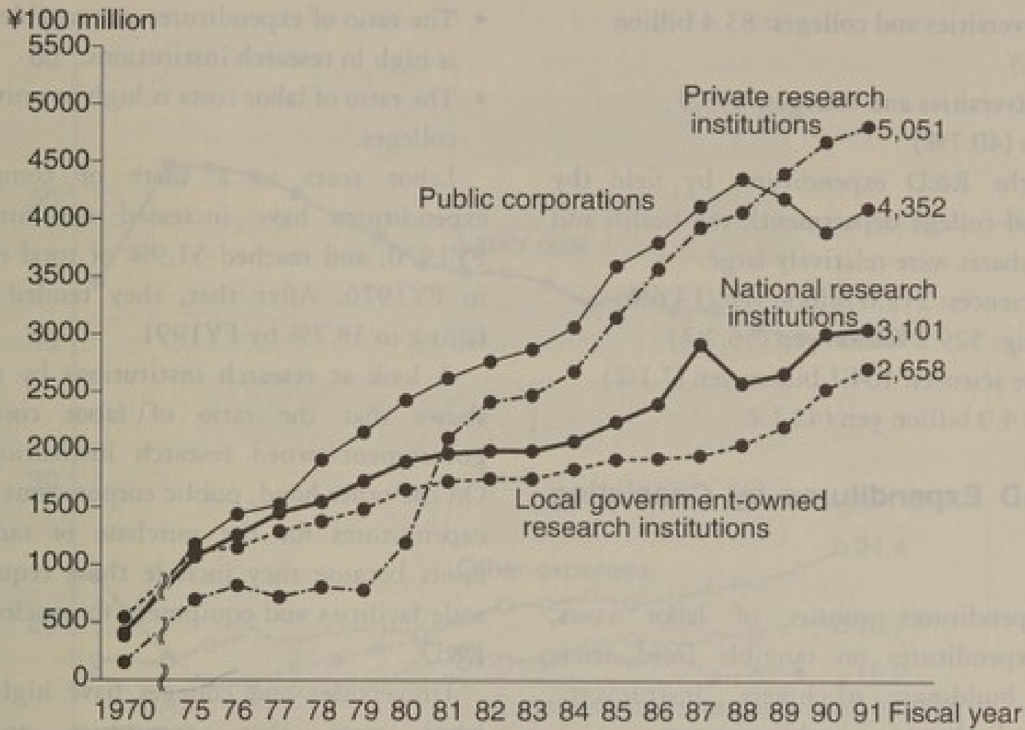


Figure 2-1-11 Trends in R&D expenditures by research institution

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 5)

private sector

The R&D expenditures by research institutions in Japan for FY1991 were 1,516.3 billion yen (The average annual rate of increase in real terms between FY1986 and FY1991 was 3.7%). This was 11.9% of the nation's total R&D expenditures. The government provides most of the R&D funds for national and local government-owned research institutions and public corporations and 27.9% of the R&D funds to private sector research institutions. As a result, the government provides 74.4% of the total funds for research institutions.

R&D expenditures by organizations in FY1991 were as follows (Figure 2-1-11);

- National research institutions: 310.1 billion yen (20.5% of total for research institutions)
- Local government-owned research institutions: 265.8 billion yen (17.5%)
- Private research institutions: 505.1 billion yen (33.3%)
- Research-centered public corporations: 435.2 billion yen (28.7%)

2.1.2.2.3 Universities and Colleges

The universities and colleges, as institutions of higher education, have an important role in cultivating research personnel while at the same time carrying out a broad area of research activities, especially basic research, to search for the truth.

The universities and colleges R&D expenditures in FY1991 were 1,460.8 billion yen, which was 11.5% of the total R&D expenditures for the nation (The average annual rate of increase from FY1986 to FY1991 was 3.7% in real terms). More than half of the R&D expenditures by universities and colleges are disbursed by national universities and colleges.

- National universities and colleges: 783.6 billion yen (53.6% of total for universities and colleges)

- Public universities and colleges: 83.4 billion yen (5.7%)
- Private universities and colleges: 593.9 billion yen (40.7%)

Viewing the R&D expenditures by field (by university and college department), the health and engineering shares were relatively large.

- Physical sciences: 212.6 billion yen (14.6%)
- Engineering: 529.2 billion yen (36.2%)
- Agriculture sciences: 104.1 billion yen (7.1%)
- Health: 614.9 billion yen (42.1%)

2.1.2.3 R&D Expenditures by Consisting Elements

R&D expenditures consist of labor costs, materials, expenditures on tangible fixed assets (land and buildings, machinery, instruments, equipment and others) and opther expenses.

The changes in the breakdown of Japan's R&D exppenditures by consisting elements show that labor costs are consistently the highest. In the early 1970s, labor costs tended to increase. However, since FY1975, they have been decreasing, accounting for 40.7% in FY1991. Material costs have been increasing slightly, and accounted for 18.7 in FY1991. Expenditures on tangible fixed assets were 16.2%. The share of other costs, including purchases of books used for research, utilities, travel, and communications, has been increasing in recent years, and accounted for 24.4% in FY1991 (Figure 2-1-12).

Comparing costs of research by sector, the following distinctive tendencies can be recognized.

- The ratio of material costs is high in companies.
- The ratio of expenditures on tangible fixed assets is high in research institutions.
- The ratio of labor costs is high in universities and colleges.

Labor costs as a share of company R&D expenditures have increased continuously since FY1970, and reached 51.9% of total expenditures in FY1976. After that, they tended to decline, falling to 38.7% by FY1991.

A look at research institutions by organization shows that the ratio of labor costs in local government-owned research institutions is high. On the other hand, public corporations have higher expenditures for the purchase of tangible fixed assets because they include those requiring large-scale facilities and equipment for nuclear and space R&D.

Universities and colleges have higher ratios of labor costs than companies and research institutions. In FY1991, university and college ratios of labor costs were 61.9%. This was 73.9% for public universities and colleges. By field, physical sciences and engineering have lower ratios of labor costs than the average ratio in universities and colleges (Figure 2-1-13).

2.1.3 R&D Expenditures by Character of Work

Classification into basic research, applied research and development[6], may differ from country to country. However R&D expenditure data by character of work generally reflects the R&D activity of each country. Recent statistical data for Japan, the United States, Germany and France

6) Report on the Survey of Research and Development compiled by the Statistics Bureau, Management and Coordination Agency defines classification of research by character of work as follows.

- Basic research: research undertaken primarily for the advancement of scientific knowledge, where a specific practical application is indirectly sought.
- Applied research: research undertaken primarily for the advancement of scientific knowledge, with a specific practical application sought directly.
- Development: the use of available knowledge obtained as the result of basic and applied research and/or practical experience which is directed to the introduction of new materials, equipment, products, systems and processes, etc., or the improvement of such already made available.

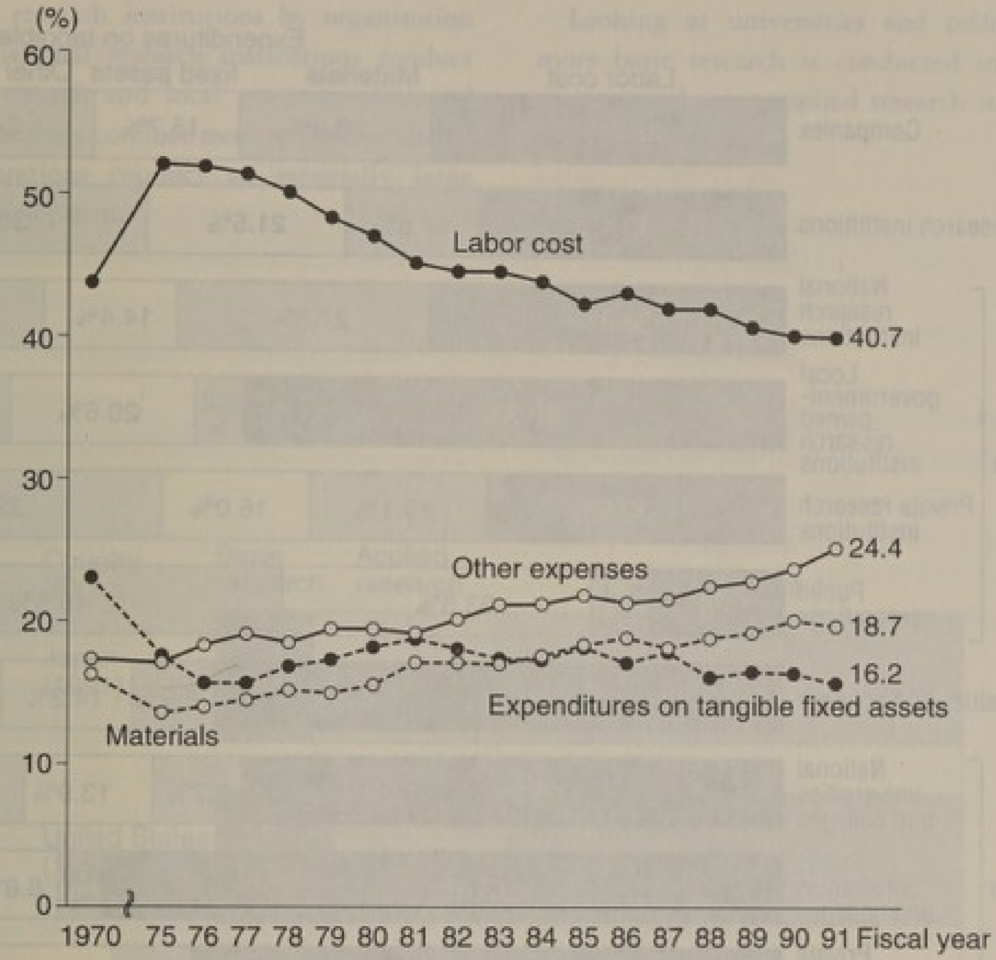


Figure 2-1-12 Trends in R&D expenditures by consisting elements

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 6)

shows that Germany and France spends more on basic research. The composition of R&D is similar in Japan and the United States, with a little higher ratio of basic research for the United States (Figure 2-1-14).

Examining basic research ratios of Japan and the United States by sector, Japan's ratio in industry is higher, while that in universities and colleges is lower, than in the United States.

Japan's R&D expenditures by character of work among companies, research institutions, and universities and colleges are distinctly different. Companies spend more on development due to the nature of corporate activities. Universities and colleges give priorities to basic and applied research. Research institutions fall between the two categories (Figures 2-1-15).

Changes in R&D expenditures by character of work for companies showed the following trend. From the 1970s, the ratio of basic and applied research decreased while that of development increased. However, from the early 1980s, the ratio of basic research started to increase, accounting for 6.8% of total R&D expenditures in FY1990, while applied research accounted for 22.2% and development was 71.1%.

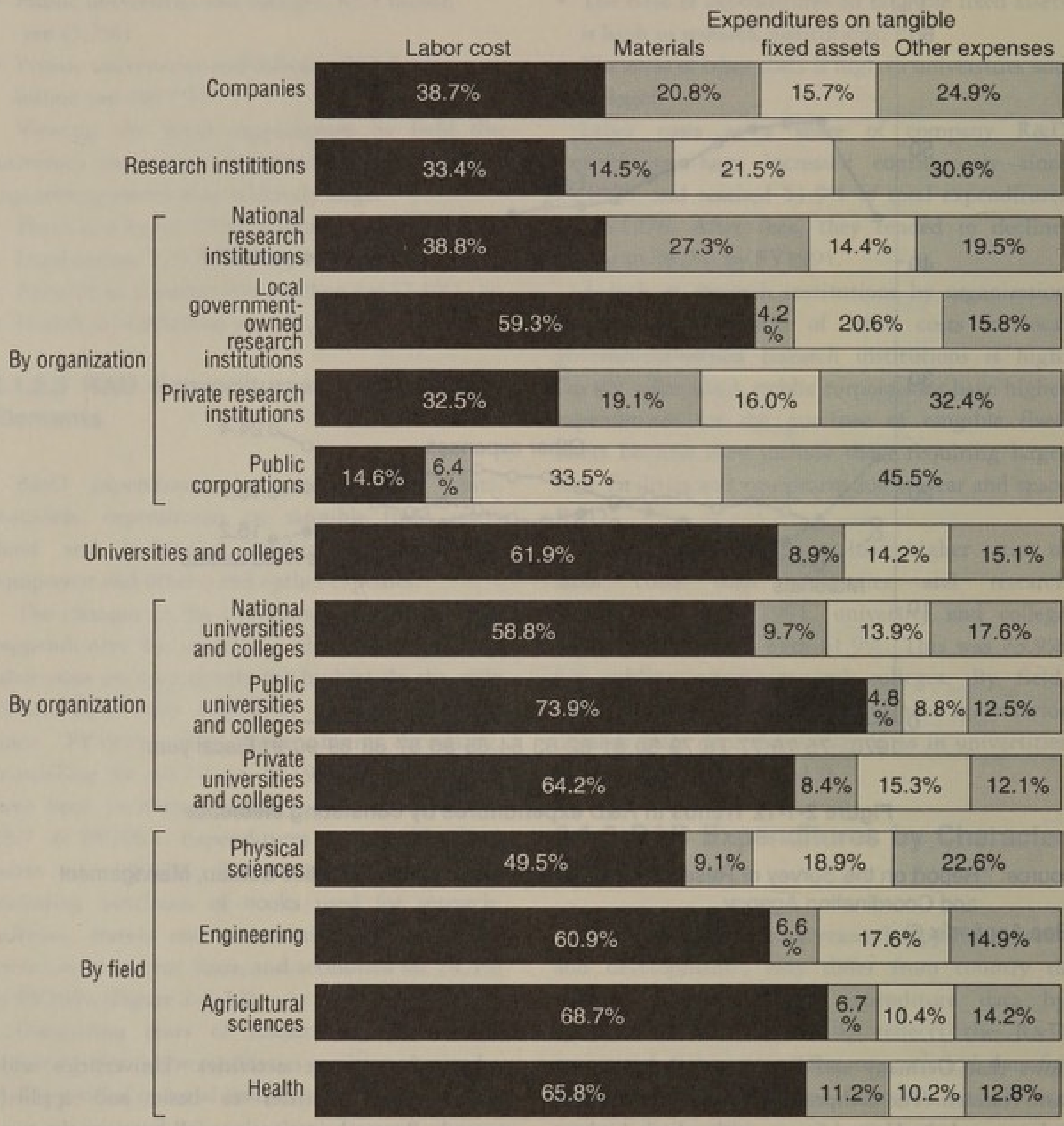


Figure 2-1-13 R&D expenditures by sector and by consisting elements (FY 1991)

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

(See Appendix 6)

A look at research institutions by organization shows that national research institutions conduct more basic research and local government-owned research institutions conduct more applied research. Public corporations conduct an especially large amount of development.

Looking at universities and colleges by field, more basic research is conducted in the physical sciences and more applied research is conducted in the health fields.

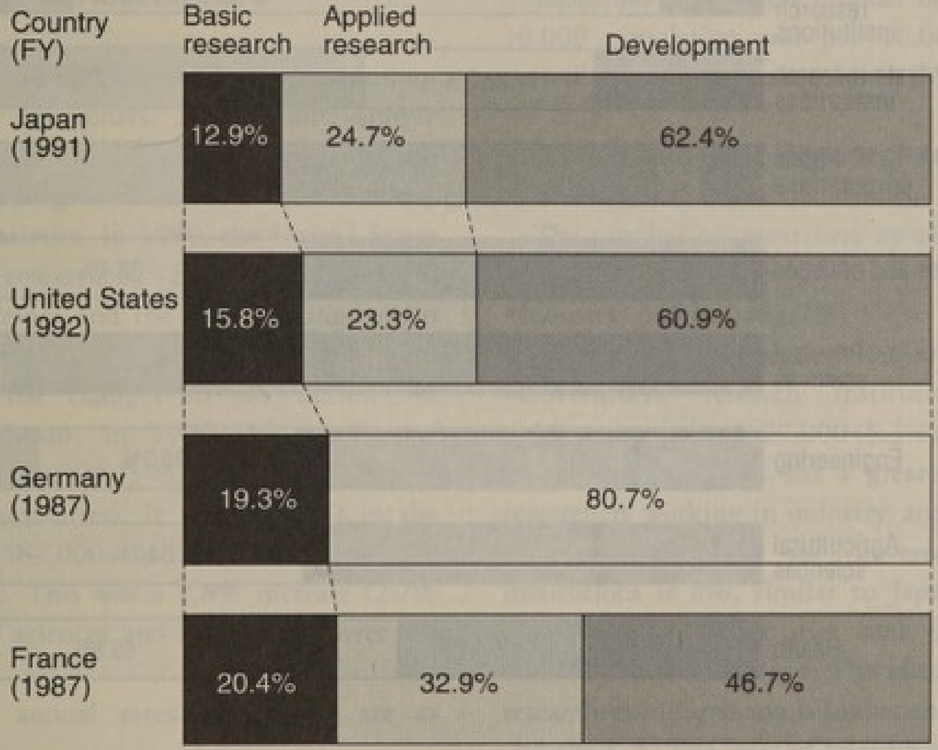


Figure 2-1-14 R&D expenditures by character of work in selected countries

Notes: 1.The figures for the United States is an estimate.
2.There is no distinction in Germany between applied research and development.

Sources: Japan,US — Same as in Figure 2-1-1.
Germany and France — OECD statistics.

(See Appendix 3)

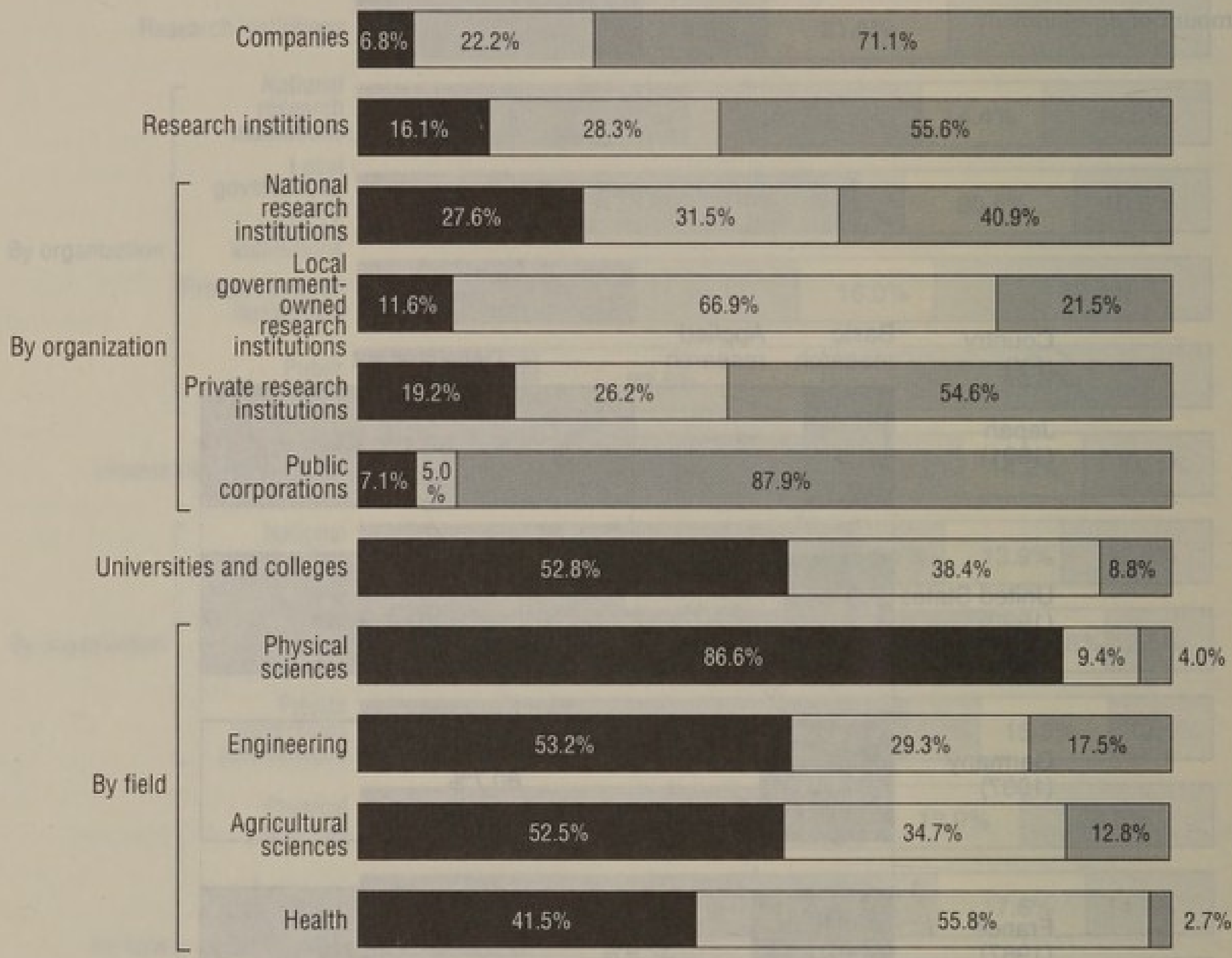


Figure 2-1-15 Composition of R&D expenditures by character of work by sector (FY 1991)

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 3)

2.2 Research Personnel

Statistics on research personnel, along with those on R&D expenditures, is another effective indicator of the extent of research activities. Personnel engaged in R&D[7] can be classified as researchers and support personnel (assistant research workers, technicians, and clerical and other supporting personnel).

2.2.1 Researchers

2.2.1.1 Number of Researchers

Countries use different methods for determining the number of researchers. As a result, simple comparisons may not be precise. It is useful, however, to look at general trends for each country from its own statistics. In 1989, the United States had 949,000 researchers, followed by Japan, Germany and France and the United Kingdom in the order named (Figure 2-2-1).

Looking at the changes in the number of researchers in Japan, in 1992 the number of researchers was 519,000 (598,000 including social sciences and humanities). It was 505,000 in the previous year (583,000 including social sciences and humanities). This was a 2.8% increase (2.7% including social sciences and humanities) over the previous year.

The average annual rates of increase are as follows:

- 1965 - 1970: 7.9%
- 1970 - 1975: 8.2%
- 1975 - 1980: 3.5%
- 1980 - 1985: 4.7%
- 1985 - 1990: 4.9%
- 1990 - 1992: 3.5%

The percentage increased steadily in the 1980s, though from the late 1980s the rate has slowed down.

2.2.1.2 Number of Researchers per 10,000 Population and per 10,000 Labor Force

Japan has the highest number of researchers per 10,000 population and per 10,000 labor force, exceeding even the United States (Figure 2-2-2).

2.2.1.3 Number of Researchers by Sector

The number of researchers by sector in Japan is as follows:

- Industry: 341,000 (65.7%)
- Universities and colleges: 140,000 (27.0%)
- Government research institutions (including public corporations): 27,000 (5.3%)

The United States has a greater percentage of researchers working in industry, and the percentage of researchers in its government research institutions is low, similar to Japan. The ratio of researchers at universities and colleges in the United States is also low. The ratio of government researchers in Germany is higher than that of Japan and the U.S. The ratio of researchers in industry in

7) "Report on the Survey of Research and Development" compiled by the Statistics Bureau, Management and Coordination agency classifies personnel engaged in R&D as follows.
Researcher: Persons who hold a university degree (or persons who have equivalent or greater knowledge in their specialty), who have research experience of at least two years, and who are engaged in research activities in their own chosen subject.
Assistant research workers: persons who assist researchers and who are engaged in research activities under their direction and who have the possibility of becoming researchers in the future.
Technicians: Persons, other than researchers and assistant research workers, who are engaged in technical services related to research activities under the guidance and supervision of researchers and assistant research workers.
Clerical and other supporting personnel: Excepting those mentioned above, persons who are engaged in miscellaneous activities, clerical work, accounting, etc. relating to research activities.
Japanese statistics on persons engaged in R&D are as of April I of the appropriate year.

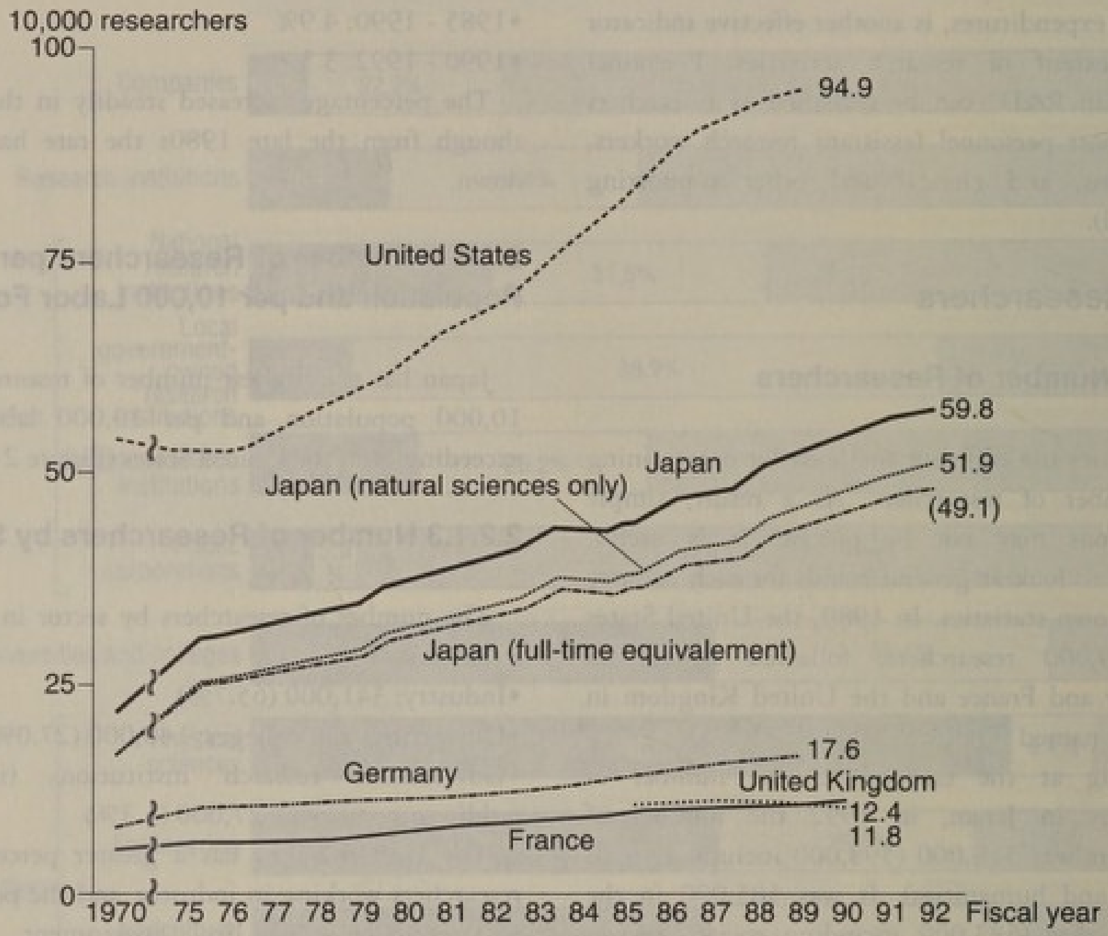


Figure 2-2-1 Trends in number of researchers in selected countries

Notes: 1. The figures for all countries include social sciences and humanities. The statistics for Japan also show numbers for researchers in natural sciences only.

2. Only the figures for Japan are not on a full-time equivalent basis. However, the figures showing a full-time equivalent basis by using OECD's estimating method including social sciences and humanities) also are indicated.

3. Germany and France: the years for which data are not available are indicated as a straight line.

Sources: Same as in Figure 2-1-1.

France — OECD statistics for the data before 1981.

(See Appendix 1)

France is low, as researchers are concentrated in government, research institutions, universities and colleges. In the United Kingdom, the ratio of researchers in industry is high and the ratio of researchers in universities and colleges is low (Figure 2-2-3).

The following sections show the characteristics of researchers in Japan by sector.

2.2.1.3.1 Companies

In the last 10 years from 1982 to 1992, the number of researchers in companies has increased 1.77 times (an average annual rate of increase of 5.9%) (Figure 2-2-4).

In industry, 326,000 of the researchers are in manufacturing (95.6%). Of all researchers within manufacturing, the electrical machinery industry tops the list at 129,000 researchers or 37.9% of the total. Next is the chemical industry with 56,000 researchers or 16.3%. These two industries account for approximately half of all company researchers.

By field of research, engineering ranks the highest at 61.7%. Next is the physical sciences at 25.6%, followed by health at 3.5%, and finally agricultural sciences at 2.8%. Within the engineering field, researchers are concentrated in electrical and telecommunications engineering, mechanical engineering, shipbuilding and aeronautical engineering.

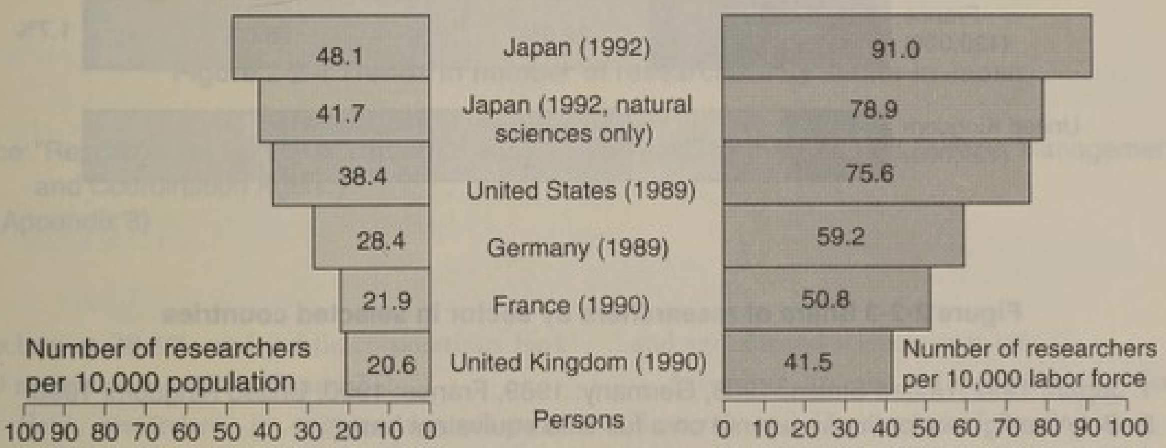


Figure 2-2-2 Researchers per 10,000 population and 10,000 labor force

Notes: 1. The figures for all countries include social sciences and humanities. The statistics for Japan also show the data for researchers in natural sciences only.
2. Only the figures for Japan are not on a full-time equivalent basis. However, the figures on a full-time equivalent basis by using OECD's estimating method (including social sciences and humanities) are 39.5 researchers per 10,000 population and 74.7 researchers per 10,000 labor force in FY 1992.

Sources: Numbers of researchers data: Same as in Figure 2-1-1.
Population and labor force data: Japan — "'Population Estimates Series" and "Monthly Report on the Labor Force Survey" by the Statistics Bureau, Management and Coordination Agency.
U.S. — Data from the Department of Commerce and the Department of Labor.
Other countries — OECD statistics.

(See Appendix 1)

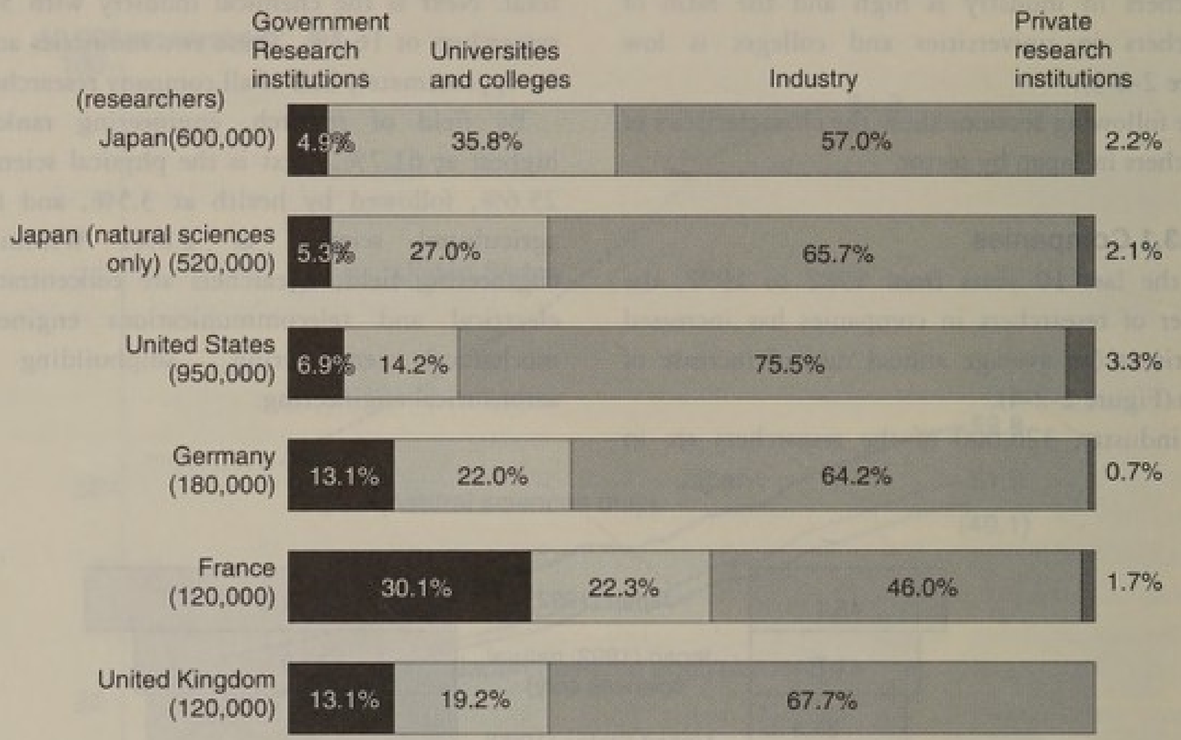


Figure 2-2-3 Share of researchers by sector in selected countries

Notes: 1. Japan: 1992, United States: 1988, Germany: 1989, France: 1990, United Kingdom: 1990.
2. Only the figures for Japan are not on a full-time equivalent basis.
3. The data for the United Kingdom do not include researchers in private research institutions.
Source: Same as in Figure 2-1-1.

Within the physical sciences, chemistry has the majority. These three fields employ three-fourths of all company researchers (Figure 2-2-5).

Regarding the number of researchers per 10,000 employees, the average number throughout all industry sectors is 497. The average number in the manufacturing sector is highest at 593. Within manufacturing, following sectors rank at the top (Figure 2-2-6).

•Electrical machinery: 991
•Chemical products: 973
•Precision instruments: 765

2.2.1.3.2 Research Institutions

For the last 10 years, researchers in research institutions have increased 16.7% (an average, annual rate of increase of 1.6%). This is due to an increase in the number of private research institutions. Looking at the number of researchers by organization, the national research institutions have 10,000 researchers or 26.9% of the total for research institutions, local government-owned research institutions have 14,000 researchers at 36.0%, private research institutions have 11,000

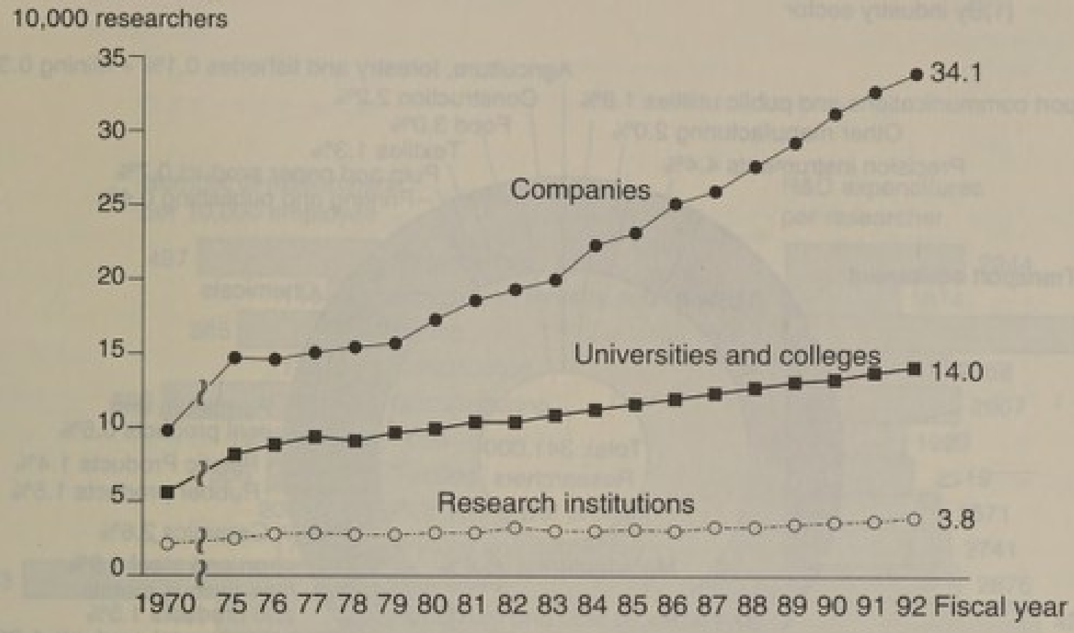


Figure 2-2-4 Trends in number of researchers by sector in Japan

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 8)

researchers at 28.3%, and public corporations have 3,000 researchers at 8.8% (Figure 2-2-7).

By field, researchers in engineering are most numerous at 38.6%, next is agricultural sciences at 32.6%, followed by the physical sciences at 20.9%, and finally health at 6.9% (Figure 2-2-8).

2.2.1.3.3 Universities and Colleges

The number of researchers at universities and colleges has increased 34.4% in the last 10 years (an average annual rate of increase of 3%). Looking at the number of researchers by type of institution in 1992, national universities and colleges have 77,000 researchers (54.8% of the total for universities and colleges), public universities and colleges have 10,000 researchers (6.8%), and private universities and colleges have 54,000 researchers (38.3%) (Figure 2-2-9).

By field, health ranks first at 58.1%, followed by engineering at 20.6%, physical sciences at 11.2%, and agricultural sciences at 6.1%.

According to the "Report on the Survey of Research and Development" by Statistics Bureau, Management and Coordination Agency, Researchers in universities and colleges are classified into teachers, students for Ph.D. degree, medical staff and others. Looking at the composition of researchers by type of institution, in national universities and colleges, students for Ph.D. degrees make up a large ratio of the researchers, public universities and colleges have a greater ratio of medical staff and others, and private universities and colleges have a greater ratio of teachers and a smaller ratio of students for Ph.D. degrees (Figure 2-2-10).

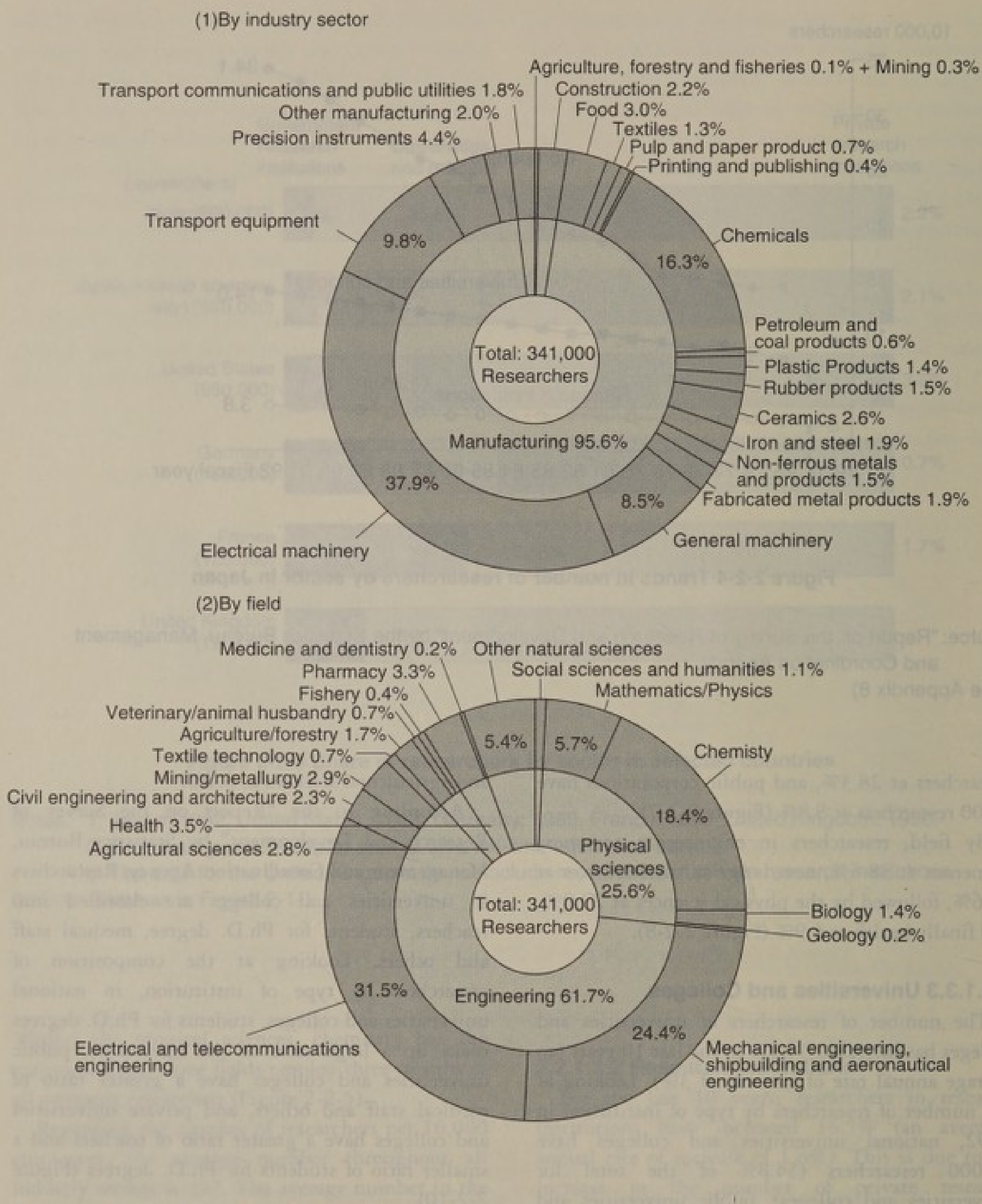


Figure 2-2-5 Number of company researchers by industry sector and by field of research(1992)

Note: Figures are their shares in percentages to total company researchers.
Souse: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 9)

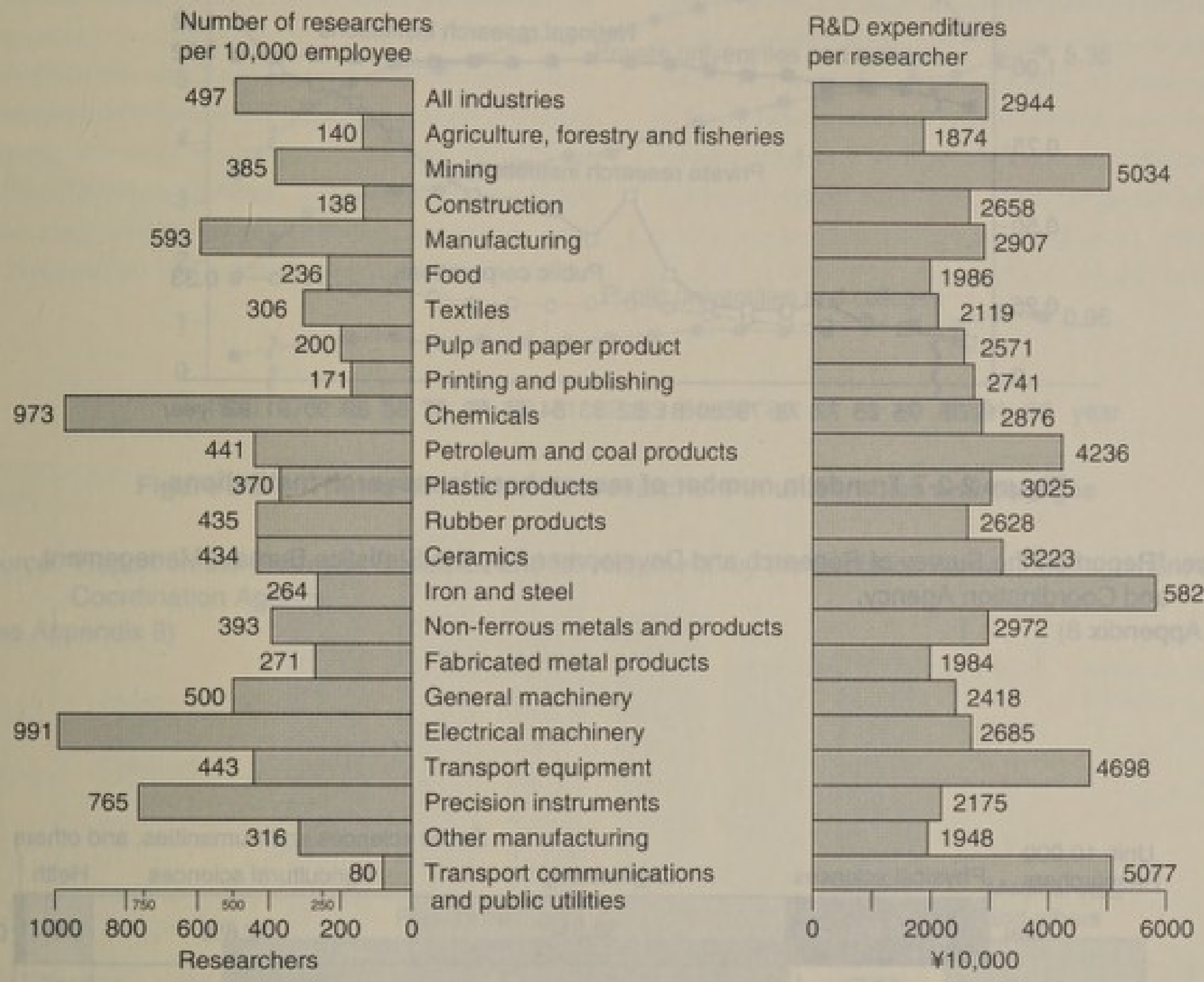


Figure 2-2-6 Number of researchers per 10,000 employees and R&D expenditures per researcher in companies

Notes: 1. As for the R&D expenditures per researcher, the data for the number of researchers are as of April 1, 1991, and the data for research expenditures are as of FY1991.
2. Regarding researchers per 10,000 employees, the data for number of employees and number of researchers are as of April 1, 1992.

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

(See Appendix 9)

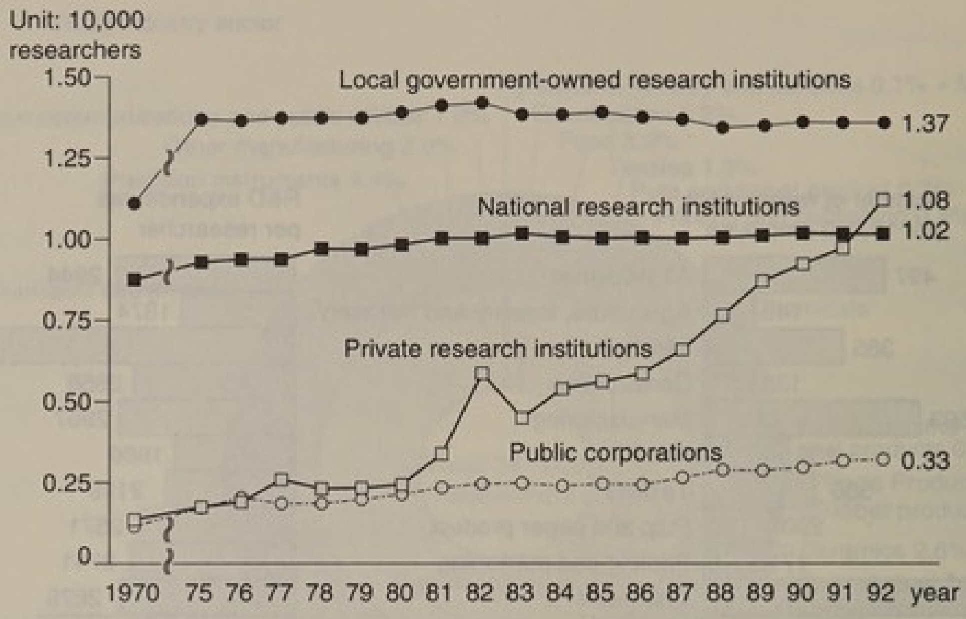


Figure 2-2-7 Trends in number of researchers in research institutions

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 8)

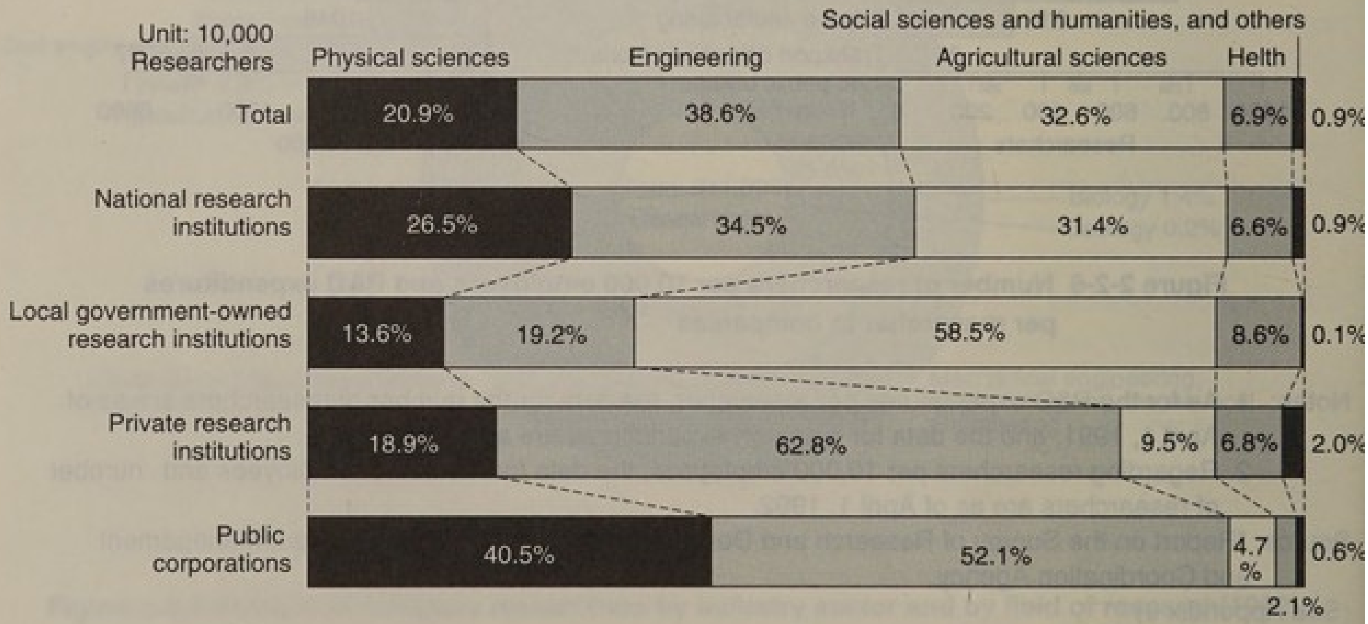


Figure 2-2-8 Share of researchers in research institutions by organization and field (1992)

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

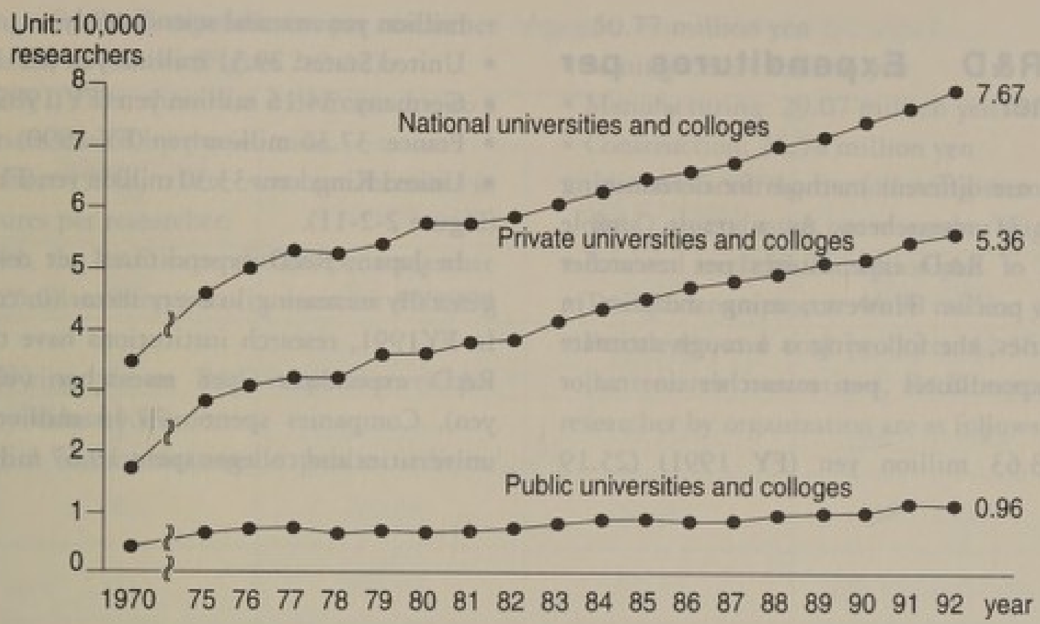


Figure 2-2-9 Trends in number of researchers in universities and colleges

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 8)

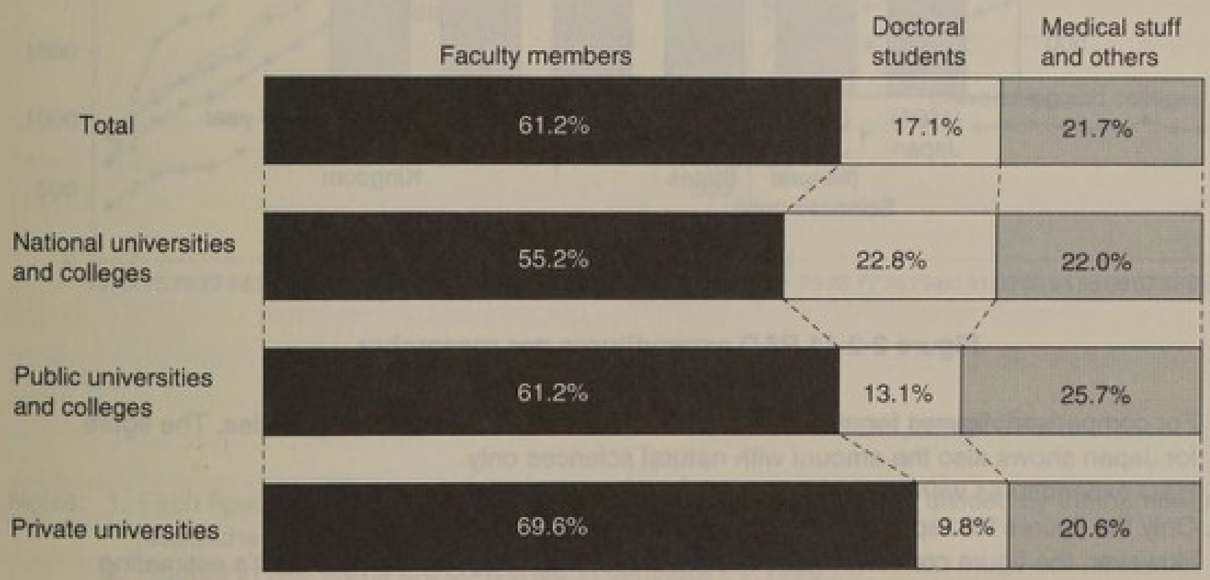


Figure 2-2-10 Composition of researchers in universities and colleges (1992)

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

2.2.2 R&D Expenditures per Researcher

Countries use different methods for determining the number of researchers. As a result, simple comparisons of R&D expenditures per researcher may not be precise. However, using statistics in major countries, the following is a rough estimate of R&D expenditures per researcher in major countries.

- Japan: 23.63 million yen (FY 1991) (25.19 million yen: natural sciences only)
- United States: 29.51 million yen (FY 1989)
- Germany: 34.16 million yen (FY 1989)
- France: 37.36 million yen (FY 1990)
- United Kingdom: 33.30 million yen (FY 1990)

(Figure 2-2-11).

In Japan, R&D expenditures per researcher are generally increasing in every sector (in current yen). In FY1991, research institutions have the greatest R&D expenditure per researcher (40.89million yen). Companies spent 29.44 million yen, and universities and colleges spent 10.67 million yen.

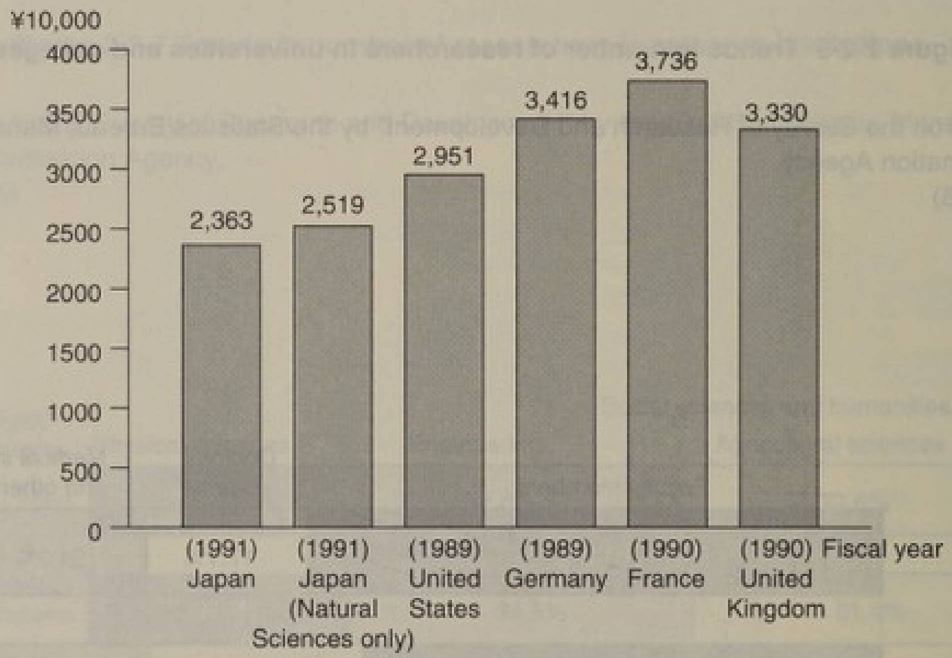


Figure 2-2-11 R&D expenditures per researcher

Notes: 1. For comparison, figures for all countries include social sciences and humanities. The figure for Japan shows also the amount with natural sciences only.
2. R&D expenditures were converted using OECD's purchase power parity.
3. Only the figures for Japan are not on a full-time equivalent basis.
However, the figure converted on a full-time equivalent basis by using OECD's estimating method (1991, including social sciences and humanities) is 27.07 million yen.

Source: Same as in Figure 2-1-1.
(See Appendix 1)

The changes in R&D expenditures per researcher in real terms are as follows (Figure 2-2-12):

- In the early 1970s, there was a decrease due to a rise in prices caused by the oil crisis.
- In the late 1970s, there was an increase in expenditures per researcher.
- In FY1991, the R&D expenditures per researcher reached 25.04 million yen (in constant FY1990 yen).

The following shows R&D expenditures per researcher by industry sector.

- Transport / communications / public utilities: 50.77 million yen
- Mining: 50.34 million yen
- Manufacturing: 29.07 million yen
- Construction: 26.58 million yen

In manufacturing the following sectors have high R&D expenditures per researcher (Figure 2-2-6).

- Iron and steel: 58.26 million yen
- Transport equipment: 46.98 million yen
- Petroleum and coal products: 42.36 million yen

In research institutions, R&D expenditures per researcher by organization are as follows:

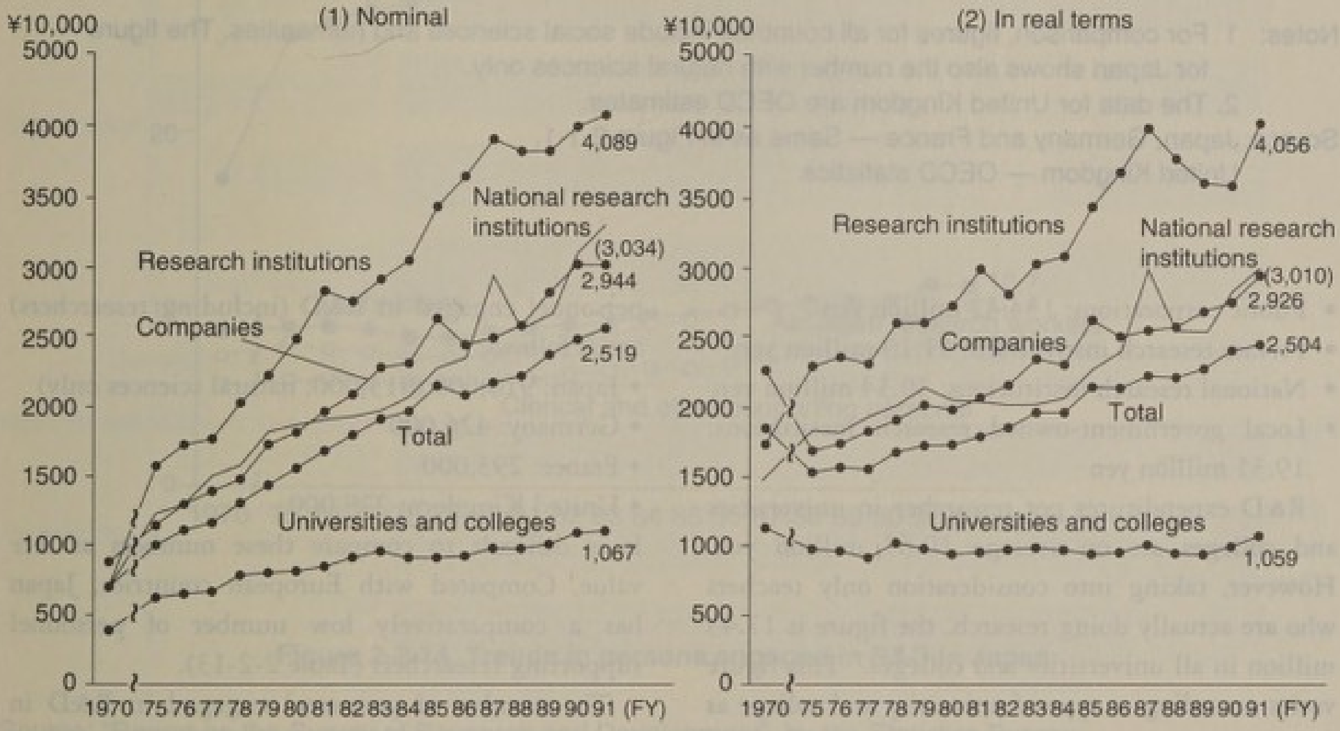


Figure 2-2-12 Trends in R&D expenditures per researcher

Notes: 1. Each figure equals R&D expenditures of the relevant fiscal year divided by the number of researchers (as of April 1).
2. Figures in real terms are converted in constant FY 1990.
3. The data for national research institutions are indicated in a thin line.

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

(See Appendix 5,8,15)

Table 2-2-13 Personnel engaged in R&D in selected countries

Country (year)	Total Number of personnel engaged in R&D	Number which are non-researchers	Non-researcher per researcher
Japan (1992)	910,051	311,718	0.52
Japan, natural sciences only (1992)	812,985	294,116	0.57
Germany (1989)	426,446	250,044	1.42
France (1990)	293,320	169,251	1.36
United Kingdom(1988)	277,800	147,800	1.14

Notes: 1. For comparison, figures for all countries include social sciences and humanities. The figure for Japan shows also the number with natural sciences only.
2. The data for United Kingdom are OECD estimates.

Source: Japan, Germany and France — Same as in Figure 2-1-1.
United Kingdom — OECD statistics.

- Public corporations: 134.42 million yen
- Private research institutions: 51.10 million yen
- National research institutions: 30.34 million yen
- Local government-owned research institutions: 19.35 million yen

R&D expenditures per researcher in universities and colleges are on average 10.67 million yen. However, taking into consideration only teachers who are actually doing research, the figure is 17.43 million in all universities and colleges. This figure varies according to type of university and college as follows:

- National universities and colleges: 18.76 million yen
- Public universities and colleges: 15.17 million yen
- Private universities and colleges: 16.24 million yen

2.2.3 Personnel Engaged in R&D

Although the definition of personnel engaged in R&D is not same in each country, numbers of personnel engaged in R&D (including researchers) are as follows:

- Japan: 910,000 (813,000: natural sciences only)
- Germany: 426,000
- France: 293,000
- United Kingdom: 278,000

It is difficult to compare these numbers at face value. Compared with European countries, Japan has a comparatively low number of personnel supporting researchers (Table 2-2-13).

The number of personnel engaged in R&D in Japan has increased 43.3% (an average annual rate of increase: 3 7%) during the 10 years from 1982 to 1992. This increase was mostly due to the increase in numbers of researchers (Figure 2-2-14). The percentage of researchers of all personnel engaged in R&D has increased from 58.1% in 1982 to 63.8% in 1992. On the other hand, the share of assistant research workers decreased from 14.7% to 12.8%. The percentage of technicians decreased from 15.9% to 13.2%. Clerical and other supporting personnel have decreased from 11.3% to 10.2%. As a result, the number of assistant research workers

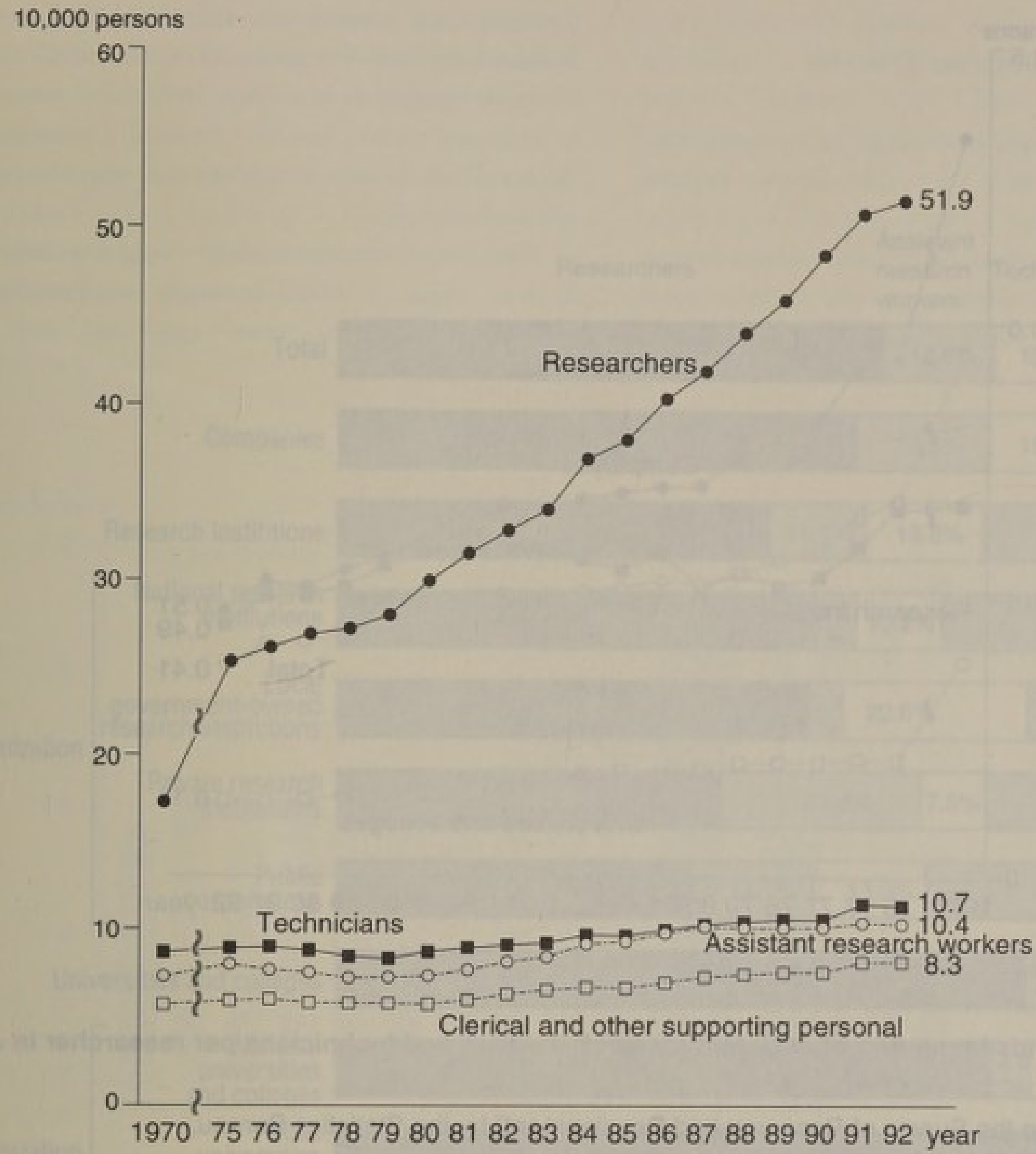


Figure 2-2-14 Trends in persons engaged in R&D in Japan

Source: "Report on the Survey of Research and Development", by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 7)

and technicians per researcher has been decreasing and was 0.41% in 1992 (Figure 2-2-15).

A breakdown of the number of personnel engaged in R&D by sector shows that companies have a larger ratio of support personnel than other sectors and that universities and colleges have a larger ratio of researchers (Figure 2-2-16).

In companies, the number of personnel engaged in R&D is 563,000. Researchers account for 341,000 (60.5% of the total for companies), assistant research workers 88,000 (15.6%), technicians 85,000 (15.1%), and clerical and other supporting personnel 49,000 (8.7%). Looking at the breakdown of personnel engaged in R&D by industry, the researcher ratio is high in transport/communications/public utilities (76.5%)

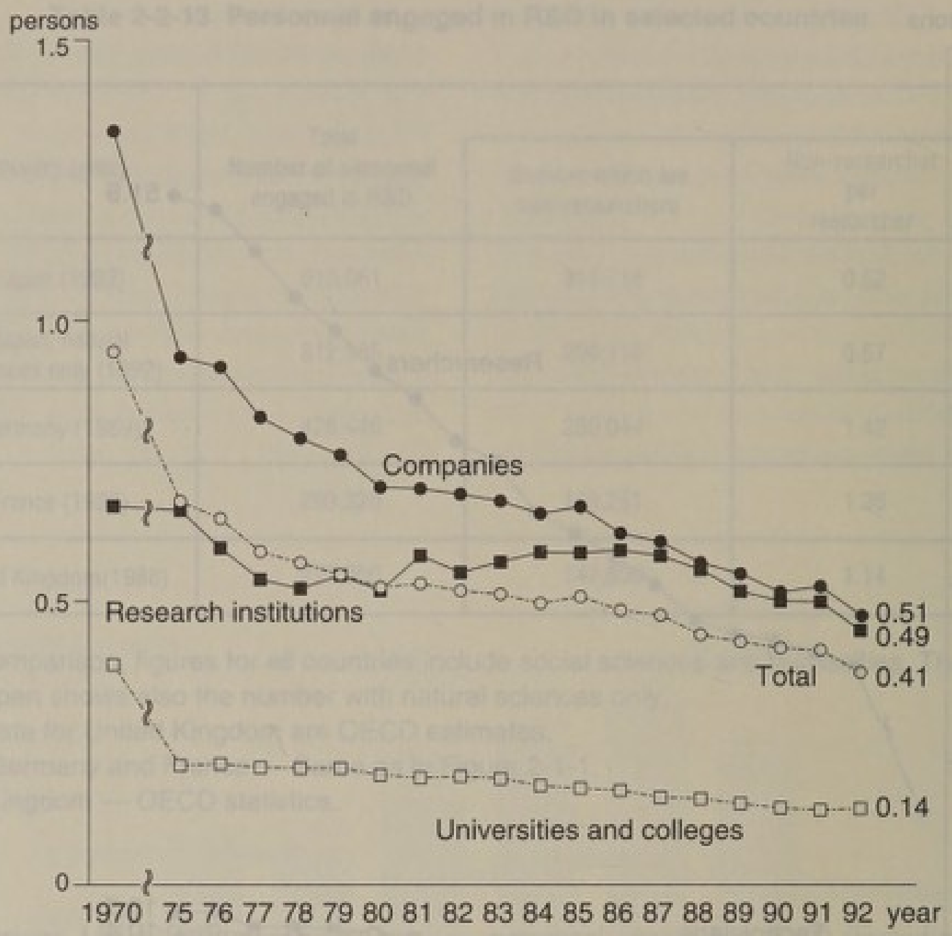


Figure 2-2-15 Trends in number of assistant research workers and technicians per researcher in Japan

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 7)

and construction (72.3%). In manufacturing, the researcher ratio is high in printing and publishing (76.5%) and precision instruments (67.5%) while the researcher ratio is relatively low in transport equipment (45.1%) and petroleum and coal products (47.9%).

In research institutions the number of personnel engaged in R&D is 76,000. Researchers account for 38,000 (50.4% of the total for research institutions), assistant research workers 8,000 (11.1%), technicians 10,000 (13.8%), and clerical and other supporting personnel 19,000 (24.7%). The data by types of research institutions indicate that national and local government-owned research institutions have a larger ratio of researchers and private research institutions and public corporations have a larger ratio of assistant research workers.

Personnel engaged in R&D at universities and colleges total 174,000. Researchers account for 140,000 (80.3% of the total for universities and colleges), assistant research workers 8,000 (4.5%), technicians 12,000 (6.6%), and clerical and other supporting personnel 15,000 (8.7%).

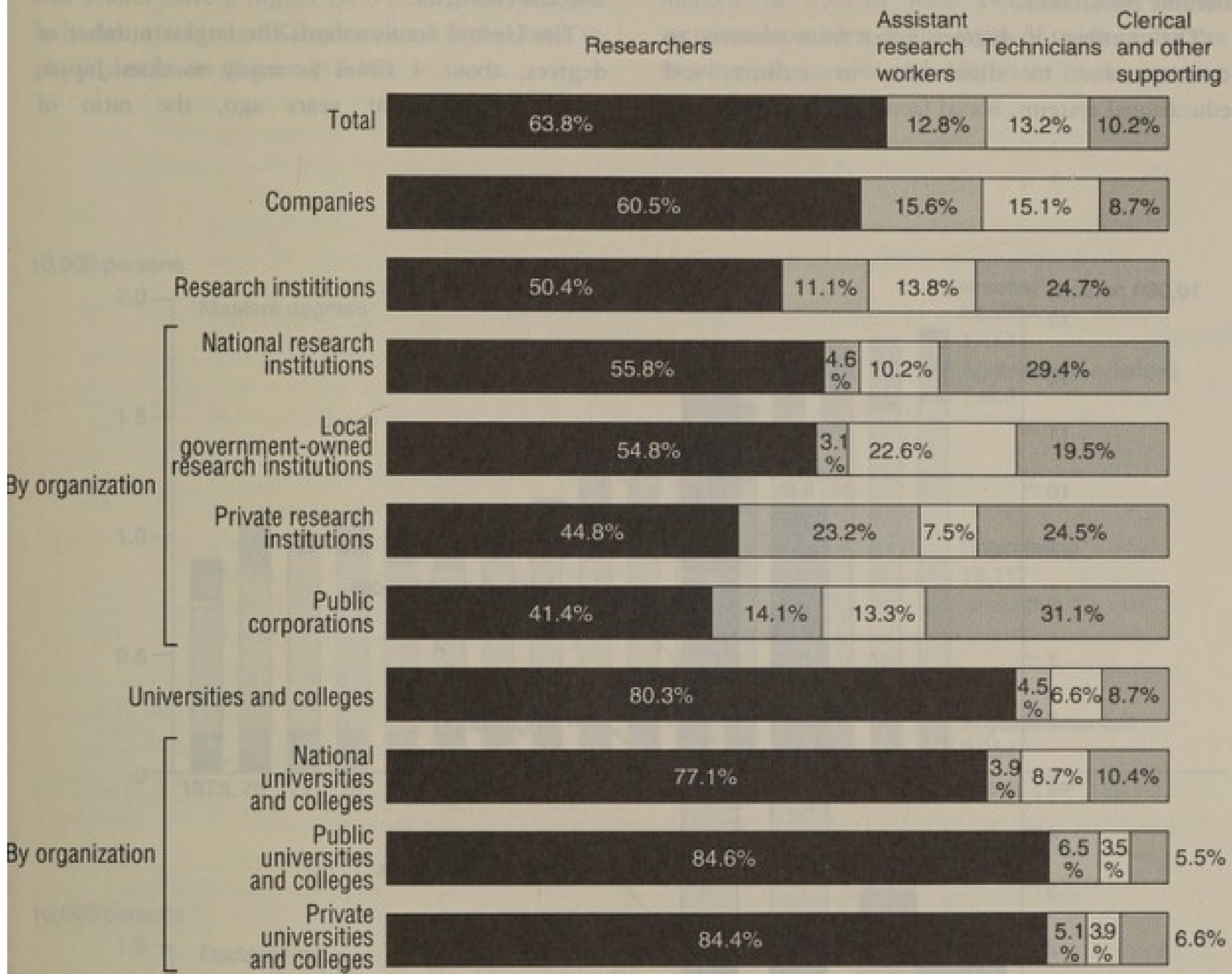


Figure 2-2-16 Composition of personnel engaged in R&D by sector in Japan (1992)

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

2.2.4 Overall Degree Trends

An especially high percentage of students who have taken the master's or the doctor's degrees become researchers.

The number of degrees differ from country to country due to differences in culture and educational systems. Social factors such as industrial structure and number of students can affect the number of awarded degrees. Thus, it is difficult to compare the data at face value. It is useful, however, to compare trends, and this section describes the degree trends in natural sciences and engineering in selected countries.

The United States awards the largest number of degrees, about 4 times as many as does Japan. Compared to eight years ago, the ratio of

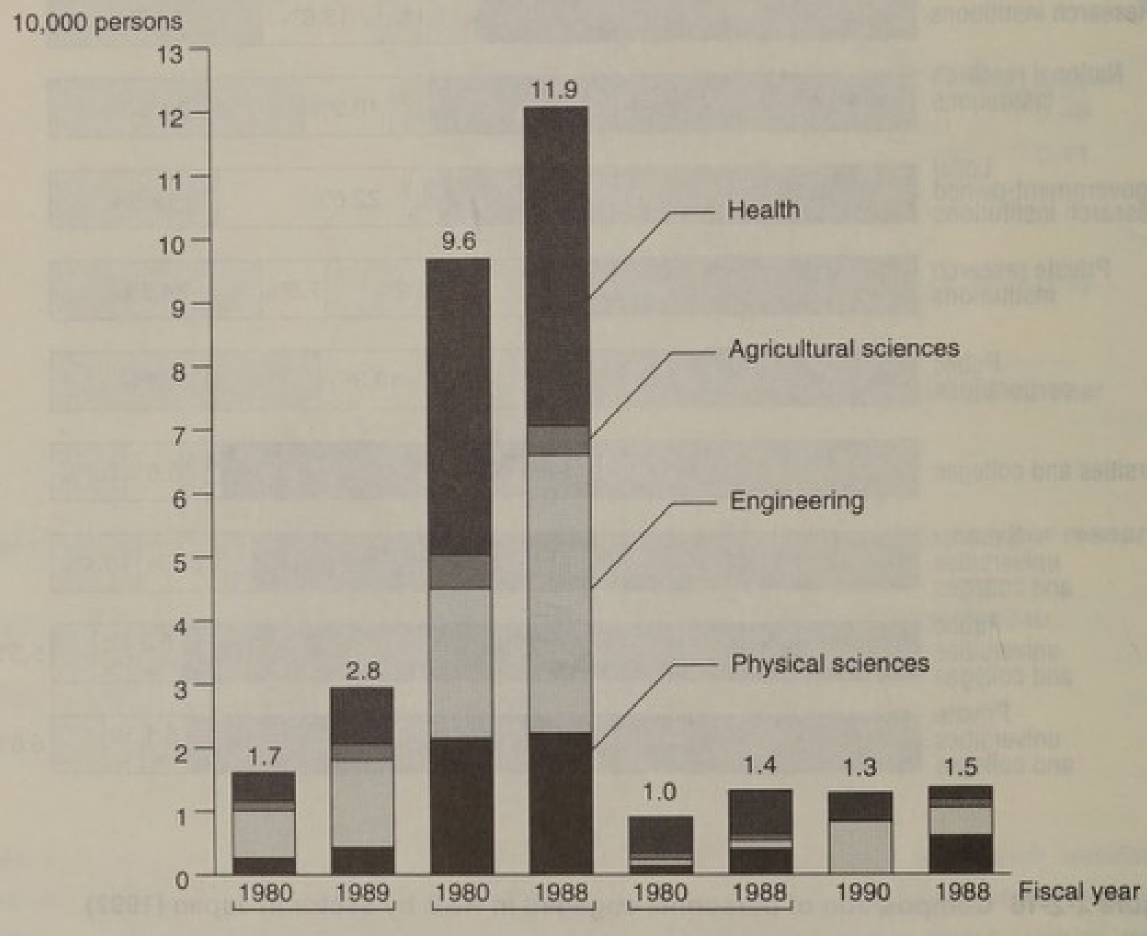


Figure 2-2-17 Number of awarded degrees in selected countries (Natural science)

Notes: 1. Totals include master's and doctoral degrees (Germany: only doctorates).
2. U.S. health degrees include first-professional degrees.
3. France does not distinguish between physical sciences, engineering, and agricultural sciences.

Source: "International Comparison of Education Indexes", by the Ministry of Education.

engineering degrees to total degrees has increased. Japan is second in number of degrees awarded following the U.S. and has a higher ratio in engineering. Germany, France, and the United Kingdom have about the same number. Germany and France have a higher ratio of degrees awarded in health, the United Kingdom has a higher ratio in physical sciences (Figure 2-2-17).

In Japan the number of awarded degrees has increased in recent years. In FY1985, 15,058 master's degrees and 7,688 doctorates were awarded. In FY1990, 19,242 master's degrees (an increase of 27.8%) and 9,957 doctorates (an increase of 29.5%) were awarded. The largest increases have been in the ratios of master's degrees in physical sciences and doctorates in engineering (Figure 2-2-18).

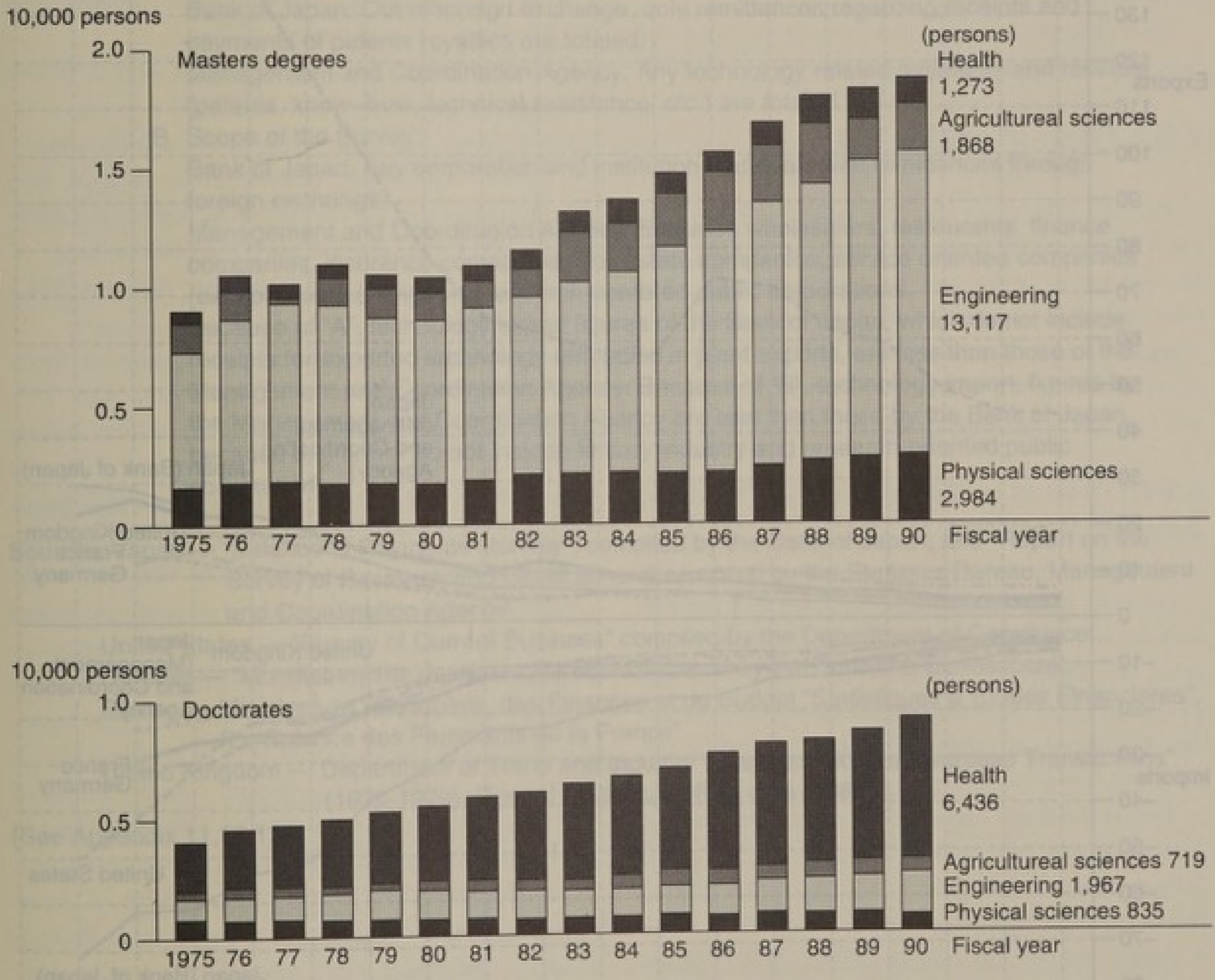


Figure 2-2-18 Degree Trends in Japan (Natural Science)

Note:The figures are awarded degrees in FY1990.
Source: "Statistical Abstract of Education, Science and Culture" by the Ministry of Education.

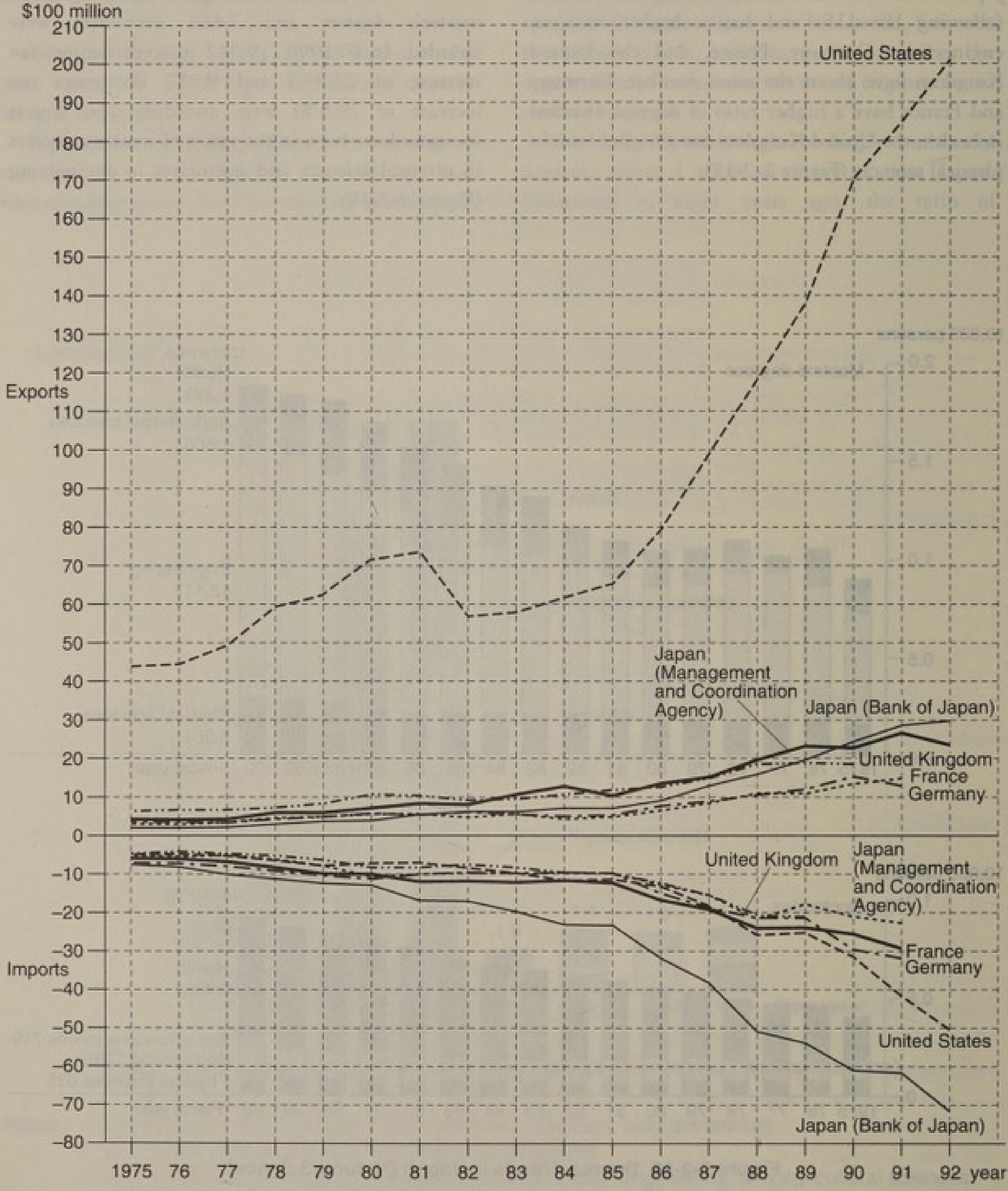


Figure 2-3-1 Trends in technology trade of selected countries

Notes: 1. The amounts are converted into dollars, according to IMF statistics.
2. Bank of Japan refers to the "Balance of Payments Monthly", compiled by the Bank of Japan. Management and Coordination Agency refers to the "Report on the Survey of Research and Development", compiled by the Statistics Bureau, the Management and Coordination Agency.
3. The figures are totals for the calendar year; the fiscal year is used only for the figures of Japan Management and Coordination Agency.
4. The United States changed the classification of statistics in 1982. Besides in 1992, the definition of import / export was reassessed, and from 1982 onward, figures were revised.
5. The United Kingdom changed its method of gathering data in 1987. Thus, new data cannot be compared with that prior to 1986.
6. The major reasons for differences between the figures provided by the Bank of Japan and those provided by the Management and Coordination Agency are as follows.

A. Method of data collection:
Bank of Japan: Out of foreign exchange, only remittances regarding receipts and payments of patents royalties are totaled.
Management and Coordination Agency: Any technology related payments and receipts (patents, know- how, technical assistance, etc.) are totaled.
B. Scope of the Survey:
Bank of Japan: Any corporation and institution that deals with remittances through foreign exchange.
Management and Coordination Agency: Excludes wholesalers, restaurants, finance companies, insurance companies, real estate companies, service oriented companies (except broadcasting) and research-centered public corporations.
Because of "A", technology export figures of the Bank of Japan, which do not include receipts for exported technology embodied in plant exports, are less than those of the Management and Coordination Agency. Because of "B", technology import, figures by the Management and Coordination Agency are less than those by the Bank of Japan, because the former do not include tertiary industry and research-oriented public corporations.

Sources: Japan — "Balance of Payments Monthly", compiled by the Bank of Japan, and "Report on the Survey of Research and Development" compiled by the Statistics Bureau, Management and Coordination Agency.
United States — "Survey of Current Business" compiled by the Department of Commerce .
German — "Monatsberichte der deutschen Bundesbank" by the Deutsche Bundesbank.
France — Ministers de l'Economie, des Finances et du Budget "Statistiques & Etudes Financieres", "La Balance des Paiements de la France".
United Kingdom — Department of Trade and Industry "Business Monitor,Overseas Transactions" (1970-1979), Central Statistical Office data (1980~).

(See Appendix 11,12,13)

2.3 Trends Related to Research Performance

The data on technology trade balances, number of patents applied for and granted, high-tech product trade balances and number of scientific papers, which indicates results of R&D activities in science and technology, reflect the activity and a nation's level and strength of R&D activities. These statistics are considered to be significant indicators demonstrating levels of R&D and technological strength.

This chapter describes these trends in Japan and selected countries.

2.3.1 Trade in Technology

Patents, utility models, and technical know-how are results of R&D efforts in science and technology. In addition to being used by corporations for their own purposes, they are traded internationally, for example in the form of transfer of rights, approval of utilization, and others. These transactions are what are known as technology trade.

2.3.1.1 Trends in the Technology Trade of Selected Countries

Looking at the value of technology exports and imports of the major countries; the trends of recent years are reflected in terms of advances in the globalization of corporate activities and emphasis of the importance of intellectual property rights, and the basic theme is expansion (Figure 2-3-1).

The technology exports (value received) of the United States are significantly larger, at 20.2 billion dollars (1992, 2.5621 trillion yen), than the following countries.

- Japan: 3.1 billion dollars (1992, 386.5 billion yen) ("Balance of Payments Monthly" by the Bank of Japan, referred to as the "Bank of Japan statistics" below)
- Japan: 2.8 billion dollars (1991, 370.6 billion yen) ("Report on the Survey of Research and Development" by Management and Coordination Agency, referred to as Management and Coordination Agency statistics below)
- United Kingdom: 2 billion dollars (1989, 272.4 billion yen)
- Germany[8]: 1.5 billion dollars (1991, 196.4 billion yen)
- France: 1.5 billion dollars (1991, 207.0 billion yen)

In contrast, technology imports (value paid) amount to the following:

- Japan: 7.2 billion dollars (910.1 billion yen) (Bank of Japan statistics)
- United States: 5.0 billion dollars (631.2 billion yen)
- Germany: 3.2 billion dollars (432.2 billion yen)
- Japan: 2.9 billion dollars (394.7 billion yen) (Management and Coordination Agency statistics)
- France: 2.2 billion dollars (299.3 billion yen)
- United Kingdom: 2.1 billion dollars (284.1 billion yen)

As a result, only the U.S. has a surplus in its technology trade balance. In 1992, the U.S. technology trade surplus was 15.3 billion dollars (1.9309 trillion yen) and its ratio (export / import) was 4.06. The United Kingdom has a small deficit and a ratio of 0.96 in 1989. France has a technology trade deficit, but this figure has moved in the direction of becoming more balanced in recent years. Its ratio was 0.69 in 1991. Germany's technology trade balance has actually moved further into deficit with a ratio of 0.45 in 1991. In Japan, the technology trade deficit was 24.1 billion yen in 1991, and the ratio became more balanced compared to the previous year at 0.94, according to Management and Coordination Agency statistics. On the other hand, according to Bank of Japan statistics, while Japan's technology trade balance ratio is becoming more balanced, the technology trade deficit in 1992 was 523.6 billion yen, and the ratio at 0.42, indicating a large-scale deficit (Figure 2-3-2).

The technology trade balance between major

8) Data up to 1989 for Germany in chapter 3 is, as a general rule, data for former West Germany.

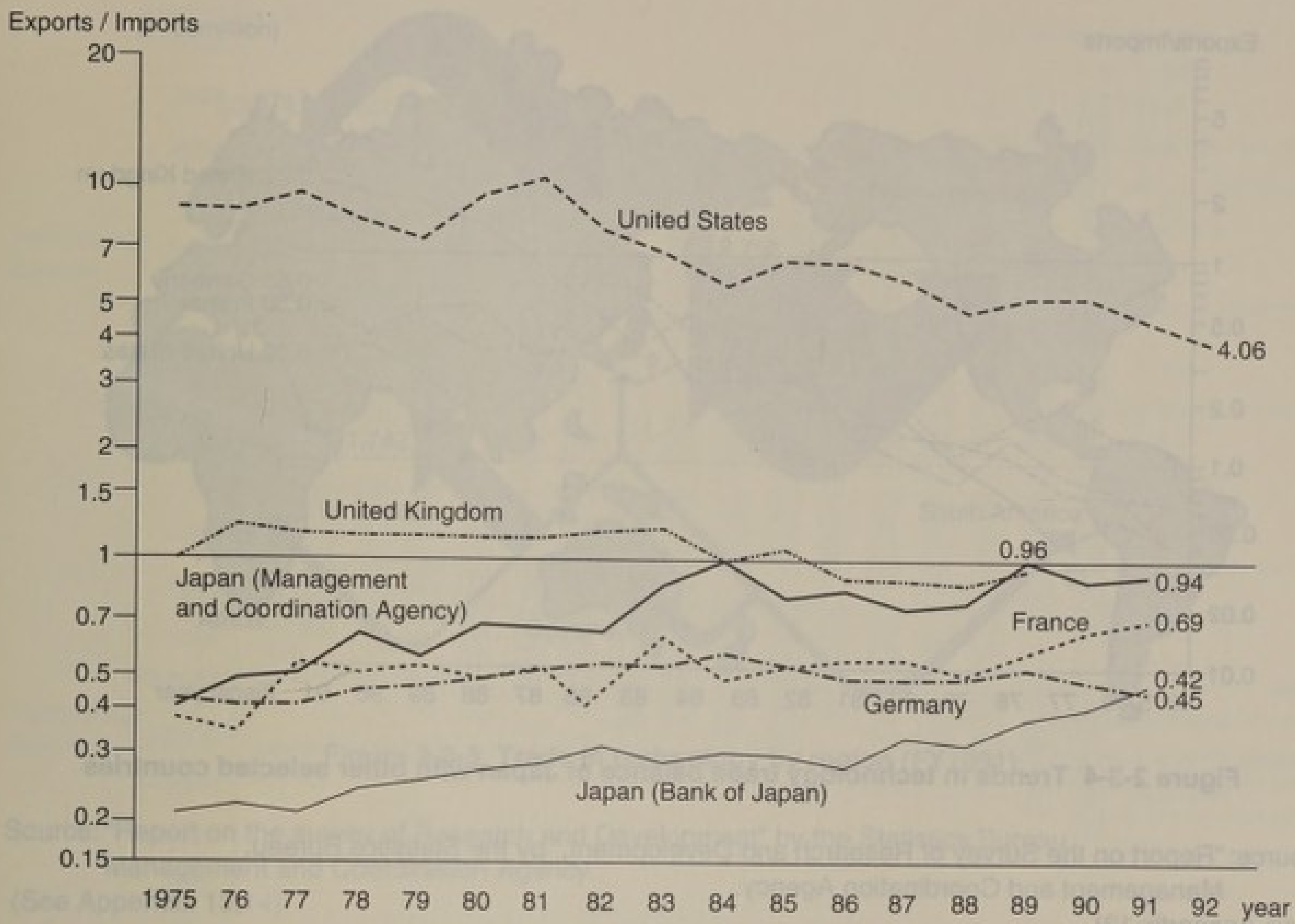


Figure 2-3-2 Trends in technology trade balance of selected countries

Note: Same as in Figure 2-3-1.
Source: Same as in Figure 2-3-1.
(See Appendix 11,12,13)

Table 2-3-3 Technology trade balance between selected countries by counterpart

Technology trade counterpart / Country(Year)	Japan	United States	Germany	France	United Kingdom
Japan(1991)		0.39	0.53	0.50	2.27
United States(1992)	4.63		4.72	4.59	1.80
Germany(1991)	1.75	0.23		0.89	0.22
France(1991)	3.52	0.19	1.66		0.68
United Kingdom(1989)	—	0.54	—	—	

Notes: 1. Each figure shows the technology trade balance (exports/imports) of each selected country with its trade counterpart based on each country's statistics. The figure for Japan is from Management and Coordination Agency statistics.
2. Canada is included in trade of France and the United Kingdom with the United States.

Source: Statistics of each country compiled by Science and Technology Agency.

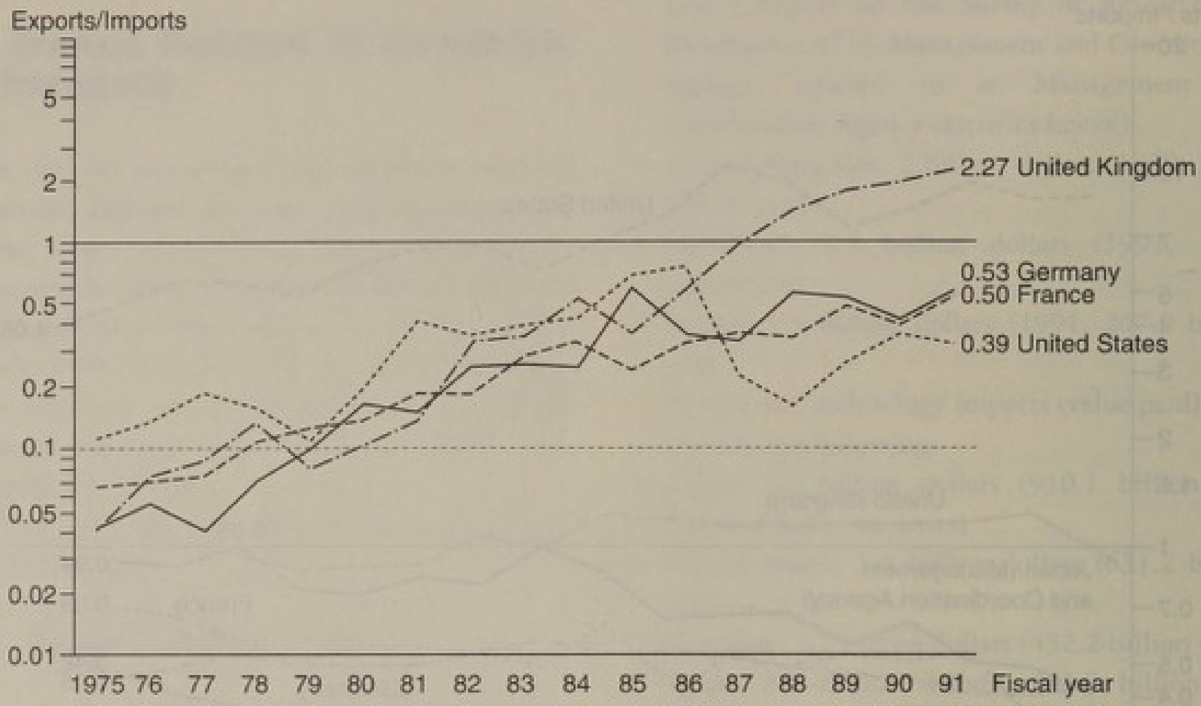


Figure 2-3-4 Trends in technology trade balance of Japan with other selected countries

Source: "Report on the Survey of Research and Development," by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 13)

countries shows the U.S. with an overwhelming surplus against the other countries. Japan has a surplus only with the United Kingdom (Table 2-3-3).

2.3.1.2 Japan's Trade in Technology with Other Countries and Regions

Japan's technology trade balance with major countries is improving in the long run with fluctuations in some years (Figure 2-3-4). This indicates that the level of domestic technology is progressing.

A look at the situation in FY 1991 by country and region shows that technology exports to Asia (excluding West Asia) were 170.5 billion yen, accounting for 46% of total exports. The breakdown by country is as follows:

- Korea: 46.5 billion yen
- China: 27.9 billion yen (including Taiwan, 20.1 billion yen)
- Singapore: 25.9 billion yen
- Indonesia: 21.7 billion yen
- Thailand: 21.6 billion yen

The United States stands as the largest importer of Japanese technology at 105.7 billion yen, accounting for 29% of the total.

Regarding technology imports into Japan, North America and Europe play an overwhelmingly large role. Above all, technology imports from the United States in FY 1991 were 273.3 billion yen (a 7.1% increase over the previous year) and 69% of Japan's total imports. After the United States, the following countries are significant (Fgure 2-3-5).

- Germany: 25.2 billion yen
- Netherlands: 24.6 billion yen
- France: 22.0 billion yen
- Switzerland: 15.6 billion yen

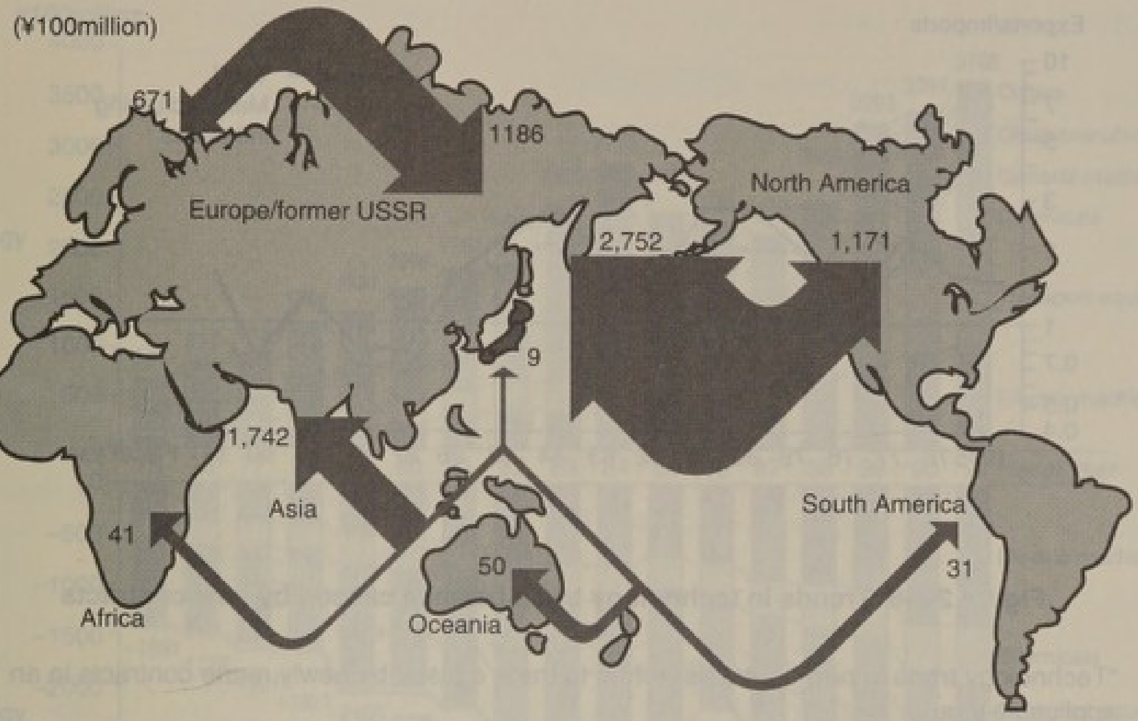


Figure 2-3-5 Trade in technology by region (FY1991)

Source: "Report on the survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 13,14)

2.3.1.3 Trends of Japan's Trade in Technology

As described earlier, according to Bank of Japan statistics for 1992, Japan's technology exports were 386.5 billion yen, a 6.5% increase over the previous year (dollar based comparison), and imports were 910.1 billion yen, a 18.7% increase over the previous year (same). These statistics indicate that the technology export / import ratio changed from 0.47 in 1990 to 0.42 in 1992. According to Management and Coordination Agency statistics, technology exports for FY1991 were 370.6 billion yen, a 17.4% increase from the previous year (same), and imports were 394.7 billion yen, a 14.1% increase over the previous year (same). As a result, the technology trade balance ratio rose from 0.91 in the previous fiscal year to 0.94.

Technology trade data compiled by Management and Coordination Agency for FY1990 indicates that technology trade for new contracts (technology trade for contracts newly established in FY1991 only) resulted in a 16.5 billion yen surplus. Technology exports from new contracts have exceeded technology imports from new contracts up through the first half of 1980s, but deficits were recorded in some years since the last half of 1980s and the new contract portion of the trade balance is changing, ranging from 0.8 to 1.5(Figure 2-3-6).

According to Management and Coordination Agency statistics, technology exports by industry sector in the manufacturing sector are as follows:

- Electrical machinery: 105.8 billion yen
- Transport equipment: 102.1 billion yen
- Chemicals: 58.8 billion yen
- General machinery: 15.1 billion yen

These industries make up 81% of the manufacturing sector. Others include the following.

- Precision machinery: 12.1 billion yen
- Ceramics: 11.6 billion yen
- Steel: 10.5 billion yen

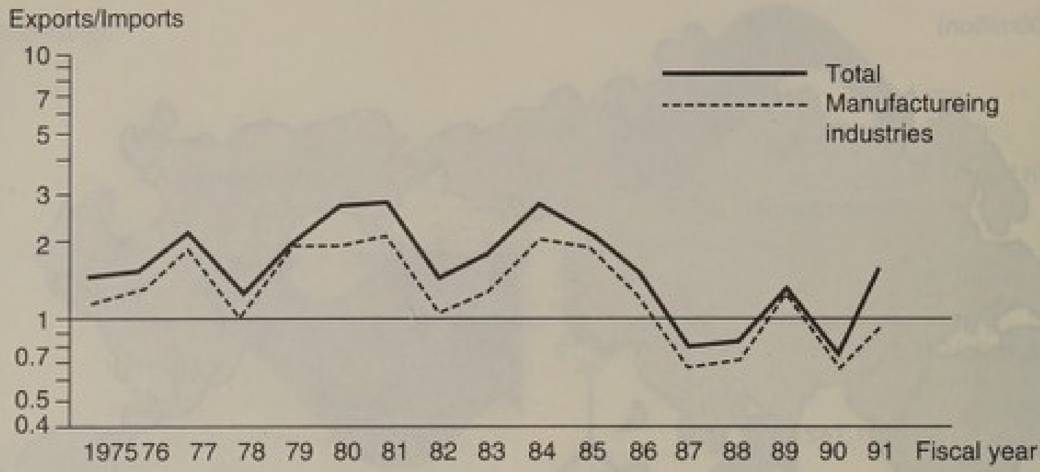


Figure 2-3-6 Trends in technology trade balance caused by new contracts

Note: "Technology trade in new contracts" refers to trade caused by newly made contracts in an applicable year.

Source: "Report on the Survey of Research and Development", by the Statistics Bureau, Management and Coordination Agency.

The following are FY1991 statistics of technology trade imports by industry sector (Figure 2-3-7).

- Electrical machinery: 161.3 billion yen
- Chemicals: 67.4 billion yen
- Transport equipment: 56.5 billion yen
- General Machinery: 33.2 billion yen
- Precision instruments: 12.7 billion yen

The following are major industry sectors in which technology exports exceed technology imports (Figure 2-3-8).

- Transport equipment: 45.6 billion yen surplus
- Construction: 20.6 billion yen surplus
- Ceramics: 6.8 billion yen surplus
- Iron and steel: 4.6 billion yen surplus

The surplus in the transport equipment industry is contributed mainly by the surplus in the motor vehicle industry and is an indication of the high technology level in Japan's motor vehicle industry.

Trade balance trends show that the transport equipment industry had its first surplus in FY1987. The construction and the iron & steel industries have had surpluses of exports over imports since the second half of 1970s, with the construction industry showing an especially large surplus ratio of about ten since FY1980. The trade balance in the electrical machinery industry became gradually more balanced until the second half of 1980s, while the recent ratio is around 0.7 and changing. The deficit in the chemical industry has remained fairly steady in recent years, at 0.87 in 1991 (Figure 2-3-9).

According to National Institute of Science and Technology Policy of the Science and Technology Agency, the number of cases of new technologies being introduced into Japan was 3,175 in FY 1991, a reduction of 36 cases (1.1%) compared to the previous year. As for the various technology classifications, 98.2% (3,117 cases) of the total cases belong to manufacturing. The further breakdown are as follows:

- Electric machinery and appliances: 1988 (62.6% of total)
- General tools and machinery: 281
- Chemical products: 201
- Clothing and textiles: 165

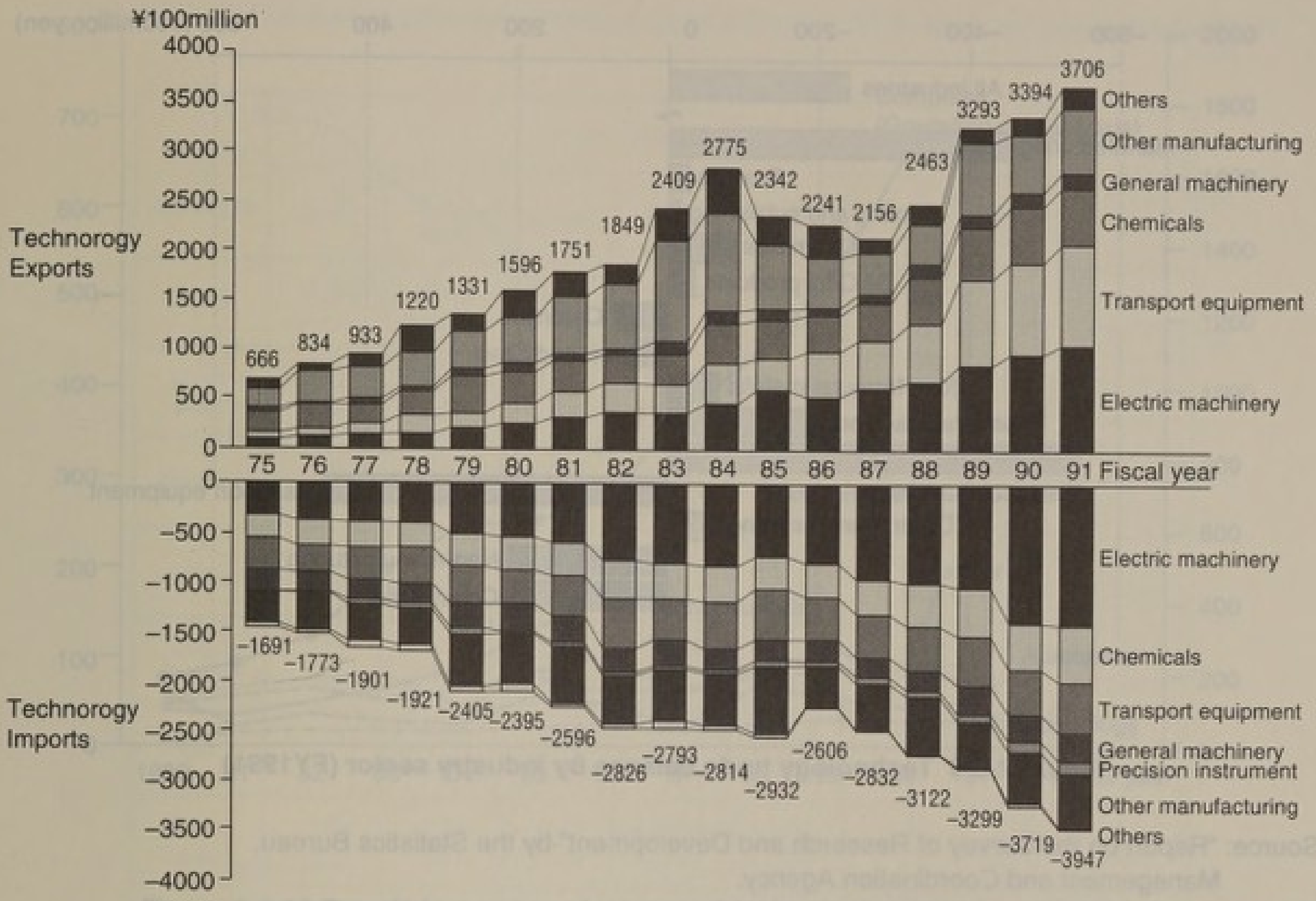


Figure 2-3-7 Trends in technology trade by industry sector

Source: "Report on the Survey of Research and Development", by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 12)

Introductions of electric machinery and appliances has increased 4.4 times compared to the number of cases 10 years before, and 2.1 times compared to five years before. This increase in the number of cases for electrical machinery and appliances was the only increase that occurred. Therefore, it is clear that introductions of technology are becoming concentrated in this industry.

Introduction of technologies bas been mostly from the United States with 2,002 case's (63.1% of the total), followed by countries such as the United Kingdom with 213 cases, France with 205 cases and Germany with 170 cases. In advanced technology fields, computer-related technologies (1664) are dominant. Software makes up the largest portion of these introductions with 1,522 cases, followed by hardware with 120 cases and service with 22 cases. (Figure 2-3-10).

2.3.2 Patents

Countries in which a large number of patents are applied for are countries in which private corporations and other organizations carry out active R&D and great importance is attached to the protection of technologies: These countries can be considered to possess a great number of high

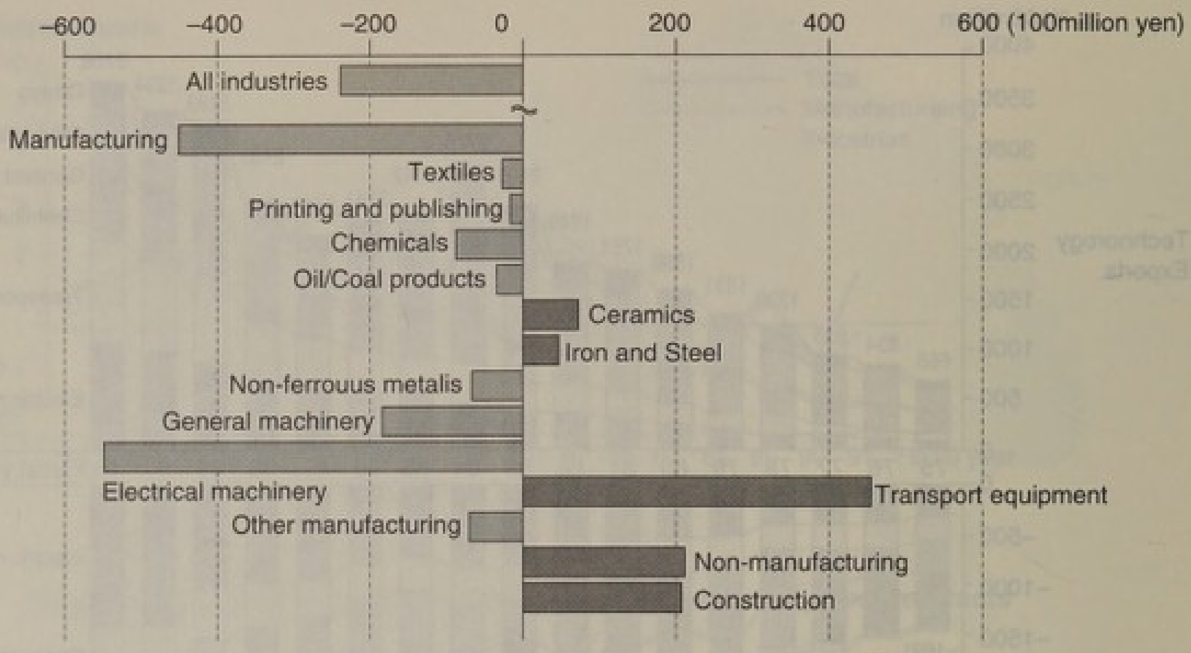


Figure 2-3-8 Technology trade balance by industry sector (FY1991)

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 12)

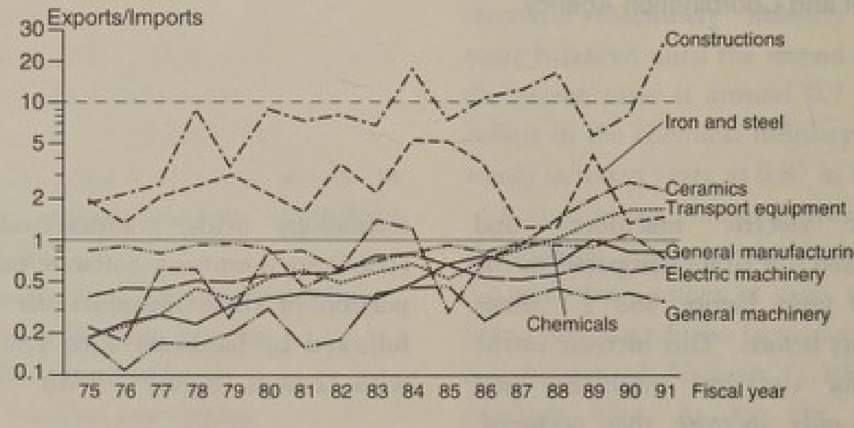


Figure 2-3-9 Trends in technology trade balance in major industry sectors

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 12)

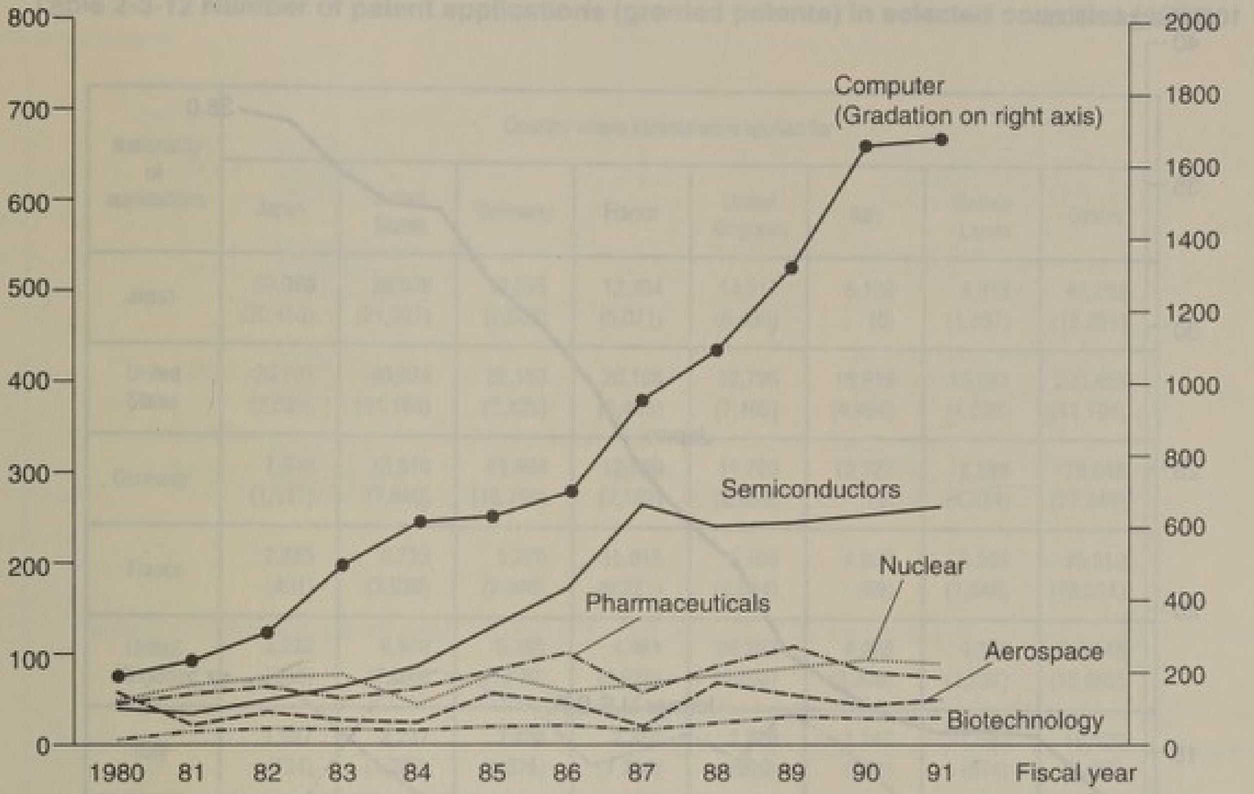


Figure 2-3-10 Trends in number of advanced technologies introduced into Japan

Source: "Analysis of Trends in Technology Imports (FY1991) " compiled by National Institute of Science and Technology Policy, Science and Technology Agency.

technologies. Also, countries to which many patent applicants and inventors belong are those where R&D and inventions are actively being carried out.

2.3.2.1 Patents in Selected Countries (Trends in Application and Registration)

Looking at the number of patents applied for in selected countries (including Patent Cooperation Treaty (PCT) applications[9] and European Patent Convention (EPC) applications[10]), Japan ranks at the top. The number of patents applied for in selected countries in 1991 follows:

- Japan: 380,000
- United States: 177,000
- Germany: 109,000
- Former U.S.S.R: 84,000 (including inventors' certificates)

9) In 1978, the Patent Cooperation Treaty (PCT) went into effect, by which it became possible for the applicant to apply for patents in more than one country (designated countries) at the same time, when he presents one application at one place. The number of PTC member countries is 49, as of January 1992.

10) In 1977, the European Patent Convention (EPC) went into effect, and since June 1978, the European Patent Office (EPO) has been processing European patent (EPC) applications. When a European patent is granted after an examination by the EPO, the patent has the same validity in the other EPC member countries designated by the applicant. The number of EPC member countries is 13, as of March 1990.

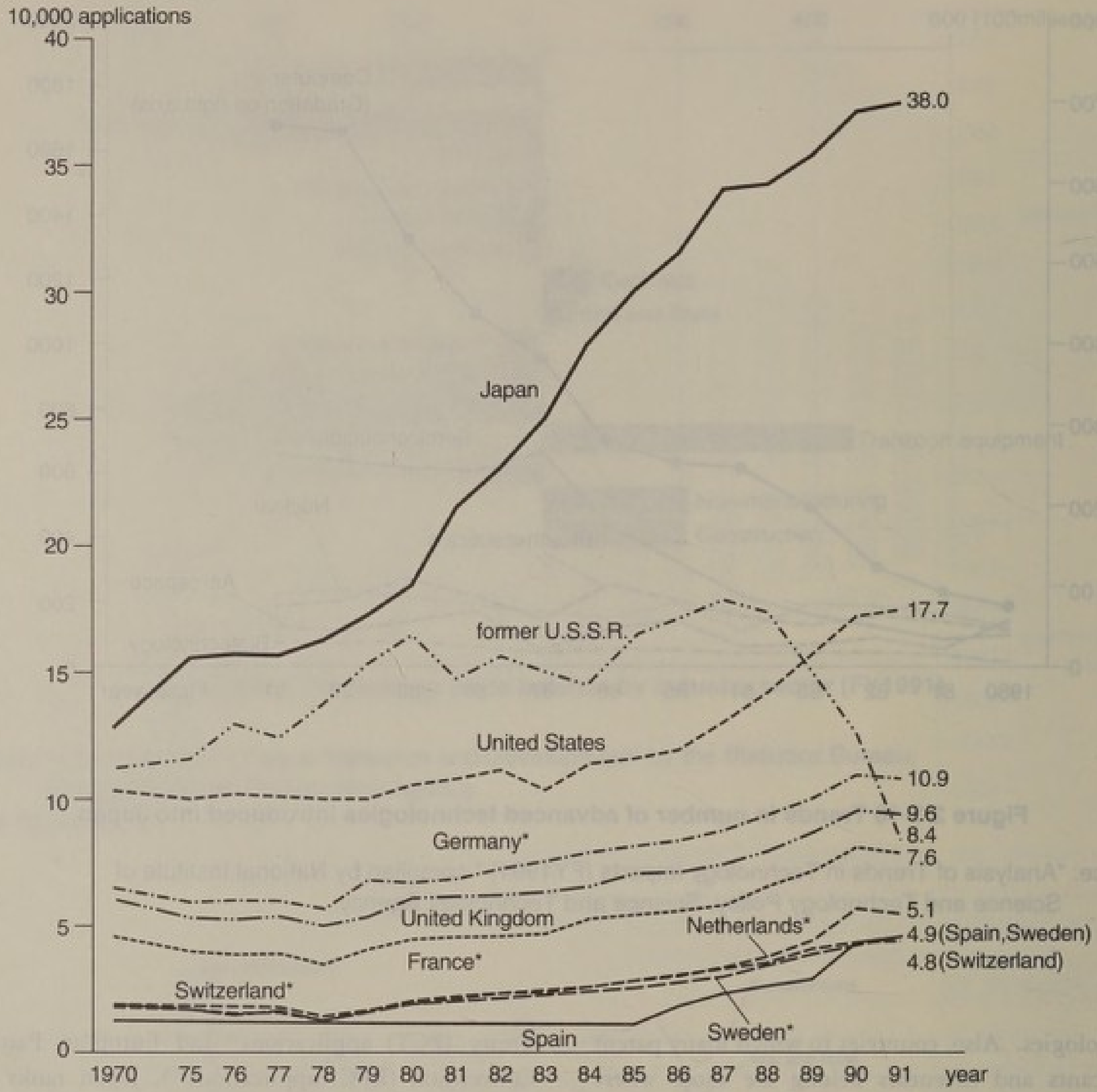


Figure 2-3-11 Trends in the number of patent applications in selected countries

Notes: 1. Numbers of applications include applications under the Patent Cooperation Treaty (PCT) and the European Patent Convention (EPC).
2. " * " indicates EPC member countries.
3. The figure for the former U.S.S.R. includes inventors' certificates. 1991 data is applies through 24 December.

Sources: "Industrial Property Statistics" compiled by the World Intellectual Property Organization (WIPO) European Patent Office statistics also were used between 1979-1984.

- United Kingdom: 96,000
- France: 79,000

The number of patents applied for in the former U.S.S.R. decreased due to a large reduction in the number of inventors' certificates (Figure 2-3-11).

Regarding the nationality of patent applicants in selected countries, the ratio of foreign patent applicants is small in Japan (11.7%, in case of

Table 2-3-12 Number of patent applications (granted patents) in selected countries (1991)

Nationality of applications	Country where patents were applied for							
	Japan	United States	Germany	France	United Kingdom	Italy	Nether-Lands	Others
Japan	33,096 (30,453)	38,609 (21,027)	16,015 (7,805)	12,334 (5,071)	14,217 (6,436)	6,130 (0)	4,915 (1,897)	40,752 (15,231)
United States	20,743 (2,589)	89,024 (51,184)	22,153 (7,220)	20,198 (6,445)	22,796 (7,465)	16,919 (4,454)	15,991 (4,030)	200,455 (41,194)
Germany	7,349 (1,117)	13,510 (7,680)	43,404 (16,756)	12,099 (7,182)	11,720 (6,958)	10,327 (5)	8,528 (4,474)	78,048 (27,849)
France	2,885 (401)	5,735 (3,030)	5,270 (2,846)	15,819 (9,221)	5,104 (2,634)	4,568 (99)	3,565 (1,848)	35,010 (13,324)
United Kingdom	3,232 (258)	6,919 (2,800)	5,155 (1,779)	4,481 (1,629)	24,253 (4,492)	4,098 (2,306)	4,349 (1,237)	55,545 (10,060)
Italy	1,027 (134)	2,237 (1,209)	2,433 (1,076)	2,362 (1,130)	2,326 (990)	1,147 (311)	1,583 (674)	16,020 (5,435)
Nether-Lands	1,524 (218)	1,668 (992)	2,228 (1,102)	2,095 (943)	2,332 (938)	1,787 (2)	3,565 (926)	17,065 (4,880)
Others	7,597 (870)	19,666 (8,592)	12,529 (4,606)	9,687 (3,960)	12,785 (4,161)	8,324 (12,326)	8,916 (2,524)	—
Total	380,453 (36,100)	177,388 (96,514)	109,187 (43,190)	79,075 (35,581)	95,533 (34,074)	53,300 (19,503)	51,412 (17,610)	—
Percentage of foreign nationalities	11.7 (15.6)	49.8 (47.0)	60.2 (61.2)	80.0 (74.1)	74.6 (86.8)	97.8 (98.4)	93.1 (94.7)	—

Notes: 1. Numbers in parentheses refer to granted patents.
2. These data include designated countries under the PCT and the EPC.
Source: "Industrial Property Statistics" by the World Intellectual Property Organization.

patents granted, 15.5%). In the United States, which has the largest number of patent applications by foreigners, the nationalities of patent applicant (1991) are as follows: (Table 2-3-12).

- United States: 50.2%
- Japan: 21.8%
- Germany: 7.6%
- United Kingdom: 3.9%
- France: 3.2%

U.S.-granted patents by nationality of inventor (1992) are as follows: (Figure 2-3-13).

- United States: 53.6%
- Japan: 22.5%
- Germany: 7.5%
- France: 3.1%
- United Kingdom: 2.5%

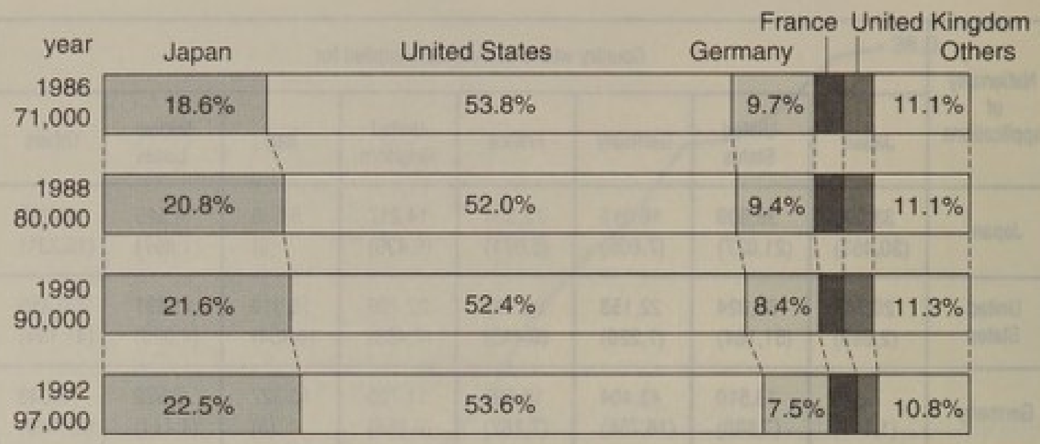


Figure 2-3-13 Breakdown of nationalities of granted patents by the United States

Note: Former East Germany is included in Germany.
Source: United States Patent and Trademark Office.

2.3.2.2 Patent Applications by Japanese in Foreign Countries

In 1991, the number of patens that were applied for in foreign countries by Japanese citizens was 133,000 (including designations under the PCT and EPC applications), an increase of 3,081 (2.4%) over the previous year. The following shows the countries where patents were applied for by Japanese (Figure 2-3-14).

- United States: 29.0%
- Germany:12.0%
- United Kingdom:10.7%
- France: 9.3%
- Korea:5.5%

The percentages of Japanese patent applicants in selected countries were as follows (Table 2-3-15).

- United States: 21.8%
- France: 14.3%
- United Kingdom: 18.9%
- Germany: 18.1%

2.3.2.3 Trends in Patent Application in Japan

The number of patent applications in Japan has been increasing. This is due to an improvement in the level of technology and to the impetus of active R&D. In 1992, the number of patent applications was 372,000, a 0.7% increase over the previous year. The number of applications for utility models was 95,000, a decrease of 17.5% from the previous year.

Numbers of patent applications in 1991[11] by technical classification are as follows:

- Physics: 93,000 (28.0% of the total applications)
- Electricity: 85,000 (25.5%)
- Processing, operations, transportation: 58,000 (17.5%)

11) Technical classification of an individual application for a patent or utility model is done approximately one year after the application has been filed.

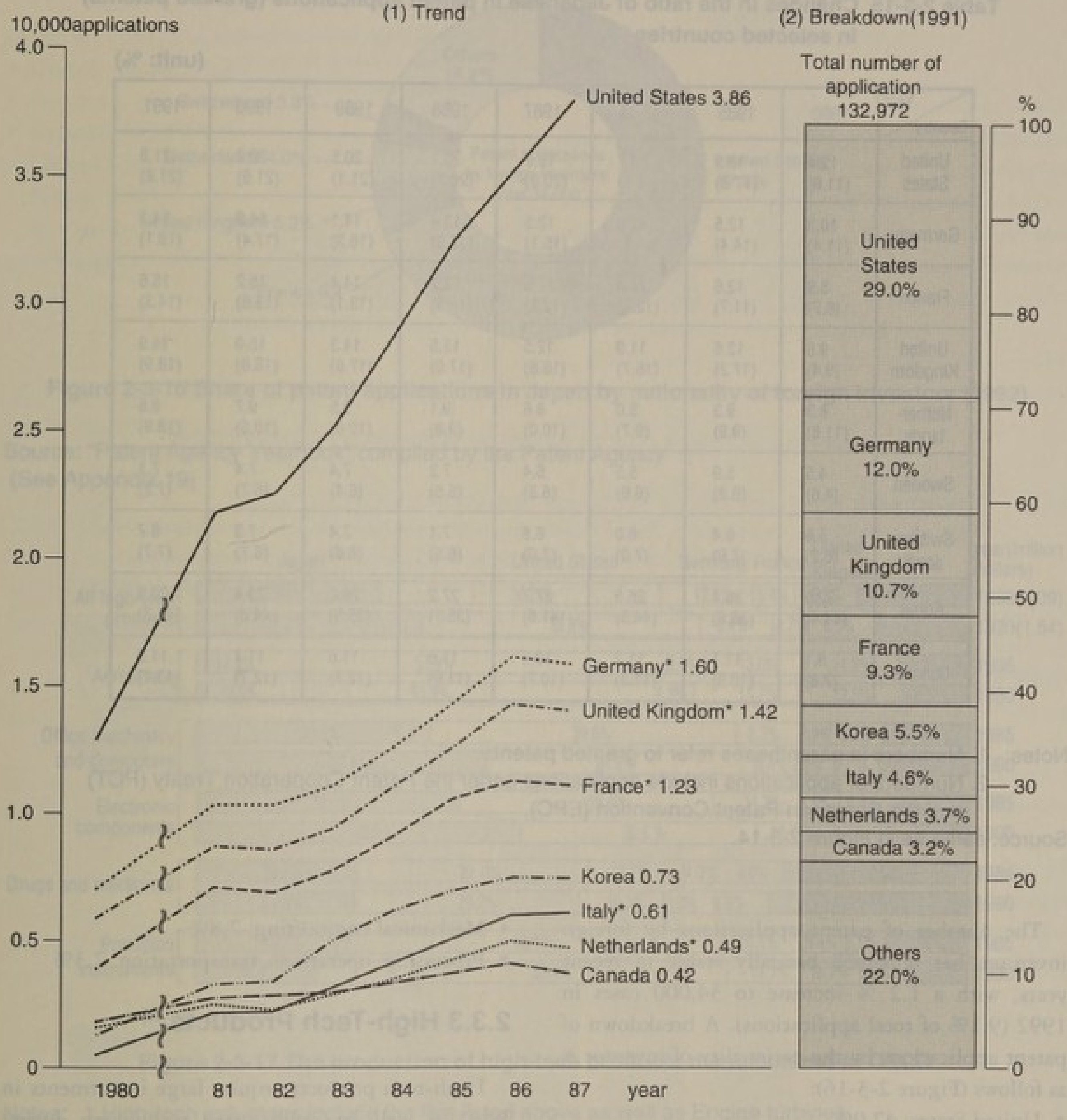


Figure 2-3-14 Trends in number of patent applications in foreign countries by Japanese

Notes: 1. Numbers of applications include applications under the Patent Cooperation Treaty (PCT) and the European Patent Convention (EPC).
2. "*" indicates EPC member countries.

Sources: "Industrial Property Statistics" by the World Intellectual Property Organization (WIPO). European Patent Office statistics are used in addition only for 1980.

Table 2-3-15 Changes in the ratio of Japanese in patent applications (granted patents) in selected countries

(unit: %)

Country \ Year	1980	1985	1986	1987	1988	1989	1990	1991
United States	12.4 (11.6)	18.9 (17.8)	18.7 (18.6)	19.1 (20.0)	20.1 (20.7)	20.5 (21.1)	20.3 (21.6)	21.8 (21.8)
Germany	10.3 (11.4)	12.5 (14.4)	12.0 (14.6)	12.5 (15.1)	13.4 (15.5)	14.1 (16.3)	14.9 (17.4)	14.7 (18.1)
France	8.9 (6.7)	12.6 (11.7)	11.8 (12.6)	12.6 (12.2)	13.7 (12.5)	14.4 (13.1)	15.2 (13.6)	15.6 (14.3)
United Kingdom	9.6 (9.4)	12.6 (17.2)	11.9 (16.7)	12.5 (16.8)	13.5 (17.0)	14.3 (17.6)	15.0 (18.0)	14.9 (18.9)
Nether-lands	8.3 (11.8)	9.3 (9.9)	8.0 (9.7)	8.6 (10.0)	9.1 (9.8)	9.5 (10.0)	9.7 (10.5)	9.6 (18.9)
Sweden	4.5 (4.6)	5.9 (6.3)	5.5 (6.6)	6.4 (6.3)	7.2 (6.5)	7.4 (6.4)	7.4 (6.7)	7.1 (7.2)
Switzer-land	5.6 (6.2)	6.4 (7.9)	6.0 (7.0)	6.8 (7.0)	7.1 (6.5)	7.4 (6.6)	7.3 (6.7)	6.7 (7.7)
Korea	32.0 (44.4)	30.1 (35.8)	26.6 (44.5)	27.7 (41.6)	27.2 (35.1)	26.0 (35.5)	23.4 (44.8)	20.3 (46.3)
Canada	8.1 (7.8)	11.1 (10.9)	11.2 (11.3)	10.9 (10.7)	11.8 (11.9)	11.6 (12.8)	11.7 (12.7)	11.0 (13.1)

Notes: 1. Numbers in parentheses refer to granted patents.
2. Numbers of applications include applications under the Patent Cooperation Treaty (PCT) and the European Patent Convention (EPC).

Source: same as in Figure 2-3-14.

The number of patent applications by foreign inventors has remained basically stable in recent years, with a 1.2 % increase to 34,000 cases in 1992 (9.1% of total applications). A breakdown of patent applications by the nationality of inventor is as follows (Figure 2-3-16):

- United States: 47.0%
- Germany: 15.3%
- France: 6.4%
- United Kingdom: 5.1%

A breakdown of patent applications by foreign inventors in 1991 by field is as follows:

- Chemicals, metals, textiles: 15.9%
- Daily commodities: 11.7%
- Mechanical engineering: 7.8%
- Processing, operations, transportation: 7.3%

2.3.3 High-Tech Products [12)]

High-tech products require large investments in R&D as well as sophisticated technology during their manufacturing process. The production of high-tech products manufactured in all the OECD countries is growing at a faster rate than that of all manufactured goods. The amount manufactured in 1990 was 2.2 times greater compared to 1980, and 1.4 times greater compared to 1985 (1980 dollar-based comparison).

12) At the OECD, the ratio of R&D expenditures to production is calculated by industry sector and classification into high-tech, mid-tech, and low-tech is done according to the size of value.

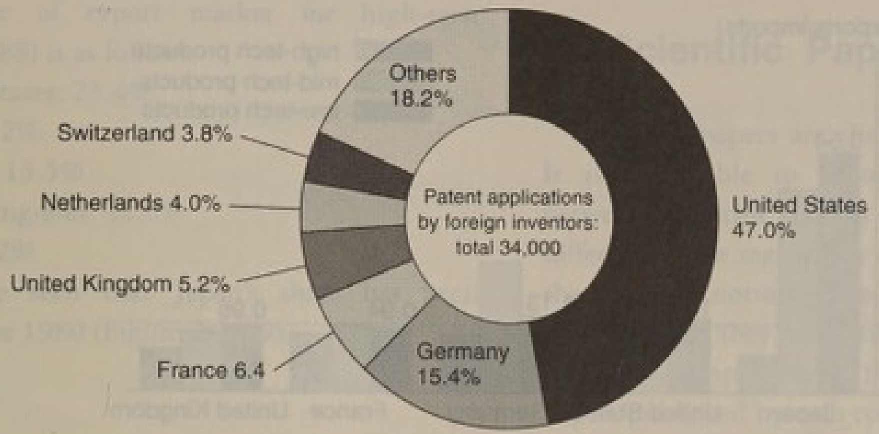


Figure 2-3-16 Share of patent applications in Japan by nationality of foreign inventors (1992)

Source: "Patent Agency Yearbook" compiled by the Patent Agency
(See Appendix 19)

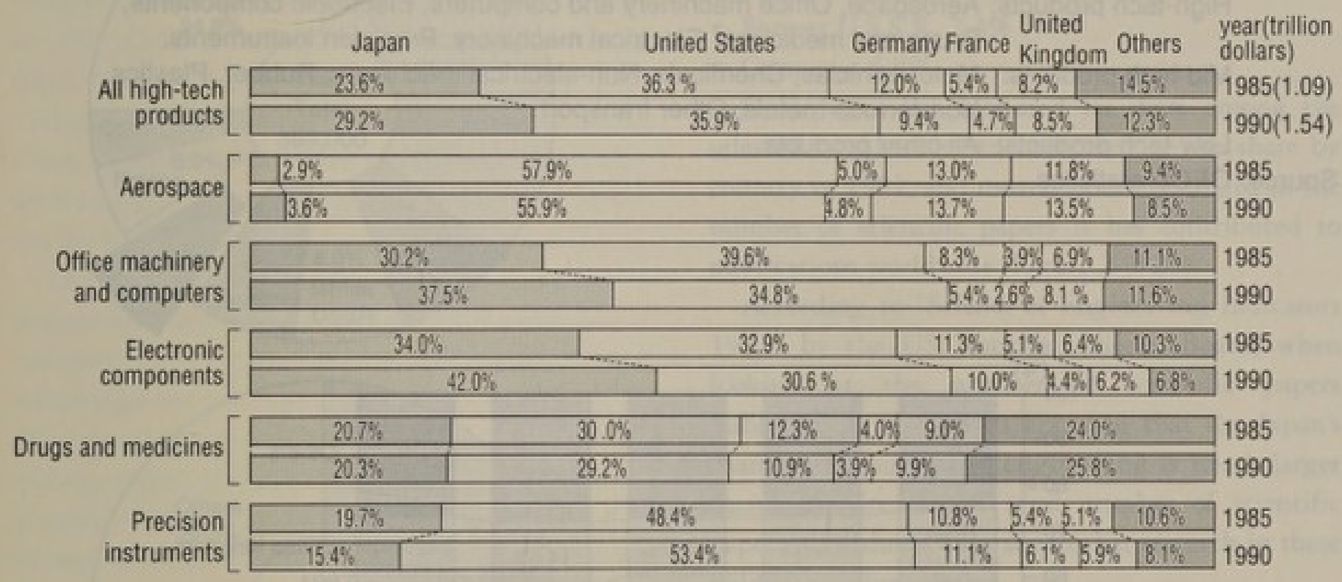


Figure 2-3-17 The production of high-tech products manufactured in OECD

Notes: 1.High-tech industries include the five listed above as well as Engine turbines.
2.Figures based on 1980 doller-based amounts. Figeures for 1990 are estimates.
Source: "Science & Engineering Indicators 1991" by the US National Science Board.

In 1990, the United States had the largest production share of high-tech products manufactured by country at 35.9%, followed by Japan (29.2%), Germany (9.4%), the United Kingdom (8.5%) and France (4.7%). Japan's share has increased over this 5-year period. By industry, electric products (42.0%) and office machines/computers (37.5%) have high shares in Japan (Figure 2-3-17).

Japan's trade balance of high-tech products was the highest among the selected countries. Germany and the United States had a slight surplus and France and the United Kingdom were generally balanced (Figure 2-3-18).

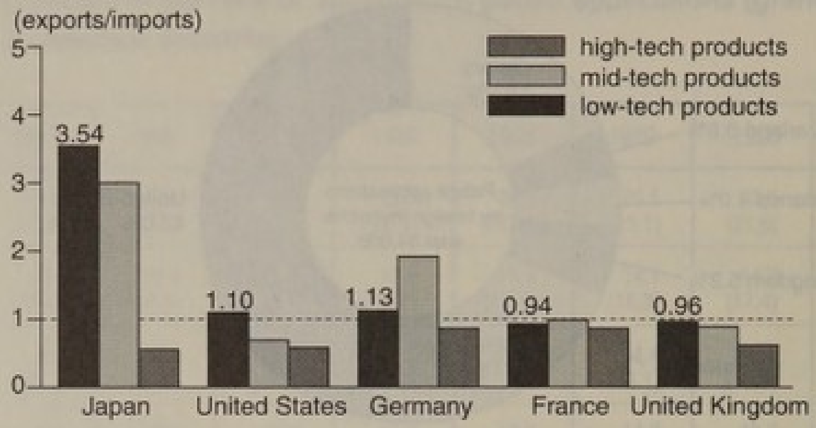


Figure 2-3-18 Product trade balance by technology intensity (1990)

Note: The following is a classfication of technology intensity by the OECD.
High-tech products: Aerospace, Office machinery and computers, Electronic components, Drugs and medicines, Electrical machinery, Precision instruments.
Mid-tech products: Motor vehicles, Chemicals, Non-electrical machinery, Rubber, Plastics, Non-ferrous metals, Other transport.
Low-tech products: All other products.
Source: OECD statistics.

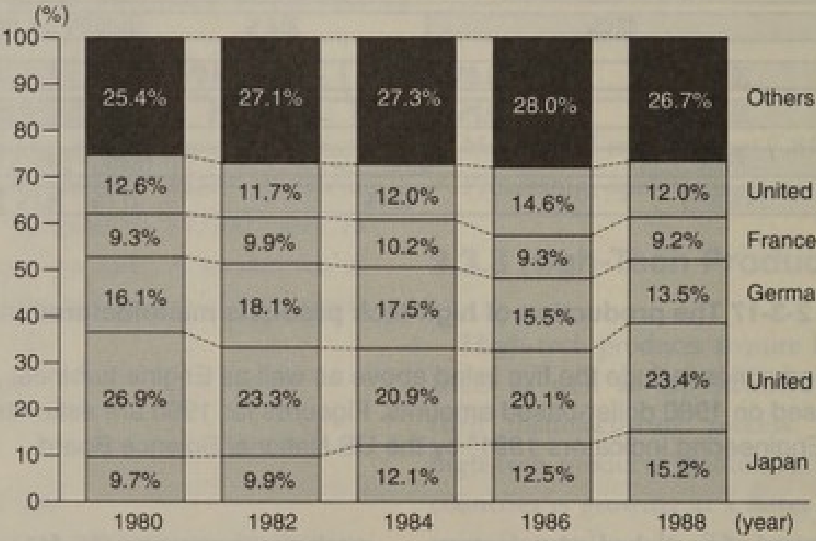


Figure 2-3-19 Export market shares for high-tech products by country

Note : Same as Figure 2-3-17.
Source : Same as Figure 2-3-17.

The share of export market for high-tech products (1988) is as follows:

- United States: 23.4%
- Japan: 15.2%
- Germany: 13.5%
- United Kingdom: 12.0%
- France: 9.2%

It can be seen that Japan's share has been growing since 1980 (Figure 2-3-19).

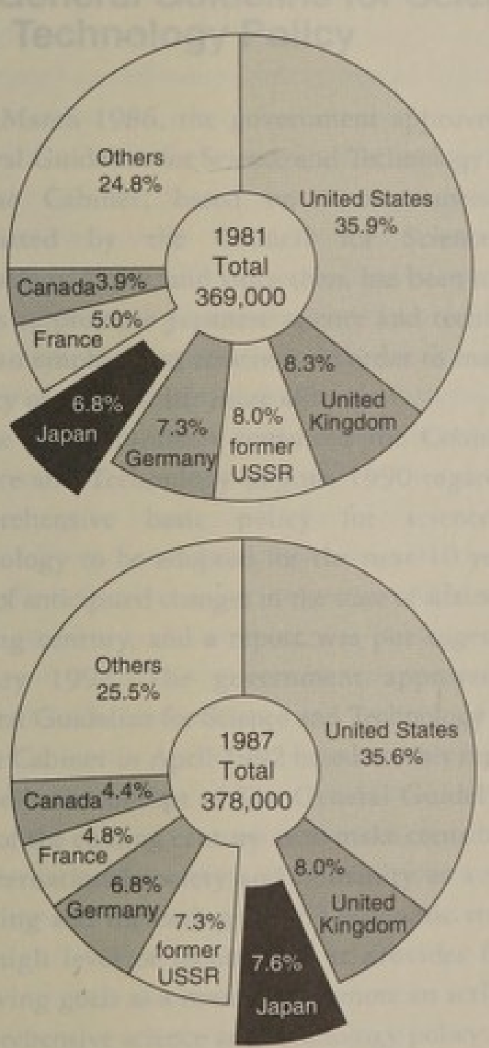


Figure 2-3-20 Share by selected country of scientific papers produced(1981,1987)

Source : "Science & Engineering Indicators 1991" by the US National Science Board.

2.4 Scientific Papers

Scientific papers are the achievements of R&D. It is impossible to make a simple comparison between scientific papers because of qualitative differences, the regionality of the research subjects, the language normally used by the researchers and the language they are written in, etc. However, here is a comparison of the number of scientific papers published by each country.

The share by country of the number of scientific papers published in major scientific journals around the world in 1987 is as follows:

- United States: 35.6%
- United Kingdom: 8.0%
- Japan: 7.6%
- Former U.S.S.R. 7.3%
- Germany: 6.8%

Only Japan has increased its share among the selected countries when compared to the share by country in 1981, and moved from 5th to 3rd in the number of scientific papers it has contributed to publications worldwide (Figure 2-3-20).

According to "Science & Engineering Indicators 1991" by the US National Science Board, when looking at the number of scientific papers published by field, it is apparent that the Japan's share of chemistry and engineering is much larger than its share of the total number of scientific papers published. This shows that research in these fields is relatively active.

Part 3
Science and Technology Policy Development in Japan

3.1 General Guideline for Science and Technology Policy

In March 1986, the government approved The General Guideline for Science and Technology Policy in the Cabinet, based on a recommendation submitted by the Council for Science and Technology (CST), and since then, has been making efforts to promote Japanese science and technology with an emphasis on creativity in order to make the quality of national life more affluent.

The prime minister consulted the Council for Science and Technology in June 1990 regarding a comprehensive basic policy for science and technology to be adopted for the next 10 years in view of anticipated changes in the state of affairs in the coming century, and a report was put together in January 1992. The government approved The General Guideline for Science and Technology Policy in the Cabinet in April 1992 based on this report.

The basic concept of The General Guideline, in view of the coming century, is to make contributions to international society and humanity as a whole, utilizing and increasing Japan's economic strength and high level of technology. It provides for the following goals as a means to promote an active and comprehensive science and technology policy:

- Coexistence of humans in harmony with the Earth
- Expansion of intellectual stock
- Construction of a charming society where people can live with peace of mind

The government has a major role in achieving these goals. The universities and national research institutes which are largely responsible for basic research, where researchers are trained and which are at the core of international science and technology activity, have to deal with low research funds, out-of-date facilities and equipment, lack of personnel, the aging of researchers, and other issues. Therefore, it has become imperative for the government to increase its investment in R&D to improve the research environment of Japan's universities and national research institutes without delay.

In order to realize these goals, the government will promote the following measures:

- Harmonization between science/technology and humans/society
- Securing scientific and technological personnel
- Increase of R&D Investment
- Intensification of the R&D Infrastructure
- Activation of research and improvement of creativity
- Intensification of international science and technology activities
- Promotion of science and technology in regions

In The General Guideline, the research fields which should be given special priority in being promoted are listed along with the 3 goals and 7 priority measures mentioned above.

General Guideline for Science and Technology Policy

I. BASIC PRINCIPLES

For humans to construct a stable and a more prosperous 21st Century, it is absolutely necessary to further promote science and technology in consideration of harmony with humans/society and the environment. Especially, in Japan, where humans are its largest resource, future prosperity is heavily dependent on science and technology.

Realizing this and recognizing that Japan should contribute to the international society and humans as a whole, the government strives to develop a positive and comprehensive policy on science and technology with the following three points as its goals.

* *Coexistence of humans in Harmony with the Earth:* Japan will aim at solving various issues such as global environment issues, energy issues and food issues, constructing a stable international order and settling the north-south problems.

* *Expansion of Intellectual Stock:* Japan will accumulate well-balanced high-quality scientific knowledge including results of basic research so that all humans will be able to benefit.

* *Construction of a Charming Society Where People Can Live with Peace of Mind:* Japan will make the quality of national life more affluent, while coping with social issues such as the sharp increase in the number of old people.

II. PRIORITY MEASURES

To improve and intensify schemes and conditions for promoting science and technology, the government will promote the following measures, while establishing basic guidelines for implementing the priority measures. Especially, awaring diverse and important roles of universities and national/public research institutes, their R&D ability and the ability of cultivating human resources should be drastically intensified with necessary reviews.

1. Harmonization between Science & Technology and Humans/Society

Recognizing that science and technology deeply affects every part of life and society, and it should exist for the sake of humans/society, in order to allow for harmonization between S&T and humans/society, the government will:

1) *make efforts to improve safety and adaptability to humans/society of the technologies which are already practically applied and exist;

* assess the influence of new technologies on humans/society from various aspects, and if necessary, make efforts to present the results to the people in an easy to understand way; and

2) *cultivate an environment in which the people can more easily understand science and technology and use it effectively, by increasing the chances of lifelong integrated learning about science and technology, improving facilities including science museums, and strengthening activities of dissemination and enlightenment.

2. Securing Scientific and Technological Personnel

Since human resource is the key for promoting science and technology, in order to increase the number of engineers, researchers and research assistants and improve their quality, the government will:

1) * make efforts to bring up its youth with more feeling and interest in science and technology by increasing the chances to have actual experiences very important for cultivating scientific interest, for example, by placing emphasis on observations and experiments in primary/secondary education, and to rise the attraction of scientific and technological occupations by improving their treatment and working environment;

2) *intensify the educational function of universities and colleges organically and systematically in order to further stimulate and educate personnel;

* for graduate schools, make efforts to increase the number of students in master courses, and to fill and increase the number in doctor's courses by further intensifying the economical assistance to the students of the doctor's courses, improve the education/research organizations, and increase the education/research funds;

3) *improve the environment to allow females to easily continue science and technology activities, for example, by eliminating the difference between males and females in chances and treatment, and by diversifying the working style during the periods of

childbirth and childcare;

* improve the environment to allow elderly people to continue their work depending on their ability; and

4) *make efforts to increase the staff in universities and national research institutes and to correct their age structure, while making the occupation attractive by improving their treatment and research infrastructure.

3. Increase of R&D Investment

Since the national R&D ability greatly depends on the accumulated knowledge/technologies and R&D infrastructure formed by R&D investment, Japan should continuously maintain its R&D investment.

The R&D investment of Japan as a whole achieved the target level indicated in the 11th Recommendation of the Prime Minister's Council for Science and Technology (1984), being one of the factors which has greatly improved the level of science and technology in Japan. On the other hand, basic research is not making as much progress as had been expected and various kinds of trouble are surfacing. Therefore, by giving priority to the measures and R&D indicated in this Basic Policy, the government will transform Japan's R&D investment structure, from one with a high ratio of investment for R&D in order to secure competitiveness, into a balanced one.

In the process of the transformation of investment structure, while continuing efforts for improving the institutions and environment to support the further increase in R&D investment by the private sector, the government will make efforts to double its own R&D investments as early as possible, taking account of financial conditions.

4. Intensification of R&D Infrastructure

In order to intensify the R&D infrastructure to meet the advancement in science and technology and the increase in its scale, the government will:

1) *systematically renew the facilities and equipment of universities and national research institutes which are remarkably superannuated or out-of-date, as soon as possible;

* install facilities/equipment indispensable for conducting leading and advanced research at universities and national/public research institutes; open more widely to industrial, academic and governmental researchers and also to overseas researchers; promote joint use;

2) *substantialize the development, preservation and supply of apparatuses, raw materials, standard materials and genetic resources, etc.; and

3) *expand the production and the distribution of S&T information by facilitating the distribution of literature information and encouraging the construction and utilization of fact databases.

5. Activation of Research and Improvement of Creativity

In order to complete a flexible and competitive research system which can stimulate research including basic research and allow the creativity of researchers to be improved, and to foster an excellent research environment which will attract excellent researchers from all over the world, the government will:

1) *increase the mobility of researchers by improving institutions for promoting the research exchanges among the industrial, academic and governmental circles and with foreign countries;

* enlarge the chances of communication among researchers from various fields;

2) *expand various types of research funds offered under a competitive system and promote smooth deployment of these funds by national research institutes, while increasing ordinary research funds as the foundation of research activities;

* promote the deployment of funds and commodities from private enterprises;

3) *promote the intensification of research assistance system and the simplification of office work in order that researchers can be engaged more exclusively in R&D;

4) *promote to employ persons, including foreigners, excellent in research ability and leadership as research managers and planners;

5) *promote freedom of researchers on condition

that appropriate evaluations are made;

* promote better treatment of brilliant researchers based on a proper evaluation; and

6) *establish diverse types of centers of excellence (which refer to core research functions with prominent research leaders, up-to-date research information, excellent facilities/equipment, and substantial research assistance) by concentrating research resources such as staff members and funds.

6. Intensification of International Science and Technology Activities

In order to intensify international activities, considering Japan's position in international society, the government will:

1) *promote international collaborative R&D;

* propose and lead international collaborative R&D adopting original idea of Japan;

* improve the environment required for promoting the international collaborative R&D;

2) *examine how Japan should cope with each project of "mega- science" (which refers to projects absolutely requiring international cooperation because participation of researchers/engineers from a wide range of areas and very large or complex facilities are necessary) with subjectivity in reference to the discussion among researchers/engineers and Japan's research potential, paying attention not to cause pressure to other R&D activities while it is being promoted;

*make efforts to form internationally common recognition of "mega-science";

3) *take following action to expand science and technology cooperation for developing countries based on the concept that cooperation suitable for the situation of each country should be extended mainly for creating human resources as an aid to fructify their own efforts;

a) *Expansion of the chances of dialogues to identify developing countries' needs for cooperation.

* Intensification of the function of clearing houses which provide information concerning S&T in developing countries and Japan.

b) *Expansion of the technical assistance in the official development aid such as the reception of trainees and dispatch of experts and improvement of effectiveness of the cooperation by intensifying liaison with fund assistance.

c) *Continuous and systematic expansion of the research cooperation and intensification of cooperation in cultivating human resources with the countries in regions including Asia Pacific region, which aim at improving their own R&D ability and have to cope with a variety of scientific and technological issues.

d) *Security of the close liaison between research cooperation and technical/fund assistance in efforts to implement cooperation effectively.

4) *extend research cooperation and, as required, technical assistance for the former Soviet Union etc. to support the reform to develop a market economy;

5) *establish an internationally opened research scheme by promoting the employment/acceptance of foreign researchers and by smoothing their activities in Japan, while implementing training on the Japanese language and expanding fellowship, and so on;

* expand the chances of dispatch of Japanese researchers and administrators to foreign countries;

6) *expand the international distribution of S&T information; and

7) *promote the international transfer of S&T by making efforts to standardize the protection level of intellectual property and other areas concerned with S&T.

7. Promotion of Science and Technology in Regions

Since S&T activities in regions are the motive power of regional activation, and they contribute to the formation of decentralized national land, and improve the quality of daily living of their inhabitants, in order to promote S&T regionally, the government will:

1) *support any promotion by local governments such as the establishment of S&T policies, the intensification of S&T promoting functions, the fostering of research institutes and testing

stations, the intensification of liaisons between regional entities;

2) *support the regional activities to grow youth by the improvement of science museums, and soon;

3) *construct fundamental and leading research facilities in regions;

* develop the S&T information network;

* promote various types of research exchanges with universities and national/public research institutes in efforts to assist and stimulate those who are engaged in S&T regionally;

4) *let universities and national/public research institutes make efforts to lead basic research and other R&D in regions where they are located; and

* promote R&D which, for example, utilizes regional characteristics or which is closely related with the living of the inhabitants, in cooperation with regional entities while utilizing R&D coordination function of universities and national research institutes as required.

III. BASIC SCIENCE AND MAJOR R&D

1. Promotion of Basic Science

The government will promote basic science which is intended to discover new phenomena, to construct original theories for elucidating them, and to forecast unknown phenomena, since it expands the intellectual frontier of humans, forms the foundation for creating new views of nature, gives hope to the people, and suggests new ideas and guidelines for the science and technology of the next generation.

2. Promotion of Major R&D

The Government will energetically and effectively conduct or support following major R&D under proper research evaluation, while establishing or reviewing R&D basic plans.

1) fundamental and leading science and technology

a) Material science and technology

b) Information/electronics science and technology

c) Life science and biotechnology

d) Soft Science and technology

e) Advanced fundamental science and technology

f) Space science and technology

g) Ocean science and technology

h) Earth science and technology

2) Science and technology for human coexistence

a) Preservation of the natural environment including global environment

b) Development and utilization of energies

c) Development and recycling of resources

d) Continuous production of foods

3) Science and technology for enriching life and society

a) Maintenance and improvement of health

b) Improvement of living environment

c) Improvement of socioeconomic foundation

d) Strengthening of disaster-preventive and safety measures

3.2 The Council for Science and Technology

The Council for Science and Technology (CST) was established in February 1959 to comprehensively promote overall science and technology policies of the government. Under the terms of the establishment Law of the Council for Science and Technology, the CST is an advisory body to the Prime Minister supervised by the Prime Minister's Office. It is chaired by the Prime Minister and its members include cabinet ministers dealing with science and technology and distinguished experts in various fields. The CST's main task is to advise the Prime Minister in the following:

- Establishment of general basic science and technology policy (Those related only to cultural sciences are omitted. Same below.)
- Establishment of comprehensive long-term research goals
- Formulation of basic guidelines for promoting research areas

These are especially important aimed at achieving these goals. The CST recommends findings on inquiries to the Prime Minister and, when appropriate, submits CST-initiated advice (Table 3-2-1).

The CST Committee on Policy Matters, composed of distinguished experts from various fields, manages important matters in a timely and appropriate manner and designs and develops flexible science and technology policy. The tasks of the Committee are as follows.

- Decide the direction for discussions on a recommendation
- Set the guidelines for expenditures of the Special Coordination Funds for Promoting Science and Technology
- Decide on priorities for promoting science and technology
- Direct basic investigations for guidelines on planning science and technology policies

3.2.1 General Basic Policy

Recommendation Pursuant to Inquiry

Recommendation Pursuant to Inquiry No. 18 "Comprehensive and Basic Science and Technology Policy toward the New Century"; (referred to as Recommendation 18 below). (submitted on January 24, 1992)

Major changes both at home and abroad are occurring in science and technology. In the international areas, there is progress in the easing of East-West tensions. There is movement among the members of the European Community (EC) towards unification, and we are confronted with the problems to solve in order for mankind to survive and prosper, such as environmental issues. Domestically, these changes include rising expectations for improvements in the standard of living, and the rising demand for fulfillment of a healthy, safe and comfortable life.

Therefore, on June 22, 1990, the Prime Minister presented Inquiry No. 18 *"Comprehensive and Basic Science and Technology Policy Toward the New Century"* to the CST to decide upon basic general policies on science and technology for the next 10 years with a view towards the future. In response to the inquiry, the CST deliberated for one and a half years and submitted a recommendation to the Prime Minister on January, 1992.

The basic concept of the recommendation was for science and technology to contribute to international society and humanity as a whole, and achieve the following goals.

- Coexistence of humans in Harmony with the Earth
- Expansion of Intellectual Stock
- Construction of a Charming Society Where People Can Live with Peace of Mind

It was suggested that active and general policies on science and technology should be developed.

3.2.2 Basic Plan for Important Areas of Research and Development

3.2.2.1 Views Concerning Basic Plans for Research and Development on Energy

(submitted on June 21, 1991)

Major changes are taking place in the energy situation as can be seen by the increase in global environmental problems and other issues, and therefore, the CST has put together a new proposal on a basic plan for energy R&D which was reported in May, 1991. In response, a new basic plan was decided in July, 1991.

In the basic plan, the following issues were defined for energy R&D programs.

1) Secure a stable supply of energy
2) Construct an energy saving society
3) Respond to global environmental problems
4) Contribute to international society

On the basis of these requests, the following items were arranged as important R&D topics which the government should be central in promoting for the next 10 years.

- Diversification of energy sources
- Increase in efficient use of energy
- Reduction of burden on the environment
- International response
- Basic and fundamental technology

Also, in order to promote the energy R&D program more effectively and with certain priorities, nine topics were selected which have the potential for being completed by about the year 2010. These topics are especially important for improving the energy supply/demand structure and responding to the problems of the global environment, and should be strongly promoted by the government in the future. Each government division or bureau is instructed to promote efficient and effective R&D by determining appropriate R&D plans and evaluating them in relatively short intervals. The following are policies which the government should adopt in promoting energy R&D:

- Comprehensive promotion of R&D
- Implementation of appropriate evaluations
- Nurturing talent
- Maintaining continuity of R&D
- Promotion of international cooperation

3.2.2.2. Inquiry No. 19 Basic Plan for R&D on Soft Science and Technology

(submitted on December 2, 1991)

Science and technology is facing a period of major change in this complex, advanced society where support for intelligent action is desired; a place where we have broken the shackles of a possession-oriented mass production/mass consumption society and come to desire a high-quality, enriched and unhurried lifestyle. Under these circumstances, in January 1991, the Prime Minister considered the need to promote planned R&D of soft science and technology in wide-ranging areas and made an inquiry to the CST concerning basic R&D plans for soft science and technology. The CST received this request and set up a new Subcommittee for Soft Science and Technology made up of well-informed individuals from a wide range of fields, from natural sciences to cultural and social sciences. This Subcommittee will carry out investigations and deliberate on this request for approximately 10 years. On December 2, 1992, after 2 years of investigation, the Subcommittee submitted a report on their findings concerning this request. Furthermore, based upon this report, a Basic Plan for R&D on Soft Science and Technology has been decided for January 1993 (decided upon by the Prime Minister).

In this report, it is stated that R&D developments in soft science and technology often require knowledge and procedures of natural sciences and cultural and social sciences mutually. Furthermore, as this is a relatively new area of science and technology, it is stated that R&D developments must be carried out placing continual importance on exterior, environmental elements that promote research, these being; the establishment of scientific and R&D fundamentals, planned advancement in R&D, consolidated research exchanges between the natural and cultural and social science fields, ensuring communication between science and technology and society, and the advancement of

Table 3-2-1 Outline of major recommemdations by the Council for Science Technology

Title	Date	Outline
Recommendation for Inquiry No. 18 "comprehensive and Basic Science and Technology Policy toward the New Century"	January 24, 1992	This report outlines the science and technology policies that Japan should pursue over the next 10 years. The basic concept of the recommendation was for science and technology to contribute to the international society and humanity as a whole, and achieve the following gorls. • Coexistence of Humans in Harmony with the Earth • Expansion of Intellectual Stock • Construction of a Charming Society Where People Can Live with Peace of Mind Based on this report, the General Guidelines for Science and Technology Policy was April 1992.
Recommendation for Inquiry No. 9 "basic plans for Research and Development on Soft Science and Technology"	December 12, 1992	This report addresses research and development related to soft science and technology that contributes to the support of intellectual activities, improvement in the comfort of the living environment, and balance with people and society. It indicates the basic thinking of Japan in its promotion of this research and development, the important research and development issues that the Government should address, and policies for the promotion of each.
Recommendation for Inquiry No. 11 "comprehensive fundamental policy for promotion of science and technology to cope with current changing situations from a long-term point of view	November 27, 1984	In order to comprehensively develop science and technology which will serve as the basis of a new culture and civilization in anticipation of the 21st century, the recommendation suggests general guidelines as a basis and management method for the science and technology policy for the next 10 years and with the following as basic cornerstones: • Promoting highly creative science and technology • Developing science and technology in harmony with man and society • Emphasizing the international aspect of science and technology
Recommendation for Inquiry No. 12 "general guideline for science and technology policy"	December 3, 1985	The recommendation specifies the content of the "general guideline for science and technology policy" which forms the basis of the policy for promoting science and technology. This recommendation ranks the promotion of science and technology based on the concept of "promoting highly creative science and technology" as a fundamental policy guide and calls for policy development focused on the support of basic and pioneering science and technology. Further, the Cabinet approved the general guideline in March 1986.
Recommendation for Inquiry No. 13 "intermediate and long-range basic policy for national research institutes"	August 28, 1987	Taking into consideration the changes in conditions surrounding national research institutes and the problems which they are facing, the recommendation suggests desirable medium- and long-term prospects for their future roles and ways to activate these roles.
Recommendation for Inquiry No. 14 "basic plan for R&D on Materials science and technology"	August 28, 1987	In order to contribute to the comprehensive and systematic promotion activities in the future concerning materials science and technology, which had been rapidly progressing in recent years, the recommendation suggests significant R&D objectives and promotion measures for the next 10 years.
Recommendation for Inquiry No. 15 "basic plan for R&D on information / Electronics science and technology"	March 14, 1989	With respect to information/electronics science and technology which have been rapidly progressing in recent years, the recommendation suggests expectations of this sort of science and technology, significant R&D tasks and promotion measures for the next 10 years
Recommendation for Inquiry No. 16 "comprehensive basic policy for upgrading and strengthening the infrastructure to support science and technology"	December 5, 1989	With respect to production and distribution of science and technology information, development, installation and provision of instruments and equipment and development, storage and supply of materials, genetic resources, etc., as well as research supporting functions as an environmental condition for activating fundamental activities and intellectual properties, the recommendation suggests the fundamental guidelines for constructing the infrastructure to support science and technology.
Recommendation for Inquiry No. 17 "basic plan for R&D on earth science and technology"	June 22, 1990	The recommendation suggests basic concepts and important R&D topics with the aim of promoting R&D in earth science technology in Japan as a whole and indicates the role that the government should have and the measures it should implement in promoting R&D.

Note: Excluding recommendations described in the text.

(Table 3-2-1)

Title	Date	Outline
Recommendation for Inquiry No. 18 "Comprehensive and Basic Science and Technology Policy toward the New Century"	January 24, 1992	This report outlines the science and technology policies that Japan should pursue over the next 10 years. The basic concept of the recommendation was for science and technology to contribute to the international society and humanity as a whole, and achieve the following goals. • Coexistence of Humans in Harmony with the Earth • Expansion of Intellectual Stock • Construction of a Charming Society Where People Can Live with Peace of Min Based on this report, the General Guidelines for Science and Technology Policy was adopted in April 1992.
Recommendation for Inquiry No. 19 "Basic plans for Research and Development on Soft Science and Technology"	December 2, 1992	This report addresses research and development related to soft science and technology that contributes to the support of intellectual activities, improvement in the comfort of the living environment, and balance with people and society. It indicates the basic thinking of Japan in its promotion of this research and development, the important research and development issues that the Government should address, and policies for the promotion of each.

international exchanges.

3.2.2.3 Request No. 20 On a Basic Policy for Securing Human Resources in the Fields of Science and Technology

(December 2, 1992)

In order to make further scientific and technical advances in an environment where these fields are becoming advanced and complex, obtaining highly creative scientists and technicians becomes an extremely important task. However, in spite of everincreasing demand for personnel in scientific and technical fields, less of them are filled due to phenomenon like decrease in the population at a productive age, and decreased interest in scientific and technical fields among young people. In order to deal with these issues, a need to strengthen policy designed to maximize the potential ability to obtain personnel in science and technical-related fields is becoming necessary.

Under such conditions, the Prime Minister submitted to the CST in December, 1992, Request No. 20, Basic Policy for Securing Human Resources in the Fields of Science and Technology. The CST, after receiving this request, is at present forming new subcommittees on human resources in the science and technical field and conducting further investigations and deliberations.

3.2.2.4 Request No. 21 Basic Plans for Research and Development on Advanced Fundamental Science and Technology

(June 7, 1993)

State-of-the art procedures used in different scientific and technical fields, or leading basic foundation science and technology, assists developments in all fields, assists in the joining of different fields, opens new fields where it can be applied, and offers a new path to solve problems that could not be dealt with effectively by the traditional methods of the past.

In order to plan for increased promotion of leading basic science and technology from here onward, continuous utilization of comprehensive knowledge from a wide range of fields, in addition to planned R&D activity in these fields, must be carried out. As such, in June 1993, the Prime Minister submitted to the CST an request on the Basic Plan for Research and Development in Leading Basic Science and Technology.

3.2.2.5 Revision of Fundamental Planning of R&D Concerning Disaster Prevention

The current fundamental planning of R&D concerning disaster prevention was decided upon in 1981 by the Prime Minister, and since then, R&D for disaster prevention in Japan has been carried out based upon this policy. All R&D for disaster prevention carried out based upon the original plan in the more than 10 years since this decision was made. However, the environment surrounding these R&D activities is undergoing major changes, such as changes in the composition of society and increased demand for international contribution and cooperation from Japan. In regard to these changes, it was decided in December 1992 by the CST Committee on Policy Matters that the current fundamental plan should be examined for revisions. As of January 1993, the Panel on Science and Technology for Disaster Prevention was reorganized, and deliberation and investigations are being conducted concerning the content of the revisions, dealing with issues such as the recent remarkable advances in new technology, etc.

3.2.3 Comprehensive Coordination of Policies for Science and Technology Promotion

3.2.3.1 The Special Coordination Funds for Promoting Science and Technology (SCF)

The SCF were first established in FY1981 to facilitate the comprehensive promotion of science and technology as a funded system; they are expended in accordance with the guidelines decided by the CST. Administration of the SCF is based on a policy document entitled *The Guiding Principals for the Special Coordination Funds for Promoting Science and Technology* which was adopted by the CST in March 1981 and finally revised in January 1992. More specifically, the SCF are expended in accordance with the annual guideline of the CST Policy Committee.

New in FY1993, distinguished individuals from around the world gathered and began promoting the Center of Excellence (COE) in order to communicate advanced core research results and other matters to the world.

3.2.3.2. Guideline on the Priority for Promoting Science and Technology

The Committee on Policy Matters decides annually the Guideline on the priority for promoting science and technology along the line with The General Guideline for Science and Technology Policy

In June 1993, the following items were selected as priority items for promotion in the *Basic Guidelines for Implementing Priority Programs for the Promotion of Science and Technology for FY1994.*

- Increased funds for basic research at universities and national testing research facilities.
- Renewal of facilities to support advanced research and update superannuated facilities and equipment.
- Strengthening of the R&D base such as maintenance of the research information distribution base, etc.
- Improving the research environment .
- Enrichment of human resources.
- Strengthening international science and technology activities.

3.2.3.3 Basic Investigations for Planning Science and Technology Policies

The Sub-committee on Research Projects under the CST Committee on Policy Matters undertakes background investigations and analyses in areas deemed essential to the formulation of policies for comprehensive and effective R&D promotion. Investigations are financed with appropriations from the SCF.

In FY1991, investigations were conducted on the following:

- Development direction of science and technology
- Promotion of international science and technology activities
- Strengthening the basis for promoting science and technology
- Science and technology in harmony with people and society

In addition, The Science and Technology Forum is being held every year as a part of the basic investigations, with the theme for FY1992 being "Dreams of Science and Technology". The 12th forum on science and technology was held in January 1992.

3.2.3.4 Investigation Concerning the Research Information Network

In July 1993 the Ad-Hoc Committee on Research Information Network was established under the CST Committee on Policy Matters to encourage the mutual use of a network and computers to distribute research information to deal with issues such as the advancement of research content. Here, investigations are being carried out on issues related to how Japan's research information network should be maintained, based on the situation of the research information network inside and outside of Japan, researcher needs and other matters.

3.2.3.5 Follow-up Activities for CST Recommendations

Follow-up activities for CST recommendations are conducted in the Committee on Policy Matters to realize the policies recommended and to coordinate the science and technology policies.

The Report on Measures Taken for the Promotion of Science and Technology was compiled and published, summing up government policy in relation to Request No.18.

3.2.3.6 International Activities

The rapid changes in the international situation around Japan have resulted in the recognition that the necessity to contribute to the international society in the field of science and technology is much more than ever before.

High level policy matters dealing with, for example, the ideal method of carrying out large-scale international cooperation and long-term R&D, and global environmental issues also have rapidly increased.

Therefore, the CST also has been required to use its own judgment to develop international activities in a more active manner.

3.2.3.6.1 The Carnegie Group Meeting (Government Summit Meeting of Science and Technology Advisors)

The members of the meeting were advisors on science and technology to the leaders of the summit countries, the EC and the former Soviet Union and Cabinet ministers in charge of science and technology with nine members all together. By the suggestion of Dr. Bromley, the then Presidential Advisor on U.S. Science and Technology, the purpose of the meeting was to exchange opinions on various problems concerning science and technology, report the results to the leaders of each country and reflect them at the summit talks.

Meetings have been held five times up to present, and was held recently in May 1993, in Toronto, Canada.

3.2.3.6.2 The Meeting of Presidents of Research Councils of G7

A meeting proposed by Dr. Heinz Maier-Leabnitz, the president of German Research Foundation, which conducts open debate concerning various science and technology-related problems with representatives from the Research Councils of the summit countries attending. The conference has been held annually for 12 years, and Japan has participated since the 6th meeting. Recently, the conference was held in Venice, Italy, in May, 1993.

3.2.3.6.3 EC-Japan-US Trilateral Meeting on Science and Technology Policy

The CST suggested holding a meeting between the three parties in which representatives from the CST, President's Council of Advisers on Science and Technology, and the EC Science and Technical Committee get together to exchange opinions on policies regarding science and technology in general. The first meeting was held in Tokyo in October 1991 after an agreement was reached between the parties involved.

3.2.3.6.4 Others

Other than these meetings, the CST started from FY1990 The International Invitation Program of the CST. Important persons from abroad involved in science and technology policy are being invited to exchange opinions with members of the Committee on Policy Matters of the CST.

3.2.3.7 Regional Activities

The "Meeting on Regional Science and Technology Policy" has been held since FY1991 with members of the Committee on Policy Matters of the CST and the Chairmen of Regional Councils on Science and Technology. The meeting is to strengthen collaboration between the CST and Prefectural Councils on Science and Technology and to contribute to planning regional science and technology policies. In addition, the CST, in cooperation with the regions, has been conducting a regional science and technology policy forum since FY1992, where various scientific and technical problems from the administrative sections of Japan are debated. Researchers connected with wide regional science and technology policy, administrative officers, etc., participate in this forum

3.3 Structures for Promotion of Science and Technology

3.3.1 Administrative Structure

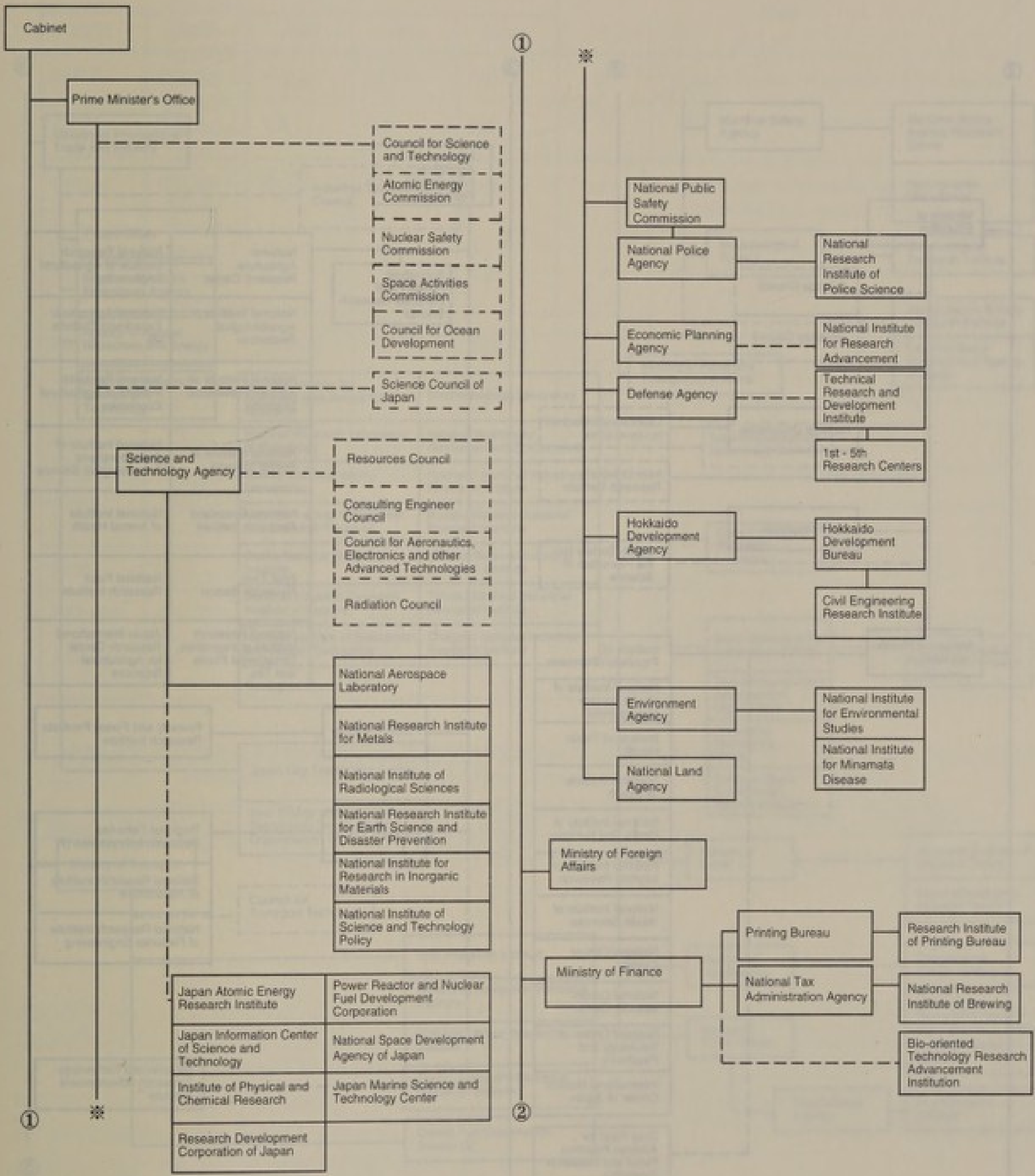
In principle, each government ministry or agency has Jurisdiction over the promotion of its own science and technology programs. Research is carried out at relevant national research institutes, public research corporations and national universities, including inter-university research institutes.

For example, the Ministry of Education administers academic research programs; the Ministry of Health and Welfare conducts research with the goal of improving health and social welfare; the Ministry of Agriculture, Forestry and Fisheries carries on research for the nation's agriculture, forestry and fisheries; the Ministry of International Trade and Industry carries on mining and industry research; the Ministry of Transport has jurisdiction over transport-related research programs; and the Ministry of Posts and Telecommunications oversees telecommunications research (Figure 3-3-1).

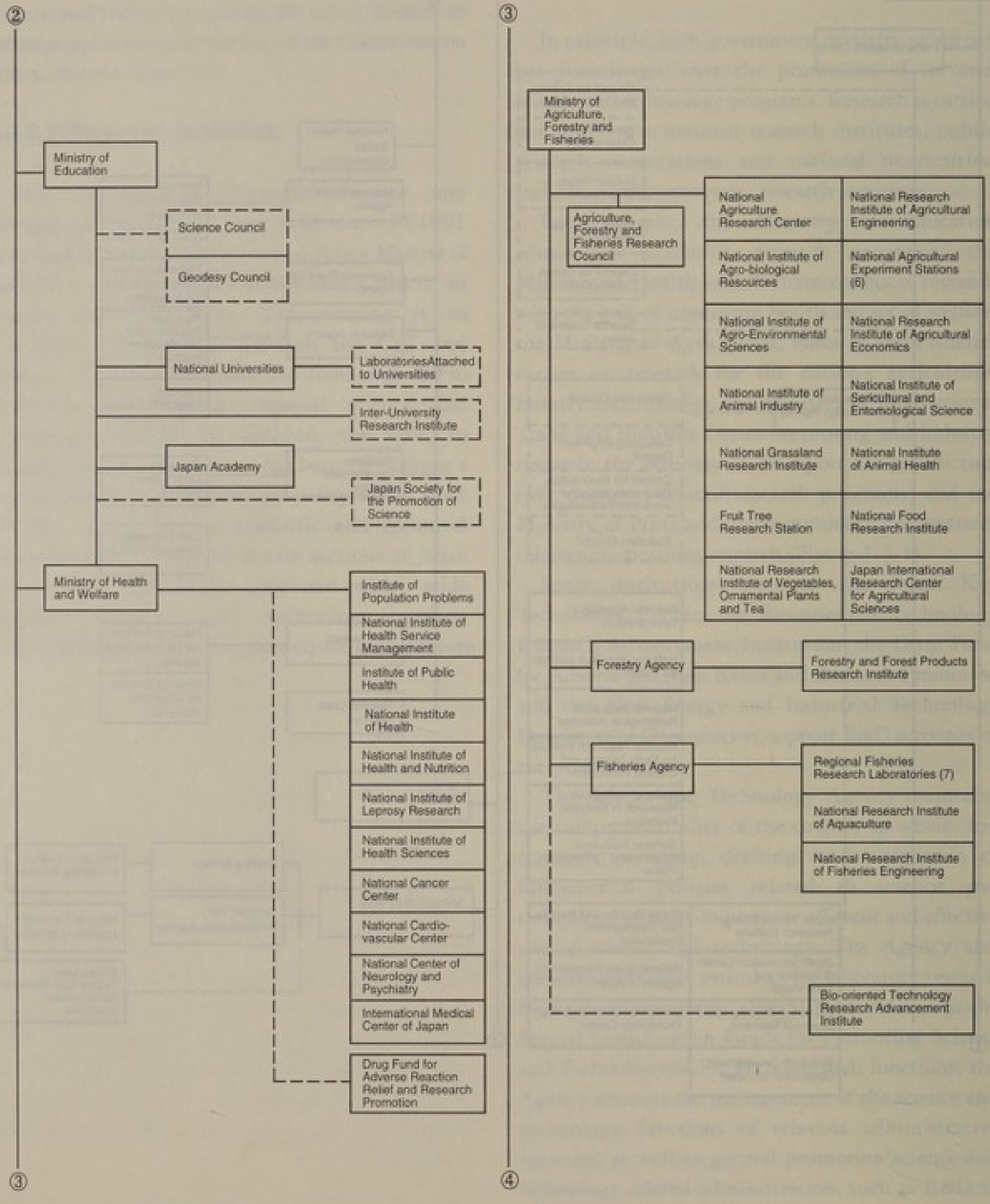
Some institutions, such as the Japan Key Technology Center, the Bio-oriented Technology Research Advancement Institution, the Drug Fund for Adverse Reaction Relief and Research Promotion and the New Energy and Industrial Technology Development Organization, support R&D activities in the private sector.

The Science and Technology Agency maintains the comprehensibility of the country as whole, and conducts planning, drafting, and promotion of fundamental policies related to science and technology in order to promote efficient and effective use of science and technology. The Agency also coordinates budget estimates for laboratory research facilities and performs clerical work related to the Special Coordination Funds for Promoting Science and Technology(SCF). Through such functions, the Agency oversees the management of the science and technology functions of relevant administrative agencies, as well as general promotion science and technology related administration, such as R&D in leading, critical science and technology fields and the

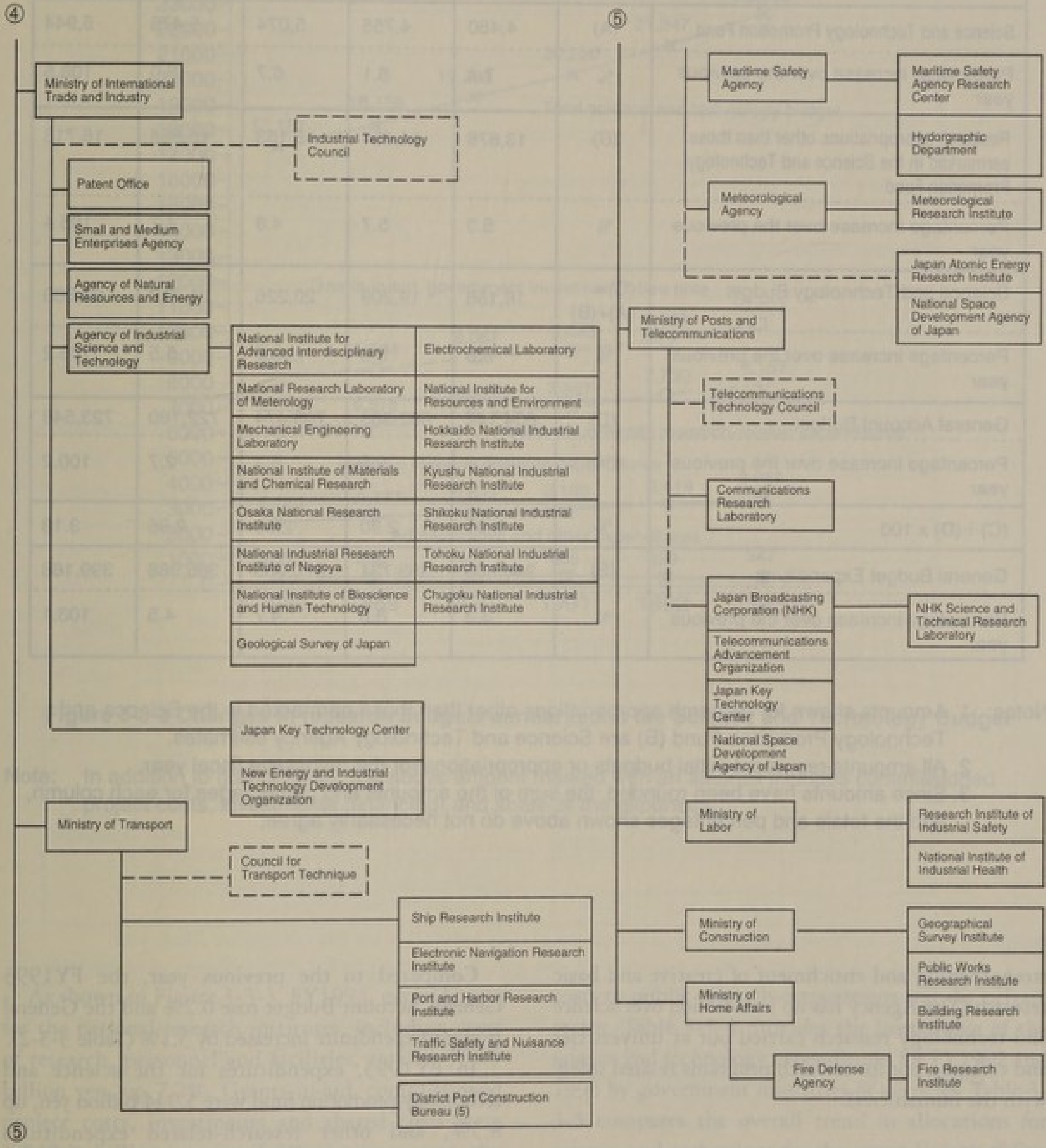
Figure 3-3-1 Administrative structure (October 1993)



(Figure 3-3-1 Administrative structure (October 1993))



(Figure 3-3-1 Administrative structure (October 1993))



Note: Laboratories or institutes related only to the humanities are not included.

Table 3-3-2 Science and technology expenditure allocations—1989 to 1993 (¥100 million)

Item		Fiscal Year				
		1989	1990	1991	1992	1993
Science and Technology Promotion Fund	(A)	4,480	4,755	5,074	5,478	5,944
Percentage increase over the previous year	%	7.4	6.1	6.7	8.0	108.5
Research appropriations other than those earmarked in the Science and Technology Promotion Fund	(B)	13,676	14,454	15,153	15,868	16,718
Percentage increase over the previous year	%	5.3	5.7	4.8	4.7	105.4
Science and Technology Budget	(C)= (A)+(B)	18,156	19,209	20,226	21,347	22,663
Percentage increase over the previous year	%	5.8	5.8	5.3	5.5	106.2
General Account Budget	(D)	604,142	662,368	703,474	722,180	723,548
Percentage increase over the previous year	%	6.6	9.6	6.2	2.7	100.2
(C) ÷ (D) x 100	%	3.01	2.90	2.88	2.96	3.13
General Budget Expenditure	(E)	340,805	353,731	370,365	386,988	399.168
Percentage increase over the previous year	%	3.3	3.8	4.7	4.5	103.1

Notes: 1. Amounts shown for research appropriations other than those earmarked in the Science and Technology Promotion Fund (B) are Science and Technology Agency estimates.
2. All amounts represent initial budgets or appropriations for the respective fiscal year.
3. Since amounts have been rounded, the sum of the amounts and percentages for each column, and the totals and percentages shown above do not necessarily agree.

strengthening and enrichment of creative and basic research (The Agency has no jurisdiction over science and technology research carried out at universities and colleges, nor for research programs related solely with the humanities).

3.3.2 Expenditures Allocations

In Fy1993, the national science and technology expenditures totaled 2.2663 trillion yen, up 6.2% from the preceding year.

Compared to the previous year, the FY1993 General Account Budget rose 0.2% and the General Budget Expenditure increased by 3.1% (Table 3-3-2).

In FY1993, expenditures for the science and technology promotion fund were 5.944 billion yen, up 8.5%, and other research-related expenditures primarily at national universities were 1,671.8 billion yen, up 5.4%.

Figure 3-3-3 shows trends in research allocations from the science and technology expenditures over the last seven years.

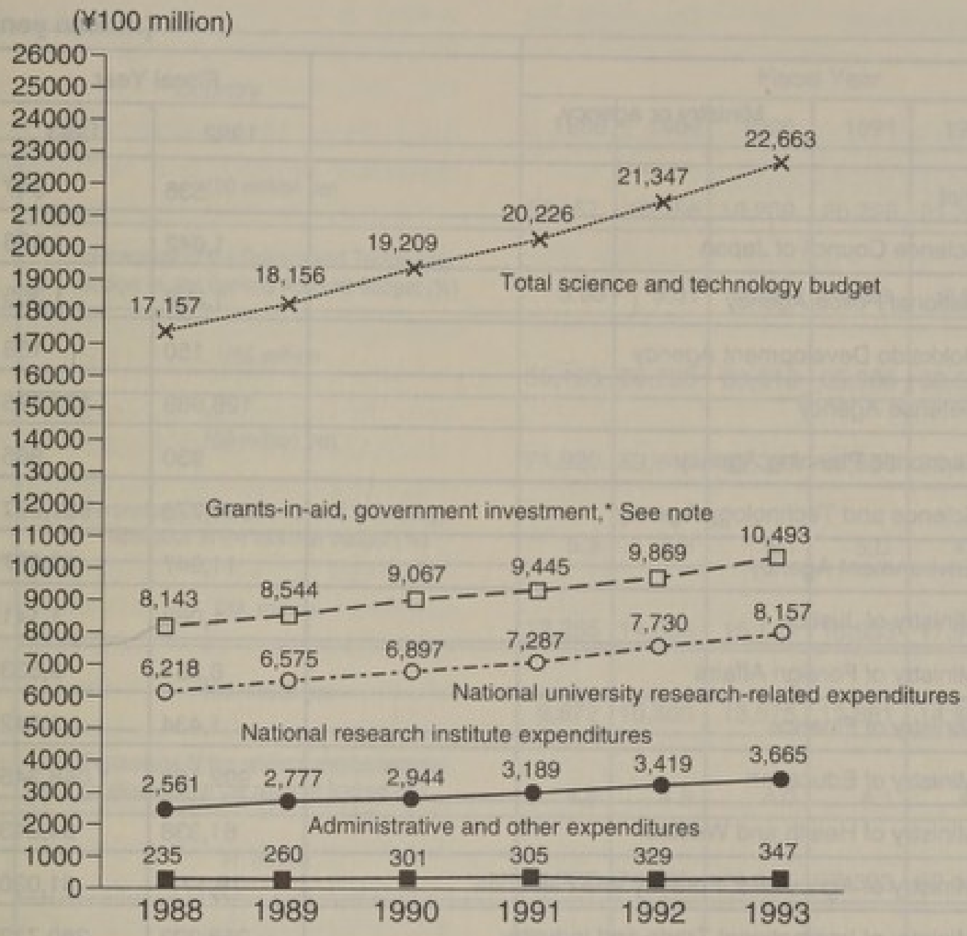


Figure 3-3-3 Changes in research budgets earmarked in the Science and Technology Budget

Note: In addition to grants-in-aid, the above amount marked with an asterisk includes commissioned project costs, investments (financing) and share of the expenses.

As shown in Figure 3-3-3, FY1993, expenditures for the national research institutes, including costs of research, personnel and facilities, totaled 366.5 billion yen, up 7.2%. Grants-in-aid, commissioned project costs, investments and shared costs were 1,049.3 billion yen, a 6.3% increase over the preceding year and accounted for 46.3% of the total science and technology budget. This expenditure consists of government support for large R&D projects, grants-in-aid and commissioned project costs to public research corporations and the private sector. Table 3-3-4 provides the breakdown of the science and technology expenditures for FY1992 and 1993 by government ministries or agencies. Table 3-3-5 compares the overall trend in allocations for science and technology in the expenditures of five selected countries. However, since fiscal accounting procedures differ from country to country, it is difficult to make direct comparisons, particularly regarding the actual amounts of money allocated.

Table 3-3-4 Science and technology expenditure breakdown by ministries and agencies

(million yen)

Ministry or agency	Fiscal Year	
	1992	1993
Diet	536	547
Science Council of Japan	1,042	1,096
National Police Agency	1,209	1,305
Hokkaido Development Agency	150	158
Defense Agency	126,989	137,175
Economic Planning Agency	930	965
Science and Technology Agency*	551,778	581,577
Environment Agency	11,847	12,597
Ministry of Justice	1,063	1,141
Ministry of Foreign Affairs	8,251	9,533
Ministry of Finance	1,434	1,542
Ministry of Education	992,108	1,046,345
Ministry of Health and Welfare	61,338	64,343
Ministry of Agriculture, Forestry and Fisheries*	76,177	81,030
Ministry of International Trade and Industry	259,223	280,712
Ministry of Transport	22,515	24,220
Ministry of Posts and Telecommunications	32,733	34,971
Ministry of Labor*	3,787	4,340
Ministry of Construction	6,936	8,010
Ministry of Home affairs	631	658
Total	2,134,676	2,266,265

Notes: 1. All amounts represent initial expenditure or appropriations for the respective fiscal year.
2. Since amounts have been rounded off, the sun of the amounts for each column, and the totals shown above do not necessarily agree.
3. The amounts for the ministries and agency marked with asterisks include the Science and Technology Expenditure appropriations from Special Accounts.
4. Some amounts include appropriations for humanities.

Table 3-3-5 Science and technology expenditures of elected countries

Country		Fiscal Year 1988	1989	1990	1991	1992	1993
Japan	100 million yen	17,157	18,156	19,209	20,226	21,347	22,663
	Percentage of the Science and Technology Budget in the General Account Budget (%)	3.03	3.01	2.90	2.88	2.96	3.13
United States	US$ million	56,100	60,760	63,810	65,965	63,570	67,951
	100 million yen	71,920	83,849	92,397	88,855	80,480	—
	Percentage of the science and technology allocation in the national budget (%)	5.3	5.3	5.1	5.0	4.6	4.6
Germany	DM. million	13,255	14,036	15,149	16,853	17,969	17,939
	100 million yen	9,672	10,300	13,575	13,681	14,564	—
	Percentage of the science and technology allocation in the national budget (%)	4.8	4.8	4.0	4.1	4.3	4.2
France	Fr. million	71,767	75,008	78,054	78,333	82,000	—
	100 million yen	15,437	16,217	20,755	18,706	19,606	—
	Percentage of the science and technology allocation in the national budget (%)	6.2	6.5	6.4	6.1	6.2	—
United Kingdom	str. million	4,504	4,770	4,963	5,074	5,588	—
	100 million yen	10,282	10,790	12,824	12,096	12,489	—
	Percentage of the science and technology allocation in the national budget (%)	3.9	3.8	3.6	3.3	3.4	—

Notes: 1. The accounting procedures for national expenditures and for science and technology allocations from national expenditures vary from country to country.

2. The amounts for Germany represent the federal budget and do not include the majority of expenditures for research at universities which are shouldered by state governments.

3. The amounts for Germany represent the federal budget and do not include the majority of expenditures for research at universities which are shouldered by state governments. The budget for 1990 includes only that of former West Germany.

Sources: Japan — The Budget Book
United States — Budget of the US Government
Germany — Faktenbericht 1990 zum Bundesbericht Forschung, 1988; Finanzbericht; Statistische Informationen;
France — attachments to the draft budget
United Kingdom — Annual Review of Government Funded R&D 1989, 1990

3.4 Promotion of Research Activities

3.4.1 Promotion of Important Areas of Research and Development

3.4.1.1 Basic and Leading Science and Technology Fields

3.4.1.1.1 Materials Science and Technology

Substance/Material Series of Science and Technology has not only been making contributions of new scientific knowledge by clarifying phenomena/functions that occur at the atomic or molecular level or in ultimate environments such as ferromagnetic fields and ultra-high-vacuum or ultra-high pressure. It has also had an extremely large influence on the economic world in the past through the discovery of new materials. As can be seen in the example of new superconductors, the appearance of new materials cultivates new technology and brings qualitative changes to even related technology, which has had a great impact on society, and of course industry as well.

The discovery of new materials has always strongly influenced societies and their economies. Such materials open the door to new fields in technology that substantially alter existing ones, precipitating changes in the manufacturing sector and in society as a whole. A recent example of such a force for change is the discovery of new superconductive materials.

The exploration of many potential R&D fields in advanced disciplines, such as information/electronics science and technology and life sciences, awaits the development of new advanced materials. The key to advancing this development is R&D in materials science and technology — the common and basic technology that supports the innovative research that lies at the basis of a scientific and technological nation.

Today the need for advanced materials is especially acute in big R&D projects related to supercomputer development, fusion technologies, and space and ocean research and development. The research, development and production of new materials are treated as an immediate priority in the nation's science and technology programs.

3.4.1.1.1.1 Comprehensive Promotion of Materials Science and Technology

Accordingly, the government is currently implementing policies for further advances in many fields of materials science and technology. This is in keeping with the CST's recommendation on priority and also is in conformance with recommendations from the Council for Aeronautics, Electronics and Other Advanced Technologies.

In May 1986 the Prime Minister presented Inquiry No.14, *Basic Plan for R&D in the Field of Materials Science and Technology,* to the CST for deliberation. The CST began an investigation of R&D objectives and guidelines, submitting its recommendation to the Prime Minister in August 1987. In response, the government announced *The Government Research and Development Plan on Substance/Material Series of Science and Technology* in October of the same year.

Furthermore, the conference studied Inquiry No.18 *General Basic Policies on Science and Technology for the Next Century* (submitted in January, 1992) and indicated the necessity of developing substances and materials with high performance and new functions which go beyond existing limits.

Also, the Council for Aeronautics, Electronics and Other Advanced Technologies established general guidelines for the advancement of materials science and technology through recommendations made in the following reports:

- Recommendation pursuant to Inquiry No. 5, *The Concept of Ultimate Science for Advanced Materials and the Guidelines on R&D Promotion,* submitted in August 1980.
- Recommendation pursuant to Inquiry No. 7, *The Concept of New Advanced Materials' Design and the Guidelines on R&D Promotion,* submitted in September 1984.
- Recommendation pursuant to Inquiry No. 9, *The Concept of Measurement Control Techniques for New Advanced Materials and the*

Guidlines on R&D Promotion, submitted in March 1986.

- Recommendation pursuant to Inquiry No. 13, *The Concept of Intelligent Materials and the Guidelines on R&D Promotion,* submitted in November 1989.

A recommendation (submitted in November, 1991) was made at the council regarding Inquiry No.16 *The Concept of Analysis/Evalution Techniques for New Advanced Materials and the Guidelines on R&D Promotion.*

3.4.1.1.1.2 Promotion of Materials R&D

Due to the demand for materials science and technology, government ministries and agencies are participating in R&D in this area.

The Science and Technology Agency is furthering common and basic research in materials science and technology through the work, for example, at the National Institute for Research in Inorganic Materials and the National Research Institute for Metals. Moreover the Agency supports research through the administration of the Special Coordination Funds for Promoting Science and Technology and a number of other programs, including Exploratory Research for Advanced Technology (ERATO), under the auspices of the Research Development Corporation of Japan (JRDC) and the International Frontier Research Program, under the auspices of the Institute of Physical and Chemical Research (RIKEN).

The Ministry of Education also is encouraging basic research in materials science and technology, as well as fostering creativity in the research environment utilizing Grants-in-aid for Scientific Research that allows scientists at national universities to pursue their own chosen avenues of study.

The Ministry of International Trade and Industry is conducting R&D on new materials in manufacturing technology, etc., according to the Industrial Science and Technology Frontier Program.

In addition, the Ministry of International Trade and Industry (MITI) promotes cutting-edge, basic R&D conducted by the international joint research teams through the International Joint Research Grant Project (NEDO grant) in order to improve the level of substance and materials science and technology internationally.

3.4.1.1.1.3 R&D in Superconductive Materials

The discovery of high, critical temperature oxide-based superconductors at the IBM Zurich Laboratories in Switzerland in 1986 captured the attention of the worldwide scientific community. In January 1988, the Science and Technology Agency's National Research Institute for Metals subsequently discovered the first of several bismuth-based superconducting compounds.

Although commercial applications of this family of materials are expected to dramatically affect the world's socioeconomic situation, the current reality is that superconductive materials are still far from being commercially useful. Basic and innovative R&D is needed in areas such as the theoretical description of high critical temperature superconducting behavior and in new materials research.

To this end, a number of government ministries and agencies are promoting R&D into superconductive materials in accordance with *The Basic Promotion for Research and Development on Superconductivity* compiled in November 1987 by the Ad-hoc Committee on Superconductivity which was set up under the CST's Policy Committee

In May 1988, the Science and Technology Agency set up *The Multi-core Research Project on Superconductivity* to promote the fundamental research required to realize the potential of new superconductive materials. This project takes a two-fold approach.

Firstly, it encourages maximum utilization of the R&D potential of research organizations such as the National Research Institute for Metals, the National Institute for Research in Inorganic Materials, the Japan Atomic Energy Research Institute, the Power Reactor and Nuclear Fuel Development Corporation, the National Space Development Agency of Japan, and the Institute of Physical and Chemical Research (RIKEN).

Secondly, it encourages joint research projects between Japanese and overseas scientists and fosters an environment that promotes the exchange of scientists and information.

The Ministry of Education is promoting basic research in superconductors utilizing Grant-in-aid for Scientific Research for innovative programs to researchers at the national universities.

The Ministry of International Trade and Industry also is promoting joint projects to develop superconductive materials by promoting industrial-academic-government cooperation. The Ministry's work is mainly carried out as part of the Moonlight Project and the Research and Development Program on Basic Technologies for Future Industries, utilizing research institutes such as the Electrotechnical Laboratory and the National Chemical Laboratory for Industry as key institutes for cooperation. The Ministry also is providing support for the International Superconductivity Technology Center (ISTEC).

The Ministry of Posts and Telecommunications is pursuing R&D on superconductor technology for advanced telecommunications systems. This research is being carried out under the auspices of *Applications of Superconductors* as a part of the Frontier Research and Development for Next-generation Telecommunications Systems Program which is being promoted through industrial-academic-government cooperation centering on its Communications Research Laboratory.

Finally, the Ministry of Transport is supporting the R&D of a magnetic-levitation railway system using superconductors. This research is being funded by subsidies provided to the Railway Technical Research Institute (RTRI).

3.4.1.1.1.4 Promotion of International Cooperation in Material Science and Technology

The government is supporting a number of bilateral and multilateral research projects and is encouraging the flow of information and interaction between researchers. Some of these projects are described below:

(1) Bilateral projects

- Research for High-Magnetic Field between the National Research Institute for Metals (Japan) and the Francis Bitter National Magnetic Laboratory (the National Science Foundation, the United States). This project was adopted in May 1990 under the Japan-U.S. Science and Technology Cooperation Agreement.
- The Atom Alignment Control for New Materials between the Research Development Corporation of Japan and Cambridge and London Universities in the United Kingdom.

(2) Multilateral projects

- The Versailles Project on Advanced Materials and Standards (VAMAS)

Further, in 1990, Japan became the selected country for the International Electrotechnical Standard Commission's (IEC) recently established Technical Committee on Superconductivity (TC-90).

3.4.1.1.2 Information/electronics Science and Technology

3.4.1.1.2.1 Importance of Promotion

The role which information and electronics related science and technology performs is becoming increasingly important as we enter an advanced information society. Up to now, information- and-electronics-related science and technology has brought major innovations to economic and social activities through the growing sophistication and functionality of semiconductors and computers. It is predicted that information will increase qualitatively and quantitatively in the future, and higher functions in information processing such as intelligent processing and handling ambiguous data, efficient and accurate transmission of information with various input/output forms and R&D related to human interfaces with information processing and transmission are strongly desired.

With an understanding of this, reporting in March, 1989 in relation to Request No. 15, Basic Plan for Research and Development on Science and Technology Related to Information and Electronics, CST presented important R&D goals and promotion policy for research developments for the next 10 year

3.4.1.1.2.2 Important R&D Tasks

(1) Devices, etc.

Microelectronics R&D of high-speed logic devices and large-capacity memory devices are prerequisites for continued advancement in high-speed image processing and high-speed, wide-bandwidth data transmission, as well as in user interface technology and in the processing, transfer and storage of information.

A medium-to long-term analysis suggests that physical and chemical research and application-oriented engineering R&D in the following fields also merits serious attention:

- Quantum behavior of electrons
- Properties of materials that have undergone atomic lattice manipulation or alteration
- Micro-functional properties of biological structure

Practical research activities are being conducted in ***The Creation of Materials for High-functional Opto-electronic Devices with a Liquid-drop Epitaxy Method*** by the National Research Institute for Metals of the Science and Technology Agency, and ***Quantized Functional Device R&D, Biological Device R&D,*** and other topics being pursued through the Ministry of International Trade and Industry's (MITI) Industrial Science and Technology Frontier Program. At The Ministry of Posts and Telecommunications, ***R&D on Device Technology for Millimetric and Submillimetric Waves*** by Communications Research Laboratory and ***R&D on Molecular Device Technology for Advanced Telecommunications*** as a part of the Frontier Research in Telecommunications are being promoted.

(2) Information Processing

Higher speeds and increased capacity promise implementation of advanced and highly functional information processing such as interpretation of information at a conceptual level and inference, learning and judgment by the function itself. Therefore, it is urgently required that not only computers be more sophisticated and functional, but also that advanced and higher software functions, algorithms, programming languages, and architecture based on a totally new concept, and open system formats be promoted.

Another important R&D field is the research on basic and fundamental technologies of neural network models and fuzzy logic systems that are essential in achieving capabilities such as understanding of imprecise expressions and knowledge, inductive reasoning, analogistic processing and learning. To this end, research on ***Fuzzy Logic Systems and Their Applicability to User Interfaces and Non-linear Logic-based Systems*** and research on ***The Development of Fundamental Technology for Sensor Fusion*** are being conducted with funding allocated from the Special Coordination Funds for Promoting Science and Technology.

In addition, ***Real World Computing*** (RWC), ***and R&D for Open Basic Software Systems*** have been started by the Ministry of International Trade and Industry, and ***R&D on Modeling a New Software Structure*** and ***Research Related to Flexible, Intelligent Processing*** based on The Industrial Science and Technology Frontier Program at the Electrotechnical Laboratory are being conducted.

(3) Human Interfaces

Properly speaking, information systems are supposed to be tools to support and enrich human activity. But the current situation is that the human side must put in a great deal of effort to, accommodate the information system during operation. Thus, in order to sufficiently utilize the abilities of information systems, it is essential to build advanced human interfaces which think from a human standpoint and which anyone can easily operate according to his or her abilities. This can be achieved by basic research in cognitive science, which aims at understanding the information processing functions of human beings, and psychology applications research to support creativity, and other activities.

As research in this field, the Ministry of Posts and Telecommunications is conducting ***The R&D Program on Network Human Interfaces*** and ***R&D on Information and Communication Systems for Groupware*** as a part of the Frontier Research in Telecommunications. In the Ministry of International Trade and Industry, ***The Future Personal Information Environment Development*** (FRIEND 21) and other activities are being promoted.

(4) Information transmission

The information-oriented structuring of society has increased the dependence on telecommunications, necessitating research in high-speed, high-volume and more advanced telecommunications systems that support more sophisticated applications.

In cable-based telecommunications, coherent-light-wave optical communication systems using lasers have the potential to realize long-distance data transmissions with an exceptionally high volume.

In addition, research is being conducted on transmission technology based on new principles such as quantum optical transmission which is seen as the next generation of communications technology as well as new communications technology such as miniature transmission satellites and stratosphere wireless relay systems.

As advances in transmission capabilities, construction of a flexible network with diverse connectability and an intelligent network with various service functions to respond to sophisticated needs are expected, and at the Ministry of Posts and Telecommunications, ***R&D on Telecommunication Technology of 3-Dimensional Moving Pictures*** as a pioneering R&D program and ***Research on Sophisticated Intelligent Functions for Next-Generation Communication Systems*** as a part of Frontier Research in Telecommunications are being conducted.

(5) Application to Social Needs

R&D is underway for technology supporting medical care, education, production and cultural pursuits to realize an abundant and comfortable lifestyle, applying the technologies in (1) - (4) to human society. Concrete research is being conducted by MITI, such as research on Applied Technology for Measuring Human Senses, as a part of R&D in large scale industrial technology, and further R&D in this field is anticipated in the future.

Table 3-4-1 summarizes the major R&D subjects in information/electronics science and technology undertaken by the various government ministries and agencies during FY1992.

3.4.1.1.3 Life Sciences

The life sciences aim at elucidating the aspects of life in its many forms and complex and elaborate mechanisms involved. Research in the life sciences has the potential to contribute substantially to the solution of many problems related to health care, medical treatment, environmental conservation, and the agriculture, forestry, fishery, and chemical industries. The life sciences are fields looked upon with high expectations to make realistic large contributions to a healthy, enriched life for the people of Japan.

3.4.1.1.3.1 Basic Policies for the Promotion of Research in the Life Sciences

In 1971 the CST submitted its Recommendation pursuant to Inquiry No. 5, citing the importance of promoting research in the life sciences. After that, steady promotion of research in life sciences has been proceeding on the basis of recommendations of the CST.

3.4.1.1.3.2 Promotion of Research on Cancer and the Acquired Immune Deficiency Syndrome (AIDS)

Cancer is the leading cause of death in Japan, being one-quarter of all moralities. The formulation of an appropriate set of policies to promote cancer research was so important that in 1983 the Cabinet Council for Cancer Counter Measures submitted a ***Comprehensive 10-year Strategy for Cancer Control.*** Since FY1984, relevant ministries and agencies have promoted cancer R&D in accordance with this strategy.

In 1987, the Cabinet Council for Counter Measures of AIDS formulated The ***Fundamental Principle for Countermeasures of AIDS*** to deal with this important disease of the immune system, and research is underway at the Science and Technology Agency, the Ministry of Education and the Ministry of Health and Welfare based on the revised version of this guideline prepared in March, 1992.

3.4.1.1.3.3 Promotion of Studies on the Human Genome Analysis

Human genome analysis is aimed at reading out the base sequence of the entire human DNA. It is expected that the analyses will bring about many benefits such as clarification, diagnosis and other illnesses and the elucidation of organisms' evolutionary mechanisms caused by genetic. Based on Recommendation No. 12 by the Council for Aeronautics, Electronics and Other Advanced Technologies in 1988, *Comprehensive Strategy for Promoting R&D on Human Genome Analysis*, and the proposal by the Science Council in 1989, various research activities have been conducted in relevant ministries and agencies. In August, 1991, a report was put together by the Human Genome Committee set up in the CST's Panel on Life Sciences (established in 1990) on the present status in this country, international trends and the future course of human genome analysis.

Based on these achievements, the Institute of Physical and Chemical Research is carrying out basic facilitation for research on the development of analysis materials and an automatic analysis system for human genome, while research focusing on particular genes and development of new methods to analyze human genome information is taking place mainly at universities. The Ministry of Agriculture, Forestry, and Fisheries started research on rice genome analysis in 1991.

In May, 1992, a Genome Data Base (GDB) was established to be managed with international support to uniformly collect the results of human genome analysis conducted around the world, and also in Japan the GDB Japan Node is scheduled to start in 1993. It is expected that research of human genome analysis will further develop in the future, based on these trends.

3.4.1.1.3.4 Promotion of Recombinant DNA Research

Experiments in recombinant DNA technology have improved the quality of life by assisting in determining the cause of diseases, manufacturing pharmaceutical compounds, developing micro-organisms for specific applications and breeding new varieties of crops. Another facet of recombinant DNA experiments is their potential to create new or altered life.

The CST responded to a governmental inquiry on the safety of experiments in recombinant DNA in its 1979 Recommendation pursuant to Inquiry No. 8, *Basic Policies for the Promotion of Research in Recombinant DNA*. Based on this, the Prime Minister enacted *Guidelines on Recombinant DNA Experimentation* the same year and R&D activities were started within this framework. The guidelines have been amended each time knowledge increases in the field. In September 1991, the 9th amendment was made due to an overall review of the guidelines based on progress in genetic introduction technology and other areas. The CST plans to continue to review the Guidelines to meet the increase of knowledge and requirements in research ensuring safety in the experiments.

In 1978, the Science Council of the Ministry of Education proposed its own set of guidelines to ensure the safe, smooth progress of research on recombinant DNA at the nation's universities and associated institutions. *The Guidelines,* which take into account recommendations from experts in the field, were first published in 1979 and have subsequently undergone seven revisions as a result of further deliberations within the Council.

In considering the use of recombinant DNA technology at the stage of commercialization, the Ministry of Health and Welfare, the Ministry of International Trade and Industry and the Ministry of Agriculture, Forestry and Fisheries have issued guidelines for R&D under their respective jurisdictions.

Table 3-4-1 Major research subjects in information / electronics science and technology (in FY1993)

Ministry or agency	Research institute or program	Subject
Science and Technology Agency	* Special Coordination Funds for Promoting Science and Technology	* Research to develop the fundamental technology of sensor fusion * Research to construct self-organization-type information base systems to support creative R&D activities * Research concerning fuzzy systems and their applications to human and natural systems * Basic research for the intellectual facilitation of creative activities
	* National Research Institute for Metals	* Creation of materials for high-functional opto-electronic devices by liquid-drop epitaxy method
	* National Institute for Research in Inorganic Materials	* Research on converting glass into intelligent optical material
	* Institute of Physical and Chemical Research	* Research on photodynamics * Research on thought functions
	* Research Development Corporation of Japan	* Information on quantum waves, atomic control surfaces and phases
Environmental Agency	* National Institute for Environmental Studies	* Construction of databases for research of the earth's environment
Ministry of Education	* National Universities (subsidies for scientific research expenses)	* Research concerning structural principles of high functional, high quality software * Research concerning conceptual formations and knowledge acquisition in knowledge science * Ultrahigh speed, massively parallel optical electronics * A basic system for information processing based on the massively parallel principle
Ministry of International Trade and Industry	* Fifth generation computer technology project	* Development of new information processing technology
	* Industrial Science and Technology Frontier Program	* Micromachine technology * Measurement and application technology of human senses * R&D of quantized functional devices * R&D of models for structuring new software * R&D of biological devices
	* Electrotechnical Laboratory	* Research concerning flexible, intelligent information processing * Research concerning integrated processing of multiphase information * New functional formation for electronic devices * Research concerning information processing schemes with flexible structures

(Table 3-4-1)

Ministry or agency	Research institute or program	Subject
Ministry of International Trade and Industry	* National Institute of Bioscience and Human-Technology	* Research concerning configurative operation properties in human interfaces * Research concerning measurement and engineering structures of human skills
	*Information-Technology Promotion Agency (IPA)	* R&D of open substrate software
Ministry of Transport	* Electronic Navigation Research Institute	* Research concerning an aircraft collision prevention system having a horizontal evasive function * Research concerning aircraft monitoring measures to shorten vertical control intervals * Research concerning utilizing GPS of aircraft
Ministry of Posts and Telecommunications	* Communications Research Laboratory	* R&D on mobile radio communication systems using microwaves frequency band * R&D of network human interfaces * Research on multi-dimensional knowledge functions for next-generation communications * R&D of unexplored electromagnetic waves * R&D concerning fundamental technology for ultra-multi-dimensional plastic networks * R&D on device technology for millimetric and submillimetric waves
Ministry of Construction	* Geographical Survey Institute	* Research concerning the development of electronic publishing technology of maps

3.4.1.1.3.5 Promotion of Research on Glyco-technology, etc.

Life sciences measures cover an extremely wide-ranging area from the elucidation of life phenomena, industrial use of animals and plants to the problems of population and food. Recently in particular, the Council for Aeronautics, Electronics and Other Advanced Technologies submitted its Recommendation No. 14 *Policy for Promoting General R&D for Basic Studies in Glyco-technology,* in July 1990. Based on the recommendation, research activities have started focusing on the elucidation of functions in the living body and the analysis of structures of sugar-chains with the cooperation and coordination of the Science and Technology Agency, the Ministry of Health and Welfare, the Ministry of Agriculture, Forestry and Fisheries and the Ministry of International Trade and Industry.

3.4.1.1.3.6 Promotion of Science and Technology Research on Longevity

Demographic trends in Japan indicate a more rapid aging of the population than that seen in other countries. In recognition of this, the Cabinet approved *The Programs for Adjusting to an Aging Population Views Concerning Basic Promotion for Science and Technology for Long Life Society* in 1986. Relevant ministries and agencies are promoting R&D on longevity in accordance with these programs.

Table 3-4-2 summarizes the major R&D subjects undertaken by the various government ministries and agencies during FY1993.

Table 3-4-2 Major research subjects in life sciences (in FY1993)

Ministry or agency	Research institute or program	Subject
Science and Technology Agency	* Special Coordination Funds for Promoting Science and Technology	* Research on the development of fundamental techniques for controlling HIV infection and expression * Development of the basic technology to analyze the mechanisms of cancer invasion and metastasis * Development of fundamental techniques for human gene mapping * Development of highly-sensitive, high resolution non-destructive techniques to elucidate the biological functions of living systems at the molecular level * Research on fundamental technology for structural and functional analysis of glycochains
	* Institute of Physical and Chemical Research	* Research on biological functions of living organisms such as human genome analysis * Bio-homeostasis research program, research program on brain mechanisms of mind and behavior, photodynamics research program, and bio-mimetic research program * Promotion of recombinant DNA experimentation * Gene bank projects
	* Research Development Corporation Japan	* Exploratory research for advanced technology such as cell configuration, plant ecochemicals geno SHERE, protein array and so on * Cells and information by projects to foster original individual research (21 pioneering projects) * Evolution of microorganisms by international joint research projects * Cooperative technology development of "Measurement device of respiratory muscle function": etc
	* National Institute of Radiological Sciences	* Application of heavy ion beams to the medical field
	* Japan Atomic Energy Research Institute	* Research into the utilization of radioactivity for biotechnology
Environment Agency	* National Institute for Environmental Studies	* Research concerning the synergetic effect of long-term exposure of chemical substances on the ecosystem in an aquatic environment * Research concerning effective use and environmental assessment of biotechnology for preservation of the environment
Ministry of Finance	* Research Institute of Brewing	* Research concerning structure and functions of organic cells involved in brewing and distillation
Ministry of Education	* National universities (through provision of grant-in-aid for scientific research and other funding)	*Overview of special studies on cancers * Molecular-biological research on cell replication control * New perspective on the RNA functional structure * Penetration of protein through membranes and the molecular mechanism of selected transportation * Mechanism of pain transmission and endogenous activated substances * Molecular structure of the environmental response of photosynthesis

(Table 3-4-2)

Ministry or agency	Research institute or program	Subject
Ministry of Health and Welfare	* National Institute of Health	* Cell-biological and molecular-biological research concerning infection and the outbreak of diseases of microorganisms * Molecular Analysis of protozasis and chlamydiasis, and development of animal models for the infectious diseases
	* National Institute of Health Nutrition	*Motor and vegetative physiological research of physical indications in health strengthening
	* National Institute of Leprosy Research	* Analytical research on specificity, structure and function of protein produced by leprosy bacillus
	* National Institute of Hygienic Sciences	* Evaluation of in vivo and in vitro systems for the measurement of biological effects of drugs and chemicals * Chemical study on biologically active stereoisomers for the evaluation of enantiomeric drugs
Ministry of Agriculture, Forestry and Fisheries	* National Institute of Agro-biological Resources * National Institute of Agro-Environmental Sciences * National Institute of Animal Industry * National Grassland Research Institute * Fruit Tree Research Station * National Research Institute of Vegetables, Ornamental Plants and Tea * National Institute of Sericultural and Entomological Science * National Institute of Animal Health * National Foods Research Institute * Forestry and Forest Products Research Institute * Regional Fisheries Research Laboratories	* Analytical research on rice genome * General research in biotechnological plant breeding * General research to develop new agricultural, forestry and fishery techniques through the clarification and control of biological information * General research to elucidate the ecological order in the agricultural, forestry and fishery systems and develop optimal controls * MAFF gene bank project * Research project on the development of insect technology * Comprehensive research to develop high-functional materials through structural changes of sugar

3.4.1.1.4 Soft Science and Technology

3.4.1.1.4.1 Decision of the Basic Plans for Research and Development

Science and technology is facing a period of major change in this complex, advanced society where support for intelligent action is desired; a place where we have broken the shackles of a possession oriented mass production/mass consumption society and come to desire a high-quality, enriched and unhurried lifestyle. It has become essential to place importance on "humans and society".

In December 1992, a report in reply to CST Request No. 19 *Basic Plans for Research and Development on Soft Science and Technology,* was submitted as a strategy in response to this type of period/situation. The Prime Minister decided upon this as a fundamental plan for soft science and technology in January 1993.

(Table 3-4-2)

Ministry or agency	Research institute or program	Subject
Ministry of International Trade and Industry	* Industrial Science and Technology Frontier Program	* Production and Utilization Technology for Complex Carbohydrates
	* National Institute of Bioscience and Human Technology	* Design, Structure and Function of Protein-unit Assemblies * Biocatalyst for Oxidation in Microacueous System * Development of Substances Regulating Cellular Signal Transduction * Research Concerning Measurement and Engineering Structure of Human Skills
	* National Industrial Research Institute of Nagoya	*High Performance Ceramics for Bio-functional Control
	* Osaka National Research Institute	* Research concerning Complex Molecular Systems having Sensing Capability
Ministry of Posts and Telecommunications	* Communications Research Laboratory	* R&D of High-efficiency Coding Technology through Models of Perception Mechanisms * Molecular Device Technology * Elucidation of Biological Functions
Ministry of Construction	* Public Works Research Institute	* Research concerning Actual Use of Sophisticated Treatment Processes using Fixation Microorganisms

In the Basic Plans for Research and Development, soft science and technology is designed to develop the capacity and functions of people, society, hardware and other practical matters. In other words, it promotes a system of science and technology that considers how hardware should be structured and moved and how intellectual abilities of humans and the industrial capacity of society should be supported and activated, and indicates important research and development issues and promotional policies. The following is a summary.

- Basic thinking

  In recognition of the growing importance of soft science and technology and the deepening and expanding of knowledge and technology that support it, the following should be emphasized in the promotion of research and development:

  —Emphasis on basic research (human features)

  —Planned promotion of research and development

  —Promotion of integration between natural sciences and human and social sciences.

- Important research and development issues based on the understanding of human qualities, including intellectual qualities and feelings, the following issues can be indicated:

  —Support of intellectual activities, improvement in comfort of living environment, understanding of complex social issues

  —Realization of hardware that gives priority to humans and harmonizes with society.

  Understanding the indistinct nature of human thought and activities and other important basic areas provide the key to the development of all of these.

- Promotion policies

  The following measures are being taken for the promotion of soft science and technology which forms the new comprehensive science and technology:

  —Enhancement of a research and development center that forms the structure and core for the cooperation between researchers from a broad area of disciplines ranging from natural sciences to human and social sciences.

  —Enhancement of high-speed, large-capacity, advanced information processing facilities, information and communications networks, and other research and development bases.

—Education of people with well-rounded knowledge through an environment in which knowledge from other disciplines can be obtained.

—Building of a research and development structure that meets the needs of the users.

—Enhancement of measures for promoting international exchange and cooperation.

Furthermore, the Resource Council, an advisory group to the Director-General of the Science and Technology Agency (Minister of State), has been grappling with policy for the importance, current conditions, future outlook and future development of intellectual technology (technology to support or replace human intellectual activities) since July 1992.

3.4.1.1.4.2 Current state of research and development

Soft science and technology shows great promise as a basic, leading area that can bring new breakthroughs and integrate human and social sciences with natural sciences. In recent years, there has been an increase in research and development activities accompanying the re-ordering of science at research organizations and universities involved in soft science and technology.

The main research topics addressed in soft science and technology in FY1993 are shown in Table 3-4-3.

3.4.1.1.5 Advanced Fundamental Science and Technology

As science and technology develops and becomes more complicated in each area, the importance of having technology which can become a common foundation utilized in different areas and be a key to further development in those areas has been recognized. For example, the promotion of technology to measure microsubstances and expansive spaces with ultra-high precision, technology to make and display real time, multi-dimensional observations, and the support of other measurement and analysis technologies are considered important.

On the other hand, new types of fundamental technology which combine the science and technology of existing areas such as micro-engineering technology which integrates microelement device technology, micro-control technology and micro-design technology, are being developed.

It is expected that this advanced, fundamental science and technology will provide breakthroughs to issues which could not be solved through the development of new application areas or with conventional approaches by encouraging the mutual exchange of science and technology in differing areas.

Therefore, advanced fundamental science and technology is ranked as a main area in the basic and pioneering science and technology in the Recommendation Pursuant to Inquiry No.18 of the CST and the Basic Policy for Science and Technology Policy and will be promoted. In addition, the Science and Technology Agency started The Survey Concerning the Future Direction of R&D for Advanced Fundamental Science and Technology from 1992 for two years through the Special Coordination Funds for Promoting Science and Technology, and will extract concrete research topics from advanced fundamental science and technology areas which should be promoted in the future and the various factors obstructing the promotion of such research, and will clarify the direction in which advanced fundamental science and technology should be developed.

In FY1993, the Special Coordination Funds for Promoting Science and Technology enabled the initiation of development of basic technology for the development and use of critical quantum sensing. The Ministry of International Trade and Industry has formed a research and development system for industrial science and technology to conduct research and development on atomic technology for securing technology for closely monitoring and operating each atomic particle.

In June 1993, in order to promote plans for research and development in leading basic science and technology, the Office of the Prime Minister

Table 3-4-3 Major research subjects in soft science and technology areas (FY 1993)

Ministry or agency	Research institute or program	Subject
Science and Technology Agency	Special Coordination Funds for Promoting Science and Technology	* Fundamental Researches on Human Characteristics for Harmonizing Systems with Human Beings * Basic Researches for Intellectual Facilitation of Creative Activities * Survey on the Developmental Mechanism of Various Social Activities and their Effective Support
	Japan Atomic Energy Research Institute	* Development of Evaluation Method of Reliability of Human Behavior
	Institute of Physical and Chemical Research	* Research Program on Brain Mechanisms of Mind and Behavior
Ministry of Education	National universities (through provision of grants-in-aid for science research and other funding)	* Perspectives on Advanced-technology Societies * Studies on the Change of Socio-system and Human Behavior in the Advanced Information Society * A Study on Concept Formation and Knowledge Acquisition in Knowledge Science * An Approach to KANSEI Information Processing from Information Science and Psychology * Research on Intelligent Artifacts Synthesizing Engineering Technology * Investigation into the Dynamic Structure of Organisms
Ministry of Agriculture, Forestry and Fisheries	Separate general research	* Development of Techniques for the Evaluation and Application of Functions of Agricultural, Forest, and Fishery Products that Contribute to Health
Ministry of International Trade and Industry	Industrial Science and Technology Frontier Program	* Human Sensory Measurement Application Technology
Ministry of Transport	Research and Development on Transportation Technology	* Research and Development on Accessibility of Public Transportation for the Elderly and the Handicapped
Ministry of Posts and Telecommunications	The Frontier Research in Telecommunications	* Realization of Highly Intelligent Functions

asked the Science and Technology Council to conduct investigations for the enactment of a basic plan in response to Request 21 on Basic Plans for Research and Development on Leading Basic Science and Technology. These investigations are currently be conducted.

3.4.1.1.6 Space/aeronautical Science and Technology

3.4.1.1.6.1 Space Development

Space development plays an important role in furthering science and technology and improving the quality of people's lives through its contributions in areas such as scientific observation, communications, broadcasting and meteorological observation.

Japan's space development bas been conducted under the cooperation of organizations including the National Space Development Agency of Japan and the Institute of Space and Astronautical Sciences. Activities are based on both the Fundamental Policy of Japan's Space Development (published in March

1978, revised in June 1989) and the Space Development Program, which specifies the annual development plans in accordance with the Fundamental Policy, as prescribed by the Space Activities Commission.

In this Fundamental Policy, the following three directions are pointed out as basic principles for Japan's space development policy:

- Response to advancing and diversifying needs
- Consistency with Japan's role in the international society to improve the nation's capability to continuously and freely conduct various space activities and international cooperation
- Encouragement of the private sector in the space development

The following are the principal objectives of this policy:

- Promote scientific research
- Establish satellite and launch vehicle technology
- Form the foundation for utilizing space environment
- Form the foundation for manned space activities

(1) Satellites

Since the successful launch of Japan's first satellite, Ohsumi, in 1970, Japan has successfully launched 51 satellites by March 1993, and ranks third following the United States and the former Soviet Union.

The following sections describe the main satellites. Table 3-4-4 provides a full listing of satellites and payloads launched during FY1992, and those planned to be launched in FY1993 and thereafter.

① Scientific Field

The Institute of Space and Astronautical Science affiliated to the Ministry of Education, in cooperation with universities nationwide, has successfully launched 22 scientific satellites so far. These include the 14th Scientific Satellite SOLAR-A to observe high-resolution imaging of solar flares during the solar maximum period as a joint Japan-U.S. project.

Other scientific satellites currently under development include the following:

1) The magnetosphere observation satellite GEOTAIL, a collaborative program with NASA, is intended to observe the structure and the dynamic of the extended tail of the magnetosphere on the night-side of the Earth.
2) The 15th Scientific Satellite ASTRO-D will investigate X-ray precision imaging and spectrum observation of heavenly bodies at the far-edge of space.
3) The 16th Scientific Satellite MUSES-B is designated to investigate the deployment of a large dexterous structure and make astronomical observations by radio waves for Space VLBI.
4) The 17th Scientific Satellite LUNAR-A is being designed to elucidate the intra-lunar crustal and thermal structure.
5) The 18th Scientific Satellite PLANET-B is intended to investigate the atmospheral structure and movement of Mars and its mutual interaction with solar wind.

② Earth and Meteorological Observation

Regarding *The Himawari series* of geostationary meteorological satellites, GMS-4 (*Himawari 4*), launched on September 6, 1989, is currently operational. GMS-5 is currently under development.

The Momo series of marine observation satellites are used to observe the color and temperature of the ocean surface and other ocean phenomena. MOS-1 (*Momo 1*) and MOS-1b (*Momo 1b*), the latter launched on February 7, 1990, are presently in service. Other satellites currently in operation or being developed are the following:

1) Japanese Earth Resources Satellite JERS-1, launched on February 11, 1992, is expected to obtain data useful for earth observation to contribute to land survey, agriculture, forestry, fishery and so on.
2) The Advanced Earth Observing Satellite ADEOS which uses platform technology, intends to monitor global environmental changes and to promote further international cooperation in the field of earth observations.
3) The Tropical Rain-fall Measuring Mission TRMM, through Japan-U.S. cooperation, intends to monitor rain-fall in the tropics which is vital to elucidating the mechanism of energy balance on a global scale.

Table 3-4-4 Satellites and payloads launched during FY 1992 and planned for FY 1993 and thereafter

Satellite / payload	Weight (kg)	Orbit	Orbital altitude (km) / location	Launch vehicle	Launch date (fiscal year)	Major objectives
* FY 1992						
GEOTAIL Geophysical Tail Resources Satellite	Approx. 1,010	Equatorial orbit	50,000 to 1.37 million	U.S. launch vehicle	Jul. 24, 1992	* Observation research by Japan-U.S. cooperation of the structure and dynamics of the extended tail of the magnetosphere on the night-side of the Earth
FMPT first First Material Processing Test (FMPT)Experiment	—	—	—	U.S. Space Shuttle	Aug. 12, 1992	* Performing experiments in materials, etc. under space environment by a Japanese Scientist, Dr. Mohri, aboard the Space Shuttle
ASTRO-D The 15th Scientific Satellite-Astronomy Satellite-"Asuka"	Approx. 420	Approximate circular orbit	Approx. 500 to 600	M-3SII	Feb. 20, 1993	* Investigation of X-ray precision imaging and spectrum observation of heavenly bodies at the far-edge of space
* Satellites and payloads to be launched during FY 1993 and after from "Space Development Plan (March 17, 1993)"						
EXPRESS (Experimental Reentry Space System)	Approx. 800	Circular orbit	Approx. 250	M-3SII	1993	* Diversification of testing measures for space use related to leading industrial technology development and engineering experiments on atmospheric penetration and recovery necessary for future satellite plans
ETS- VI engineering test satellite-VI	Approx. 2,000	Geo-stationary orbit	—	H-II	1994	* Confirmation of H-II test rocket performance * Further development of large-scale geo-stationary 3-axis satellite bus technology required for the development of satellites in the 1990s * Development of technology and testing of high-performance satellite communications systems
SFU space flyer unit	Approx. 4,000	Circular orbit	Approx. 300 to 500	H-II	1994	* Various scientific and engineering experiments * Astronomical observations * Acquiring the opportunity required for the R&D of advanced industrial technologies * Reliability testing and improvement of exposed facility of JEM common experiment equipment

(Table 3-4-4)

Satellite / payload	Weight (kg)	Orbit	Orbital altitude (km) / location	Launch vehicle	Launch date (fiscal year)	Major objectives
GMS-5 geostationary meteorological satellite 5	Approx. 340	Geostationary orbit	—	H-II	1994	* Improvement of weather observation * Development of meteorological satellite technology
ADEOS advanced earth observing satellite	Approx . 3,500	Sun synchronous sub-recurrent orbit	Approx. 800	H-II	1995	* International cooperation in monitoring global environmental changes * Development of technology which will be required by the next generation of earth observation plat forms and similar satellites * Development of the technology required for the relaying earth observation data
MUSES-B The 16th Scientific Satellite-Mu Space Engeneering Satellite-B	Approx. 700	Extended elliptical orbit	1,000 to 20,000	M-V	1995	* Large-scale precision development structure organization research and radio astronomy observation
COMETS communications and broadcasting engineering test satellite	Approx. 2,000	Geostationary orbit	—	H-II	1996	* New technologies of sophisticated moving-body satellite communications technology, inter-satellites communications technology and sophisticated satellite-broadcasting technology in the communications and broadcasting areas, multi-frequency bandwidth integration technology and efficiency-increasing technology of large-scale stationary satellites will be developed, experimented with and demonstrated
PLANET-B 18th scientific satellite	Approx. 340	—	—	M-V	1996	* Investigation of the atmospheral structure and movement of Mars and its mutual interaction with solar wind
TRMM (Tropical Rainfall Measuring Mission)	Approx. 3,600	Circular orbit	Approx.3 350	H-II	1997	* Monitoring of tropical rains necessary for explaining global energy use mechanisms
LUNAR-A 17th scientific satellite	Approx. 585	Circular orbit	100km over the moon surface	M-V	1997	* Elucidation of crustal structure and thermal structure of the moon
JEM Japanese experiment module	Undecid -ed	Circular orbit	400	U.S. Space Shuttle	1998	*Expansion of Japan's space activities, promotion of leading science and technology development, and contribution to the advancement of international cooperation

③ Communications and Broadcasting

The Sakura series of communications satellites, CS-3a (*Sakura 3a*), launched on February 19, 1988, and CS-3b (*Sakura 3b*), launched on September 16, 1988 are currently operational.

As for the *Yuri series* of broadcasting satellites, BS-3a (*Yuri- 3a*) which was launched on August 28, 1990, and BS-3b (*Yuri-3b*) which was launched on August 25, 1991, are currently operational.

The development of the Communications and Broadcasting Engineering Test Satellite (COMETS) is proceeding with the purpose to develop, experiment with, and demonstrate technology of advanced mobile satellite communications, inter-satellite communications, high-performance satellite broadcasting' multiple frequency-band integration and higher-performance largescale geostationary satellites.

In terms of effective optical communications technology for satellite communications systems, research and development is being conducted in cooperation with the European Space Agency (ESA) on the Optical Inter-orbit Communications Engineering Test Satellite (OICETS) which is designed to conduct experiments in orbit on essential technology focusing on the link-up with the static satellite ARTEMIS of the European Space Agency (ESA).

④ General Satellite Technology

The Kiku series of engineering test satellites are used to test common technologies of variety types of satellites. The engineering test satellite ETS-V (*Kiku 5*) which was launched on August 27, 1987, designed to test mobile communication technology, is currently in operation. The following satellites are under development:

1) The 6th Engineering Test Satellite ETS-VI will be utilized to establish large scale three-axis stabilized geostationary satellite bus technology, and to develop advanced technologies for fixed and mobile communications and inter-satellite communications.
2) The 7th Engineering Test Satellite ETS-VII will be used to acquire basic technologies of rendezvous, docking and space robotics that are essential to the future space activities through in-orbit experiment.

(2) Launch Vehicles

For launching scientific satellites, the M (mu) series rockets have been developed, succeeding the L (lambda) series rockets. M series launch vehicles use solid propellants for all stages. Currently the M-3 SII is being used. However, development of the three-stage M-V launch vehicle, with enlargement of each stage and a simpler configuration, is underway to meet the requirements of scientific observation missions after the 1990s.

Regarding launch vehicles for satellites, after completing development of the N series rockets, the H series rockets have been developed. The H-I launch vehicle, which can launch a 550-kg payload in a geostationally earth orbit, has succeeded in being launched 9 times. H-I rocket program ended with the launch of Japanese Earth Resources Satellite JERS-1 in February 1992. The H-II launch vehicle is a large two-stage vehicle being developed to launch two-ton class geostationary satellites to meet the satellite demand of the 1990s. This launch vehicle uses liquid-hydrogen/oxygen engines in both stages. The first test launch of the H-II is planned for FY1993. Also, R&D of the J-I launch vehicle which can transport an 1-ton payload in a low earth orbit, is being carried out to respond to demands for small scale and inexpensive launches (Table 3-4-5).

(3) Space Utilization and Manned Space Activities

① First material processing test *(Fuwatto '92)*

In September 1992, Japanese astronaut Mamoru Mohri boarded the U.S. Space Shuttle Endeavor and launched into space for about eight days where he used the special characteristics of the space environment to conduct Japan's Fuwatto '92 experiment covering 43 topics of investigation: 22 related to materials experiments of Japan, 12 related to life sciences experiments of Japan and 9 related to U.S. experiments. This mission will provide an important opportunity to acquire the technology needed for manned space flights.

② Space Station Program

The Space Station Program is an international project in which the U.S., Europe, Canada and Japan participate in the goal of constructing a manned space station in a low earth orbit at an altitude of

Table 3-4-5 Main specification of vehicles used to launch satellites

Launch vehicle type	Stages	Overall length (m)	Diameter (m)	Gross Weight (tons)	Propellant
M-3SII	3	27.8	1.41	Approx. 61	Solid for all stages
M-V	3	Approx. 30	Approx. 2.5	Approx. 128	Solid for all stages
N-II	2	35.4	2.44	133.4	1st and 2nd stages, liquid; SOB, solid
	3	35.4	2.44	134.7	1st and 2nd stages, liquid; 3rd stage and SOB, solid
H-I	2	40.3	2.44	137.7	1st stage, liquid; 2nd stage, liquid oxygen / hydrogen; SOB, solid
	3	40.3	2.44	139.3	1st stage, liquid; 2nd stage, liquid oxygen / hydrogen; 3rd stage and SOB, solid
H-II	2	Approx. 50	Approx. 4	Approx. 264	1st and 2nd stages, liquid oxygen / hydrogen; SRB, Solid
J-I	3	Approx. 33	Approx. 1.8	Approx. 87	All stages solid

400km. The space station will establish the infrastructure for utilizing the space environment and for furthering manned space activities.

Japan has been developing Japanese Experiment Module (JEM) and Japanese astronauts will be stationed on board for a long period. On September 5, 1989, Japan signed the Inter-Governmental Agreement, which sets up a cooperative framework after the detailed design stage of the program. The agreement was followed on January 30, 1992 by the U.S. to make the agreement effective from that date. Japan's space station project has already entered the full-scale development phase.

③ Others

Japan is committed to a number of other activities aimed at utilizing the space environment and at acquiring the technology for manned space activities. These include the following:

1) Development of the SFU (space flyer unit)

The SFU is a reusable satellite that will fly in a low earth orbit for several months at a time to ensure Japan an opportunity for space experiments.

2) Participation in the International Microgravity Laboratory (IML) program Japan participated in the First International Microgravity Laboratory (IML-1) on January 22, 1992 and will participate in the Second International Microgravity Laboratory (IML-2) planned in 1994 on board the U.S. Space Shuttle. Japanese astronaut Chiaki Mukai is scheduled to board the Space Shuttle. Through these two projects, Japan will accumulate the technology required for the Space Station Program.

(4) Fundamental and Advanced Research on Satellite and Launch Vehicle Technology

The National Aerospace Laboratory and research institutes of related ministries and agencies are conducting fundamental research on launch vehicle and satellite technology. The laboratories and research institutes are also working in a number of advanced research areas, including the H-II orbiting plane (HOPE), an unmanned winged reusable space vehicle which can be used to transport cargo to the

Space Station and a manned space-plane.

(5) International exchange in the area of space development

In light of the collapse of the Soviet Union, which competed with the United States in space development, and the increase in global surveillance satellites and other projects requiring international cooperation, there is an increasing need for cooperation between the countries of the world in the area of space. Under these conditions, the Space Agency Forum (SAF) was initiated with the aim of continuing the spirit of the International Space Year, which came to a successful conclusion in 1992, and of promoting exchange and cooperation between the space organizations of the world. The first meeting of the SAF took place in Rome, Italy, in May 1993.

3.4.1.1.6.2 Aeronautical Technology

R&D in aeronautical technology is knowledge-intensive and makes use of state-of-the-art technologies from a wide range of disciplines. As a result, developments in this field can promote advancements over a wide range of downstream technologies, in addition to the basic goal of improving the equipment and infrastructure for air transportation.

Given its technologically strategic nature, extensive R&D in aeronautics is critical to the overall promotion of science and technology and to the development of a technologically-oriented society.

The current state of the nation's aeronautical technology is the direct result of knowledge acquired through R&D on the Japanese-developed YS-11 commercial transport airplane, the international joint development of the Boeing 767 passenger jet and other aircraft. This technology is now at the stage where Japanese private sector corporations are participating or intending to participate in a number of domestic and international aircraft development projects, some of which are listed below.

- The design and manufacture of the 350-seat twin-engine Boeing 777 passenger jet
- The design and manufacture of the 150-seat YXX passenger aircraft
- Investigation of the development of a next-generation supersonic commercial transport airplane
- Development of the V2500 jet engine with aeroengine companies in the United States, the United Kingdom, Germany and Italy

To actively promote the development of aircraft and their engines, it is necessary to enhance futuristic technological levels. To this end, the government is formulating measures designed to encourage R&D in this field in accordance with recommendations contained in reports prepared by the Council for Aeronautics, Electronics and Other Advanced Technologies.

In March 1991, the Council conducted its final report on ***The Examination of Practical Plans for R&D of Fan-jet STOL Aircraft*** (Request No. 1). In January 1993, the Council conducted investigations and deliberations on ***Policy for long-term development of Aeronautical Technologies*** (Request No. 18).

National Aerospace Laboratory of the Science and Technology Agency is promoting research with the goal of establishing the technologies required for futuristic aeronautics development. Since FY1987, the laboratory has encouraged research on aerodynamics technology that will be required for future aircraft such as hypersonic transport planes, space planes and highly efficient, large payload transport airplanes, the technology of new composite material structures, flight control technology, propulsion technology and other state-of-the-art aeronautical transportation technologies. Also, on top of promoting basic technology such as numerical value simulations using computers, the laboratory maintains large-scale test research facilities for wind tunnel experiments to be jointly used by related agencies, and takes a leading role in advancing Japan's aerospace technology.

The Ministry of Transport's Electronic Navigation Research Institute is conducting R&D on navigation and air-traffic control systems to improve air safety. Findings from this research will ensure steady development of the air transportation system.

The Ministry of International Trade and Industry is furthering R&D of propulsion systems for future high-reliability supersonic transport planes capable of operating at low air speeds through Mach 5.

European and American engine manufacturers are participating in this R&D.

3.4.1.1.7 Ocean Science and Technology

The development and use of the ocean, which contains an abundance of resources, including biological and mineral resources, as well as vast space, is an important issue for a country as physically small and confined by sea as Japan.

Because the ocean plays an important role in global change and the crustal dynamics of the earth greatly influence earthquake and volcanoes, it is urgent that mechanisms in and around the ocean be elucidated.

In light of these conditions, the United Nations Educational, Scientific and Cultural Organization (UNESCO) and Intergovernmental Oceanographic Commission (IOC) began to make calls in the 1990s for the GOOS plan which aims to build a system for conducting comprehensive observation and research of ocean phenomena on a worldwide scale. This plan was also promoted at Agenda 21, adopted by the United Nations Conference on Environment and Development held in Brazil in June of 1992.

Based on these international efforts, it is crucial to promote ocean research related to global environmental issues and other research and development on ocean science and technology.

3.4.1.1.7.1 Basic Guidelines for the Promotion of Ocean Science and Technology

The Council for Ocean Development is an advisory committee to the Prime Minister which decides basic and general concepts related to ocean development. The Council's Recommendation pursuant to the Prime Minister's Inquiry on *Basic Concepts and Promotional Guidelines for Long-term Ocean Development*, submitted in May 1990, identifies the following basic principles guiding the advancement of ocean science and technology.

- The promotion of oceanographic studies and development of technologies for the elucidation of global change and ocean phenomena.
- The promotion of science and technology which is useful for overcoming severe oceanic conditions and for creating new ways of ocean development.

Related government ministries and agencies are engaged in promoting R&D in ocean science and technology under their respective jurisdictions in accordance with the guidelines of the Council's recommendation. Further, the various ministries and agencies coordinate closely to ensure comprehensive promotion by following the Promotion Program for Ocean Development compiled annually by the Liaison Council for Ocean Development-related Ministries and Agencies.

Furthermore, in order to shed some light on ocean phenomena occurring on a global scale, positive efforts are being made to participate with related government agencies and universities in international ocean research programs such as GOOS.

3.4.1.1.7.2 Promoting R&D in Ocean Science and Technology

The Science and Technology Agency is promoting pioneering and fundamental R&D, mainly by the Japan Marine Science and Technology Center (JAMSTEC) and also by comprehensive projects with the cooperation of ministries and agencies concerned.

JAMSTEC is developing submersible vessels to provide information in areas related to exploration of the ocean floor, prediction of seismic activity, studies on deep-sea microorganisms, and so on. In 1992 the Japan Marine Science and Technology Center (JAMSTEC) promoted deep-sea investigations and research activities with the manned research submersible SHINKAI 2000, SHINKAI 6500 and the remotely operated vehicle DOLPHIN 3K, and began development of a remotely operated vehicle which can dive to 10,000m. In addition, JAMSTEC started R&D on a deep-sea drilling vessel system to elucidate the plate tectonics and global environmental changes.

In ocean observations for clarifying ocean phenomena, JAMSTEC conducted R&D on wide area observation technology such as ocean laser technology and acoustic tomography. Also, JAMSTEC has promoted R&D on technology utilizing wave power and joint R&D projects with municipalities in each region to contribute to appropriate management and development of coastal areas.

The Science and Technology Agency also promotes comprehensive joint research projects among related ministries, agencies and universities. These joint research projects include the Japan-China Joint Research Program on the Kuroshio to research the meandering flow of the Kuroshio and its large effect on weather and fishery around Japan and East Asia; by allocation of the Special Coordination Funds for Promoting Science and Technology, research concerning atmospheric-oceanic interaction in the tropical and equatorial areas and research on global ocean circulation and material flux.

Through the University of Tokyo Ocean Research Institute, the Ministry of Education has been conducting basic research related to GOOS, which aims to build a comprehensive observation system for explaining, predicting, and protecting shifts in the ocean environment; participating in the ODP, which excavates the ocean floor and helps to explain the movements and structures of the ocean floor plates, and joint surveys of the Pacific Ocean region; conducting ocean flux research and other academic research on the ocean which contributes to an understanding of the physical environment of the ocean.

The Ministry of Agriculture, forestry and Fisheries, through the Fisheries Agency, is conducting R&D on the following areas.

- Promotion of fish farming with the introduction of bio-technology
- Cultivation of marine resources
- Preservation of the fishing ground environment
- Proper evaluation of the functions marine products have which benefit human health and their effective usage

The Ministry of International Trade and Industry, through the Agency of Natural Resources and Energy and the Geological Survey of Japan, is developing ocean floor mineral resources and carrying out geological surveys on the seabed.

The Ministry of Transport is conducting the following activities.

- Oceanographic observations for hydrographic services through the Maritime Safety Agency
- Meteorological observations at sea for meteorological operations and investigations and research on weather analysis and prediction such as the El Nino phenomenon, etc.

The Ministry of Posts and Telecommunications is using its comprehensive communications research center to conduct high-resolution three-dimensional microwave radar research to confirm measuring and prediction technologies related to ocean oil pollution, ocean currents and waves and to conduct research and development on ocean satellite technology for space communication.

The Ministry of Construction is using its civil engineering research center to implement Study on Beach Stabilization and Sorting of Mixed Grain Size Sand as well as for Development of Coastal Environment Conservation Program in Tropical Zones. Its Geographical Survey Institute is conducting basic surveys of coastal sea areas, etc.

Table 3-4-6 summarizes the main R&D subjects undertaken by the various government ministries and agencies during FY1993.

3.4.1.1.8 Earth Science and Technology

Mankind has explored the earth for a great number of years and reached a stage in recent years where knowledge on the earth and global phenomena is rapidly accumulating and comprehension of the earth as a single system has become possible. In addition to using these results for predicting global phenomena and sustaining the development of mankind, there have also been an increasing quest for knowledge of the unknown. Shifts in the global environment stemming from the increase in human activities, however, has also created major problems in the world. As a result, there has been a strong shift toward science and technology that changes the attitude of the earth as a limitless resource and provides a balance between humans and the global environment.

Based on these conditions, in August 1990, Japan responded to the conclusions of the Council for Science and Technology through a decision by the Prime Minister to adopt the Basic Plan for Research and Development on Earth Science and Technology which looks 10 years into the future. This plan outlines the necessary role and measures to be taken by

Table 3-4-6 Major research subjects in marine science and technology (in FY 1993)

Ministry or agency	Research institute or program	Subject
Science and Technology Agency	Special Coordination Funds for Promoting Science and Technology	* Japanese ocean circulation experiment * International joint research concerning the elucidation of the substance circulation mechanism in the coastline sea * Japanese Pacific climate study (JPACS)
	Research and Development Bureau	* Kuroshio exploitation and utilization research
	Japan Marine Science and Technology Center	* R&D of a deep-sea research submersible * Research on marine observation and R&D of observation technology * Research and investigations into comprehensive observation of the North Pacific Ocean and Arctic sea areas
Environmental Agency	Research Funding to the National Research Institute engaged in Environmental Pollution Research	* Research concerning nitrogen cycle of deposits in inland bays
	Water Maintenance Bureau	* Research on red tide
	National Institute for Environmental Studies	* Research concerning the elucidation and maintenance of the ecosystem mechanism on the hydrosphere in a closed-type sea area
National Land Agency		* Surveys for the Promotion of the fisheries in the Amami Islands
Ministry of Education	National Universities and Other Research Institutions	* Ocean Drilling Program (ODP) * Cooperative study of the Western Pacific (WESTPAC) * International Cooperative Research Programme on Global Ocean Observing System (GOOS)
Ministry of Agriculture, Forestry and Fisheries	Fisheries Agency	* R&D of the fish breeding industry * R&D of new fisheries technologies * Comprehensive research on the ecological order of the agricultural, forestry and fisheries systems and their optimum control
	Japan Marine Fisheries Resource Research Center	* Research project on oceanic fisheries resources
Ministry of International Trade and Industry	Metal mining Agency of Japan	* Surveys for the development of deep-sea bottom mineral resources
	National Institute for Resource and Environment	* R&D into underwater manganese nodule mining systems
	Geological Survey of Japan	* Marine geological study of continental shelves in the eastern margin of the central Japan Sea
Ministry of Transport	Marine Technology Research Center	* Research concerning the development of next generational oceanic structures and evaluating their safety
	Ports and Harbor Technological Research Center	* Research on hydrophilic ports and harbors, and coastal structures
	Meteorological Research Institute	* Cooperative study of the Western Pacific (WESTPAC) * Study of ocean general circulation with advanced numerical model

(Table 3-4-6)

Ministry or agency	Research institute or program	Subject
Ministry of Posts and Telecommunications	Communications Research Laboratory	*Research of global environment monitoring technology using airborne high-resolution topographic and polarimetric imaging radar *R&D of ocean observing aircraft and satellite technology
Ministry of Construction	Public Works Research Institute	*Study on beach stabilization and sorting of mixed grain sized sand *Development of coastal environment conservation program in tropical zone
	Geographical Survey Institute	*Shema of coastal sea areas

the Government in deepening its understanding of the earth and using research results to promote the basic thinking for advancing research and development, important research and development issues, and the promotion of global science and technology that contribute to the prosperity of all mankind. In terms of conserving the global environment, every fiscal year beginning in FY1990, plans for the comprehensive promotion of research on global environmental conservation have been enacted at meetings of the Cabinet established within the Government for these purposes.

In terms of global environmental issues, at the United Nations Conference on Environment and Development held in Rio De Janeiro in June 1992, the Rio Declaration on Environment and Development, an outline of principles for guiding the actions of nations and individuals toward the 21st century, and Agenda 21, a plan for the implementation of these principles, were adopted and the Framework Convention on Climate Change was signed by numerous nations. Based on these results, it is necessary to actively address these types of issues in the future as well. It is important for Japan, with its advanced science and technology, to positively address the science and technology side of these issues and make contributions to the international community.

3.4.1.1.8.1 R&D and Related Measures for Understanding Global Phenomena

Global warming, ozone depletion, abnormal weather, earthquakes, volcanic eruptions and other global phenomena are closely linked to the social activities of human beings and pose the danger of exerting an enormous impact. For this reason, there is a strong need to understand these phenomena on a scientific level and make an appropriate response.

Since problems such as global warming and crustal movement are long term and are not confined to a country, it is of crucial importance to maintain a sense of global partnership and cooperation in R&D in earth science and technology. Accordingly, it is important that Japan play an active role in the World Climate Research Program (WCRP), the International Geosphere-Biosphere Program (IGBP) and other joint research programs and expand joint research projects with research institutions abroad. In consideration of Japan's geographical position in the Asia-Pacific region and its close economic relationship with the countries of the region, there is a need for it to promote research and development that gives priority to this region.

In addition to using their budgets to conduct research and development aimed at explaining global phenomena, the ministries and agencies of the Japanese Government make use of special coordination Funds for Promoting Science and Technology, Funds for the Promotion of Surveys and Research in Earth Science and Technologies and Ocean Development, Funds for the Overall Promotion of Environmental Research in order to link a broad range of research capacities, including those of national research institutes, universities and overseas research organizations, and positively conduct research and development on a comprehensive and international level that is aimed at assessing the influence exerted on the global environment by human activity.

Furthermore, in December 1992, the Asia-Pacific Global Shift Research Workshop was set up through the cooperation of related ministries and agencies. This workshop was the first time for a great number of scientists and policy makers from 15 countries in the Asia-Pacific region to meet together with the purpose of promoting cooperation between the countries of the region in the area of research on global changes. A meaningful exchange of opinions took place at this workshop, forming the basis for the promotion of future cooperation.

Table 3-4-7 summarizes the major research and development subjects in the area of earth science and technology that are currently promoted by related ministries and agencies.

3.4.1.1.8.2 R&D on Earth Observation Technology

R&D on earth observation technology is important to accumulate the information necessary to understand various global phenomena. For this purpose, in January 1993, Council for Aeronautics, Electronics and Other Advanced Technologies addressed Recommendation for Request No.17 on Promotion Policy for Comprehensive Research on Earth Observation for the Resolution of Global Environmental Problems. Japan's two major thrusts in this area are the R&D on earth observation technology, including the R&D on earth observation satellites, and the R&D on marine observation technology such as the development of deep-sea survey vessels.

(1) Earth Observation Satellites

Earth observation using satellites is extremely effective for continuous acquisition of various information covering areas and currently, Japan is promoting a comprehensive project, cooperating with related organizations domestically and abroad.

The National Space Development Agency of Japan (NASDA) is operating earth observation satellites including the Marine Observation Satellite-1or "Momo 1" (MOS-1), "Momo 2" (MOS-lb) and the Japanese Earth Resources Satellite-1 or "Fuyo 1" (JERS-1), and is developing the Advanced Earth Observing Satellite(ADEOS) and the Tropical Rainfall Measuring Mission (TRMM), in cooperation with related organizations.

The Ministry of International Trade and Industry is promoting the development of the Advanced Spaceborne Thermal Emission and Reflection radiometer (ASTER) which is to be loaded on the first Polar Orbit Platform (EOS-AM1) of the United States National Aeronautics and Space Administration (NASA).

For establishing observation and data processing techniques of the global environment by using satellites, the Science and Technology Agency, in cooperation with related organizations, is encouraging Research on Earth Environment Remote-Sensing Technology.

The Science and Technology Agency is consolidating databases in preparation for the international networking of information that will allow the effective use of the above mentioned data obtained from earth observation satellites.

International cooperation is important for performing observation using these earth observation satellites. Therefore, in 1993 Japan played a pivotal role in vigorously participating in and contributing to various venues of international coordination, including the Committee on Earth Observation Satellites (CEOS) and the Polar Orbit Platform Coordination Working Group (EO-ICWG).

(2) Marine Observation Technology

Elucidation of the relationships between the oceans and the occurrence of natural phenomena is an important issue in our understanding of global

Table 3-4-7 Major research subjects in earth science and technology (in FY 1993)

Ministry or agency	Research institute or program	Subject
Science and Technology Agency	Special Coordination Funds for Promoting Science and Technology	* Japan-China joint study on desertification * Japanese experimental study in the Arctic Area
	Funds for the Promotion of Surveys and Research in Earth Science and Technologies and Ocean Development	* An observational study of cloud effects for global warming * Japanese study on the behavior of greenhouse gases and aerosols * Research on the Asian monsoon mechanism
	National Research Institute for Earth Science and Disaster Prevention	* Studies on mechanisms and impacts of climate change cansed global warming
Environment Agency	Global Environment Research Program Fund	* Comprehensive observation and analysis of variability of the ozone layer * Study on the carbon cycle in oceanic and terrestrial ecosystems * Studies to clarify the behavlor of acidic and oxidative component of the atomosphere in East Asia * Evaluation of material circulation and the biological uptake and accumulation of pollutants in marine ecosystems * Anaysis of the environment and structure of tropical forest ecosystem * Evaluation of interaction between desertification and human activities * Establishing an environmental accounting system (Green GNP)
Ministry of Education	National Research Institute for Polar Regions, Universities, etc.	* Academic research into earthquake and volcanic eruption prediction systems * Research on global environmental change with emphasis on the Asia and the Pacific region * Arctic environment cooperative research project * Solar terrestrial energy programme * International geosphere-biosphere programme * Japan antarctic research * A sientific approach toward globalism human society in harmony with the earth: man-earth system
Ministry of Agriculture, Forestry and Fisheries	National Institute of Agro-Environmental Sciences	* Managing the agro-, forest-,marine-ecosystems to control global change
Ministry of International Trade and Industry	Geological Survey of Japan	* Geological, geochemical and geophysical research of active volcanoes * Marine geological research concerning sea areas surrounding the continental shelf in the eastern edge of the central Japan Sea and other subjects
	Global Environment Industrial Technology Development	* Research on technological development related to the fixing and effective use of carbon dioxide

(Table 3-4-7)

Ministry or agency	Research institute or program	Subject
Ministry of Transport	Hydrographic Department, Marine Safety Agency	* General ocean surveys of sea areas under agency supervision, oceanographic surveys using earth observation satellites, surveys of ocean floor contours and subterranean structures for volcanic eruption prediction, survey of water temperature, currents and waves in the Western Pacific Ocean as part of the agency's sea lane supervisory activities * Collection, supervision and supply of information on water temperature and the role of currents in ocean water circulation, and materials involved in ocean floor contours, geology and earth-related physics
	Meteorological Research Institute, Meteorological Agency	* Research concerning of global warming prediction technology * Analytical research on small-scale meteorological phenomena
Ministry of Posts and Telecommunications	Communications Research Laboratory	* International joint research on advanced electromagnetic technology for the global environment * Research concerning binary frequency Doppler radar for observation of rainfall from space * Research concerning measurement technology of the global environment by means of short-wave length electro-magnetic waves in mill-wave bandwidths * R&D concerning measurement technology of the global environment with optical sphere active sensors * R&D concerning measurement and information networks of the global environment
Ministry of Construction	Geographical Survey Institute	* Research on building a large-scale GPS land survey network
	Public Works Research Institute	* Research on methods for grasping water circulation by remote sensing

change.

To further knowledge in this area, the Japan Marine Science and Technology Center is promoting several areas of R&D, including the construction of a 10,000 meter-class remotely operated vehicle and R&D on ocean acoustic tomography.

3.4.1.1.8.3 Science and Technology on Disaster Prevention such as Earthquake Prediction

Japan is located at the boundary where the Asian continent meets the Pacific Ocean. The nation comprises an arc-shaped archipelago lying within a zone of mountain ranges that circle the Pacific. The country's land mass is continuously subjected to crustal movements. The country's islands have mountainous topography with many steep slopes, cascading rivers, and few plains. The climate ranges from subtropical to subarctic. Offshore there are both hot and cold ocean currents, such as the Japan or Black Current and the Kuril Current. The changes in seasons are dramatic due to the influence of the Ogasawara air mass in summer, the Siberian air mass in winter, and the Okhotsk air mass during the rainy season. Typhoons spawned in the Western Pacific frequently pass nearby or cross over the islands.

As a result of this geography, the country has experienced almost every possible form of natural disaster caused by air, earth and water–earthquakes, volcanic eruptions, gale force winds, heavy localized rainfall, heavy snowfall, landslides, earthfalls, floods, high tides and tidal waves.

Table 3-4-8 Major research subjects in disaster prevention science and technology (in FY 1993)

Ministry or agency	Research institutes, etc.	Subject
Hokkaido Development Agency	Civil Engineering Research Institute	* Study of a road traffic information system for safety and amenity of winter traffic
Science and Technology Agency	Special Coordination Funds for Promoting Science and Technology National Research Institute for Earth Science and Disaster Prevention	* Research on the sophistication of technologies for the prediction of earthquakes beneath the metropolitan area * Research on crustal activities in the Kanto-Tokai area * Study on prediction techniques for earthquake disasters * Research on natural science and technology of snow disaster prevention in inhabited areas * Research on prediction of volcanic eruption * Research on mechanisms and damage assessment of meteorological disasters * Study on the development of regional prediction method and utilization of regional warning systems of snowstorm * A study of disaster predictions in global hydrological processes and other projects
Ministry of Education	Universities, etc.	* Basic research on natural disasters * Basic research for earthquake prediction * Basic research on other disasters (e.g. volcanic eruption prediction research)
Ministry of Agriculture, Forestry and Fisheries	National Research Institute of Agricultural Engineering Forestry and Forest Products Research Institute National Research Institute of Fisheries and Engineering	* Development of soil engineering and engineering geology for land improvement structure * Elucidation of forest disaster prevention function and improvement of forest disaster prevention technology * Study on development and improvement of technology for construction of fishing port
Ministry of International Trade and Industry	Geological Survey of Japan	* Research into the mechanisms and locations of earthquake occurrences * Geological, geochemical and geophysical research on active volcanoes, etc.
Ministry of Transport	Railway Technical Research Institute	* Technical development of synthetic disaster prevention systems
	Hydro-graphic Department, Maritime Safety Agency	* Surveys of submarine topography and geological structures
	Meteorological Research Institute, Meteorological Agency	* Submarine topographic and geological survey * Synthetic studies on practical prediction technique for earthquake under urban areas * Studies on meteorological and hydrological phenomena including typhoons and local severe rain * Study on highly rational seismic design method of water front facilities against big earthquakes near great cities

(Table 3-4-8)

Ministry or agency	Research institutes, etc.	Subject
Ministry of Posts and Telecommunications	Communications Research Laboratory	* R&D of high precision technology measuring time and space with cosmic radio waves
Ministry of Construction	Comprehensive research and development	* Development of earthquake prevention technology in large urban areas * Development of disaster prevention systems on sediment disaster and river disasters, etc., and other projects
	Public Works Research Institute	* Study on active control system for wind resistant design
	Building Research Institute	* The U.S.-Japan joint seismic research program utilizing large-scale testing facilities
Ministry of Home Affairs	Fire Defense Agency	* Study on regionality of long-period ground motion

With this historical background, it is important to gather and fully utilize scientific knowledge on disaster-causing natural phenomena over the entire disaster cycle, from the initial prediction and forecast, through the prediction of an imminent disaster, to its prevention or minimization.

These considerations led the Prime Minister to approve *The Basic Plan for R&D on Disaster Prevention* in July 1981. The Basic Plan outlines the following four areas for priority disaster-prevention research and the development and implementation of countermeasures.

- Establishment of an adequate foundation for basic disaster-prevention science and technology, including elucidation of the disaster cycle, observation and research for the mechanism of natural phenomena which cause disasters, and measures to prevent or minimize their effects.
- Promotion of R&D projects for disaster prevention taking account of area-dependency of disasters such as heavy snowfall and volcanic eruptions.
- R&D to expand the capabilities of existing technologies applied in earthquake, fire and flood protection and to provide comprehensive and effective disaster-prevention measures for urban areas from a people-centered standpoint by considering cities as a single system.
- General promotion of research for disaster prevention with a wide range of disciplines, including interdisciplinary research, making use of the knowledge of social and behavioral sciences.

Over 10 years have passed since the current Basic Plan was formulated. During this period, R&D related to disaster prevention has been proceeding based on the current Basic Plan. At the same time, great changes have been taking place in the circumstances surrounding the R&D activities related to disaster prevention in Japan, including changes in Japan's social structure and an increasing number of requests for international contributions from Japan. As a result, currently the Panel on Science and Technology for Disaster Prevention of the Council for Science and Technology is studying the formulation of a new Basic Plan.

Table 3-4-8 summarizes the R&D subjects in science and technology for disaster prevention by ministries and agencies. Research classifications include earthquake prediction, countermeasures for earthquakes, volcanic eruption prediction, snow- and ice-related disaster countermeasures, wind and water disaster countermeasures and earth science and technology. The research makes use of knowledge from all fields in earth science and technology, space science and technology, ocean, science and technology and others.

In addition, an emergency research project entitled "Research on the Earthquake Swarm around Iriomote Island" was carried out using the FY1992 Special Coordination Funds for Promoting Science and Technology in order to investigate the earthquake the Iriomote Island region which had occurred in January 1991, and then, after a temporary lull, again in August 1992. Another emergency research project, "Research on the 1993 Hokkaido-Nansei-Oki Earthquake", was performed using the FY1993 Special Coordination Funds for Promoting Science and Technology in order to study the Hokkaido-Nansei-Oki Earthquake which occurred on July 12, 1993 and caused great damage. Other emergency research projects performed with Grant-in-Aid for Scientific Research included the "Investigation of Successive Occurrence of Earthquake Swarm in Iriomote Island" in FY1992, the "Study on the Damage Investigation of the 1993 Hokkaido-Nansei-Oki Earthquake " in FY1993 and the "Studies on the Heavy Disasters in Kagoshima related to the Intense Rainstorms of August 1993".

The Headquarters for Earthquake Prediction, headed by the Minister of State for Technology conduct seismic studies for use in predicting earthquakes and implement comprehensive, planned measures in response to impending quakes. The Council for Measurements and Earth Science proposed the "Seventh Earthquake Prediction Plan of Japan" and the "Fifth Volcanic Eruption Prediction Plan of Japan" in July 1993, designed to predict earthquakes and volcanic eruptions.

Furthermore, the Science and Technology Agency is preparing wide-area depth observation facilities, such as the 3,000m level earthquake observation system, at the National Research Institute for Earth Science and Disaster Prevention to strengthen the observation system in metropolitan areas.

At the worldwide level, the Japan International Cooperation Association (JICA) furthers international cooperation by bringing researchers from developing countries to study or train at Japanese research organizations. In FY1991, JICA conducted seminars on disaster-prevention technology applicable to flood and erosion control engineering, and earthquake countermeasures. Training programs were held in earthquake engineering, volcanology, volcanic sabo engineering, geodesy training and meteorology.

Other international cooperation includes bilateral programs and The U.S.-Japan Committee on the Use of Natural Resources (UJNR), the United Nations Economic and Social Committee for the Asia-Pacific Region (ESCAP) and the World Meteorological Organization (WMO) Typhoon Committee. In addition, the 1990s have been declared as the International Decade for Natural Disaster Reduction (IDNDR) to encourage international cooperation in reducing human and monetary losses caused by natural disasters. In May 1989, The IDNDR Promotion Headquarters was established under the directorship of the Prime Minister, and the basic guidelines for its operation were formulated in November of the same year. In addition, a workshop on snow-and-ice-related disaster mitigation technology was held in line with this goal in March, 1993.

3.4.1.2 Promotion of Science and Technology for the Coexistence of Human Beings

With the expansion of human activities, issues caused by the finite of the earth such as global environmental issues are revealed. In order to solve these issues and provide new means which allow human beings to coexist in harmony with the earth, the *General Guideline for Science and Technology* established at the Cabinet meeting in April 1992 positioned the following fields as science and technology for the coexistence of human beings.

- Preservation of the earth and natural environment
- Development and utilization of energies
- Development and recycling of resources
- Continuous production of foods

3.4.1.2.1 Preservation of the Earth and Natural Environment

In recent years, environmental issues on a global scale such as global warming are revealed, and it is urgent that these issues be solved through international cooperation. It is also important to prevent regional pollution and preserve the natural environment in order to improve a comfortable living environment. Therefore, it is necessary to promote R&D to respond to environmental issues on a global scale, prevent pollution, and preserve the natural environment.

In this field, the following were established and given priority in promoting R&D.

- *Comprehensive Plan to Promote Research and Investigations concerning the Preservation of the Global Environment in FY1993* (related Cabinet meetings on the preservation of the global environment, June 1993)
- *Basic Plan for R&D on Earth Science and Technology in step with the 17th recommendation of the CST* (decided by the Prime Minister in August 1990)
- *Prioritization and General Promotion of Research on Pollution Prevention, etc.* (annually by the Environmental Agency)

The Science and Technology Agency, Environmental Agency, Ministry of Education,

Ministry of Agriculture, Forestry and Fisheries, Ministry of International Trade and Industry, Ministry of Transport, Ministry of Posts and Telecommunications and Ministry of Construction, etc. are promoting R&D to comprehend changes in the global environment, evaluate the effects, and develop countermeasure technology and to prevent environmental pollution.

3.4.1.2.2 Development and Utilization of Energy

Overall R&D promotion in energy-related fields requires careful prioritization, planning and implementation because of the broad range of scientific disciplines involved and the substantial, long-term monetary and personnel investments required. For these reasons, the government has assumed the responsibility to coordinate R&D in energy-related fields.

In August 1978, *The Basic Plan for R&D on Energy* was established. Since then, the plan has been steadily promoted. In June 1991, by taking into consideration the changes in conditions of energy in recent years including global environmental problems, the CST presented *The Recommendation Concerning the Basic Plan for R&D on Energy* to the Prime Minister, requesting a substantial revision of the current basic plan. Based on this opinion, the government set down the new Basic Plan for R&D on Energy in July 1991.

3.4.1.2.2.1 Development and Utilization of Nuclear Energy

Nuclear energy facilities are capable of providing a steady supply of low-cost electricity without discharging harmful gases, such as carbon dioxide or nitrogen oxides, into the atmosphere. For this reason, the government is committed to promoting on-going R&D to strengthen the nation's energy infrastructure by making nuclear energy a primary source of supply.

In June 1987, the Long-term Program for Development and Utilization of Nuclear Energy was formulated by the Atomic Energy Commission. This currently guides the overall planning and promotion of nuclear energy in Japan.

Currently, the Atomic Energy Commission is proceeding with the work of revising the present Long-Term Program on the basis of such factors as the steady expansion of the development and utilization of atomic energy within Japan and the changes taking place in the international society.

(1) Measures for Assuring Nuclear Safety and Nuclear Non-proliferation

In Japan, from the beginning, the development and commercialization of nuclear energy have been conducted with priority to safety and the containment of radioactive materials.

To assure nuclear safety, stringent regulation is conducted by the government that is not observed in other industrial areas. The regulation includes the environmental radiation monitoring, emergency measures for accidents, etc.

To ensure even higher safety standards, the Nuclear Safety Commission establishes Annual Nuclear Safety Research Program and evaluates the results of researches to promote safety research comprehensively and systematically.

In accordance with the Annual Nuclear Safety Research Plans (three annual safety research plans dealing with nuclear energy facilities, environmental radioactivity, and high-level radioactive wastes established in 1990, and the annual safety research plan for low-level radioactive wastes established in 1989), the following nuclear safety research activities are being promoted.

The Japan Atomic Energy Research Institute (JAERI) is the principal body conducting research on safety in light water reactor facilities. Of particular interest are possible reactivity accidents and loss of coolant accidents (LOCA).

The Power Reactor and Nuclear Fuel Development Corporation (PNC) and JAERI are responsible for research in all areas of safety for advanced thermal reactors and fast breeder reactors, as well as for nuclear fuel facilities and radioactive treatment and disposal repositories.

The national research institutes are researching the safety of transportation of radioactive materials and seismic safety of nuclear facilities.

Both JAERI and PNC conduct research on methods for probabilistic assessment of safety and reliability of nuclear facilities.

The National Institute of Radiological Sciences (NIRS) and other organizations are conducting research on effects of low dose-rate radiation on people, evaluation of effects through internal radiation by taking into account the peculiarity of the exposure type, and the behavior of radioactive substances in the environment.

In accordance with the Atomic Energy Basic Law, Japan has been ensuring that the research, development and utilization of nuclear energy is only used for peaceful purposes, and has been implementing the safeguards of the International Atomic Energy Agency (IAEA) regarding all nuclear materials both inside and outside Japan after concluding the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) and the Bilateral Agreements for Cooperation Concerning Peaceful Uses of Nuclear Energy concluded with the United States and other countries. R&D for safeguards technology is being conducted in order to implement these treaties and agreements more effectively. Furthermore, recognizing that international consensus that prevention of unlawful transfers of nuclear materials and sabotage against nuclear energy facilities is important in order to keep nuclear non-proliferation, Japan has joined the Convention on the Physical Protection of Nuclear Material, has established related internal laws and regulations and conducts research and investigations concerning physical protection of nuclear materials.

(2) Current State of Nuclear Power Generation

As of September 1993, there were 45 commercial nuclear power plants in operation, with a total output capacity of 37.196 gigawatts. In FY1992, an estimated 28.3% of the nation's electrical power was supplied by these facilities.

Most nuclear power in Japan is currently generated using light water reactors. Here, the government, electric utility companies and manufacturers of atomic power generation equipment, etc. have cooperated to develop technology that enhances the level of reactor reliability, minimizes downtime and reduces employee exposure to radiation. But the current level of light-water reactor safety not being overrelied, the technology should be advanced with the aim of improving the economies, reliability and safety.

(3) Establishment of a Nuclear Fuel Cycle

In order to promote nuclear power generation continuously and smoothly, establishment of a nuclear fuel cycle aiming at stable fuel supplies and optimal utilization of uranium resources is an important policy issue.

PNC is actively promoting R&D of gas centrifuge uranium enrichment technology which can be used to provide a stable supply of enriched uranium for the nation's power reactors. A commercial uranium enrichment plant at Rokkasho-mura in Aomori Prefecture, started partial operation in March 1992 on the basis of PNC's research results. R&D also has been conducted on new technologies including laser isotope separation that make uranium enrichment more economical.

It is the government's policy to reprocess spent fuel in order to allow for the optimal utilization of uranium resources.

PNC's Tokai Reprocessing Plant reprocesses spent fuel from the nation's power reactors. As of the end of March 1993, the plant had reprocessed approximately 680 tons of spent fuel. Plans are underway for a commercial reprocessing plant at Rokkasho-mura with an annual reprocessing capacity of approximately 800 tons.

PNC also is conducting R&D on the reprocessing of spent fuel from fast breeder reactors.

(4) Promotion of the nuclear energy back end policy

Taking measures to treat and dispose of radioactive waste appropriately is a very important issue on the nuclear fuel cycle.

As for low-level radioactive wastes, measures are taken to reduce their generation, and the generated wastes are submitted to proper volume reduction and solidification treatment.

The plan to bury low-level radioactive solid wastes at shallow depths is underway in Rokkasho-mura and laying of wastes was launched in December 1992.

High-level radioactive waste generated from the reprocessing plant is vitrified into a stable form, followed by storage for 30 to 50 years for cooling, after which it will be disposed of underground in a geological formation deeper than several hundred meters. The construction of a temporary storage facility for vitrified waste is being planned at Rokkasho-mura in Aomori Prefecture. The project was approved by the Prime Minister in April 1992. In addition, the Steering Committee on High-Level-Radioactive-Waste Project (SHP) was established in May 1993 to prepare and promote the disposal of high-level radioactive waste materials. In addition, R&D is being promoted on geological disposal by the PNC. As a part of these activities and to consolidate geological disposal technology, PNC also is planning to set up the Storage Engineering Center as an integrated research center for storing high-level radioactive waste and other materials.

Separation of nuclides contained in high-level radioactive waste so that useful nuclides can be utilized, and conversion of long-lived nuclides into short-lived, or non-radioactive nuclides are important research themes. R&D activities are carried out with the cooperation of the JAERI, PNC and other concerned organizations.

Since FY1981, the Japan Atomic Energy Research Institute has been tackling R&D on technological developments related to measures to abolish nuclear reactors from nuclear power facilities modeled on the Japan Power Demonstration Reactor (JPDR). They have been implementing the dismantlement field test of the JPDR since FY1986, and started to dismantle the radiation screen in FY1990. In addition, the Nuclear Power Engineering Corporation (NUPEC) has been proceeding with a verification test for reactor abolishment technology since FY1981.

(5) Advanced Reactors and Plutonium Utilization

One of Japan's nuclear energy goals is to establish a system for utilizing plutonium recovered by reprocessing spent fuel in order to stabilize the nation's energy supply and to optimize utilization of uranium resources. Fast-breeder reactors will be the principal reactors for the use of plutonium in future.

For some time, plutonium extracted by reprocessing will be mainly used in light-water reactors and in advanced thermal reactors in order to establish a broad technological base for the use of recovered plutonium. Plans for small-scale testing of mixed uranium and plutonium oxide fuel (MOX) in light-water reactors are underway. This will be followed by the use of MOX fuel in one PWR unit and one BWR unit of 800,000 kw class or above in the mid 1990s, whereby the MOX fuel will be loaded into 1/4 of the reactor core. The scale of this operation will be gradually and systematically expanded to four units with a 1 million kw class light-water reactor at the end of the 1990s, in which the MOX fuel will be loaded into 1/3 of the reactor, and to about twelve units after the year 2000.

PNC has developed the technology for the advanced thermal reactor and the prototype reactor, FUGEN, is now operated well. As for the demonstration reactor, construction plan is proceeding on the initiative of private firms.

PNC also has carried out extensive development work for the fast breeder reactor. The experimental reactor, JOYO, also is now operated well by PNC.

With respect to the prototype reactor MONJU which is under construction by PNC (based on the results of JOYO), installation of machines and equipment was completed in April 1991 and comprehensive function tests were started in May 1991, and were completed in December 1992. Continuous performance tests are being carried out. The R & D plan for the demonstration reactor has carried out under initiative taken by the utilities. This plan is proceeding, setting the target date for the start of construction at the 2nd half of the1990s.

The plutonium being used in the nation's fast-breeder reactors and in other R&D programs is provided by reprocessing of nuclear fuel used at Japanese power plants. As regards the method of transportation to return the plutonium which has been recovered by reprocessing done in France and the United Kingdom, the first transportation by sea based on the Japan-United States Nuclear Power Cooperation Agreement (revised in 1988) was carried out by the PNC, and completed in January 1993.

The formulation of subsequent plans are being examined, based on the experience gained by this transportation and the supply and demand situation for plutonium in Japan.

(6) Promotion of Advanced Projects

Fusion energy has the potential of ensuring a virtually inexhaustible supply of energy for future generations and is expected to become a reality. In Japan, R&D on nuclear fusion is being carried out systematically and comprehensively based on the basic program determined by the Atomic Energy Commission (AEC). In June 1992, the AEC adopted "The Third Phase Basic Program of Fusion Research and Development", and currently, The Japan Atomic Energy Research Institute (JAERI), the National Institute for Fusion Science (NIFS) of the Ministry of Education, universities and other national research institutes are executing the fusion R&D based on this program.

With regard to the state of progress of R&D on nuclear fusion, since July 1991, JAERI has been performing experiments to develop a higher plasma performance with the Break-even Plasma Test Device (JT-60) using heavy water. The results broke the existing world record for fusion results (results of core ion temperature, core plasma density and confinement time) which exhibit the overall performance of plasma. As for the International Thermonuclear Experimental Reactor (ITER) project, jointly undertaken by Japan, the United States, the European Community and the Russian Federation, the four parties concluded an agreement for the ITER Engineering Design Activities in July 1992 on the basis of the results of the Conceptual Design Activities, and engineering design activities have started. The world's largest Large Helical Device (LHD) with a superconductive coil is now under construction at the NIFS in order to investigate the confinement physics of the helical-type steady-state operation and high-temperature plasma.

As regards the utilization of radiation, the Atomic Energy Commission/Advisory Committee on Utilization of Radiation issued the paper "Developments of Radiation Utilization" in June 1993, which formulated their policies on the promotion and diffusion of the advanced R&D using accelerators.

Radiation has come to be used in a wide range of fields, beginning with the basic sciences and extending into medicine, agriculture and industry. In medical sciences, research is being conducted on the uses of fast neutrons, protons or heavy ion beams to treat malignant tumors, while diagnostic technology employing X-ray computer tomography and X-/ y-ray radiotherapy for malignant tumors already is widely utilized. In particular, the National Institute of Radiological Sciences (NIRS) is using fast neutron and proton beams, and also heavy ion beams for the remarkable treatment of cancer cells. The Institute currently is building a heavy-ion medical accelerator to demonstrate the clinical potential of radiation for cancer treatment. Research in this area is also under way at some universities. Researchers at Tsukuba University's Proton Medical Research Center, for example, are carrying out studies on the diagnosis and treatment of cancer using proton beams.

In agriculture, forestry and fisheries, radiation is being used for plant breeding, sterilization of vermin, and food irradiation, etc.

In industry, radiation is being used for non-destructive testing, for quality improvement of polymers, etc.

Since FY1987, JAERI has been constructing an

Ion Irradiation Research Facility. Its completion is scheduled for 1993, although it began partial operation in FY1991.

JAERI and the Institute of Physical and Chemical Research (RIKEN) have been constructing since FY1989 a next-generation synchrotron radiation facility (SPring-8) at the Harima Science Garden City in Hyogo Prefecture. Its completion is scheduled for FY1998. The National Laboratory for High-Energy Pyisics of the Ministry of Education also has been conducting high-intensity synchrotron radiation research using the "TRISTAN" injection-accumulation ring.

A promising field for R&D in high-temperature engineering is the generation of energy using high-temperature gas reactors. Advances in this field hold the promise of opening up many possible alternative sources of energy. JAERI is now constructing a high-temperature engineering test reactor (HTTR) with the goal of establishing high-temperature gas reactor technology and pioneering basic research into high-temperature phenomena.

JAERI is leading R&D on the Mutsu nuclear-powered ship which in February 1991, began a year-long series of test voyages to obtain knowledge concerning the effects of vibration, pitching and rolling, and variation in load on the nuclear reactor in an oceanic environment, and all experiments were finished successfully in February 1992. During this period, there were four journeys offshore of the Hawaiian Islands to the east, the Fiji Islands to the south and the Kamchatka Peninsula to the south, to obtain worthwhile data, on normal sea areas, high temperature sea areas and violent sea areas. Currently, the Mutsu nuclear-powered ship is being relieved of its duty by the "removal and separation" method in which the nuclear reactor is removed and dismounted from the ship's hull together with the nuclear reactor chamber, and the spent fuel is being removed. In addition, making full use of the results obtained from the Mutsu, research on design evaluation is being conducted with the aim of improving the economies and reliability of future marine reactors.

In addition to the above programs, JAERI, the national universities and the national research institutes are furthering basic research in the following fields. In particular, the JAERI established the Advanced Science Research Center in April 1993 in order to further consolidate basic research activities.

- Nuclear and reactor physics
- The physiological effects of radiation
- Irradiation testing of fuel assemblies and materials

Also JAERI, PNC, RIKEN and the national research institutes are developing a number of underlying technologies in the following four areas.

- Materials technology for nuclear facilities
- Artificial intelligence technology for nuclear facilities
- Laser technology for the nuclear energy field
- Technology for assessment and reduction of radiation risk

In April 1993, the Specialist Working Group for Promoting Basic Technology of the Atomic Energy Commission published the paper, "The Development of Basic Research and Development of Underlying Technologies". This set out the three areas of technology: new advanced measuring and analysis technologies using radiation beams, computing science and technology for nuclear Energy, and technologies supporting people's intellectual activities in the nuclear power field. The paper also described the necessity for industry, universities and government agencies to vigorously promote these areas of technology.

(7) Contribution to the World Community

While developing nuclear energy, nations have become interdependent, making international cooperation an important factor in ensuring that R&D in this area are carried out as efficiently as possible.

Japan's efforts in nuclear energy R&D are both bilateral and multilateral. Bilateral activities include information sharing, exchanges of personnel and joint research projects. Multilateral activities are encouraged at national government levels through treaties and agreements and through support provided to international organizations. In April 1991, the Japan-Soviet Agreement for Cooperation concerning Peaceful Uses Nuclear Energy was concluded. Japan also is cooperating with developing countries through regional projects with neighboring Asian nations including the sponsorship of the International Conference for Nuclear Cooperation in Asia.

(8) Public Acceptance of Nuclear Energy

Public acceptance and cooperation are essential to the smooth development and utilization of nuclear energy. First of all, the government is taking all measures possible to ensure safety. It also disseminates information on nuclear energy through the mass media, encourages public relations at the grass roots level by sending instructors to study groups around the country, and conducts public relations through personal experience in which simple gauges are rented to actually measure the radiation around oneself.

3.4.1.2.2.2 R&D on Natural Energy

The practical use of solar energy, geothermal energy, ocean energy, wind energy, biomass energy and other natural energy alternatives faces a number of obstacles that are largely due to the characteristics of these resources. However, it is important to overcome the various problems that impede their development, since natural sources of energy are clean and, unlike fossil fuels, do not discharge carbon dioxide, the principle cause of global warming. Eventual widespread use of such energy can only have a positive effect on global environmental issues.

R&D on natural energy is being carried out at the Institute of Physical and Chemical Research, the Japan Marine Science and Technology Center, as well as through work on other related programs.

Solar energy can be utilized for hot water supply, heating, cooling, photovoltaic power generation and other needs. Technological development of solar water heater systems for residential use has been completed and the system is spreading among general households. R&D into technologies to promote the industrial use of solar energy are underway. The government also is encouraging R&D on photovoltaic power generation with the goal of substantially lowering the cost of solar batteries and their systems while improving their efficiency.

Geothermal energy resources are abundant and a Japanese-produced source of energy. In preparation for expanding the uses of geothermal energy, R&D is progressing on techniques for assessing deposits of geothermal resources, technology for exploration, drilling and extraction of geothermal resources, and technology for power generation systems using hot water.

Ocean energy can be used in different ways depending on conditions in each particular area. R&D are progressing in the application of efficient wave energy utilization systems, ocean thermal energy conversion systems and others. R&D is also being furthered on combined systems that would integrate these, technologies with power generation by breakwaters and the use of deep-sea water.

Wind-powered energy already has been introduced and widely used as a part of electric power supply sources in Europe and America. Japan is now promoting the R&D of medium and small-scale wind powered generation systems. Also, R&D of large-scale wind powered generation systems are progressing toward the goal of expanding use of wind energy.

The development of biomass and biological energy technology including photosynthesis is faced with many obstacles, including the low energy output density of the energy sources, and difficulties in transport and storage. However, these energy resources would not only be renewable, but would have little or no negative impact on the environment. Research is progressing into the evaluation, introduction and influence of the new technology for producing methanol-driven automobiles.

3.4.1.2.2.3 R&D on Fossil Energy

Oil is Japan's principle source of energy and the government is encouraging R&D of technologies for oil development to offset the effect of deteriorating conditions in the petroleum industry, such as the diminishing capacities of new oil fields. In addition, R&D is being conducted concerning identification of deposit conditions and effective utilization of petroleum in the neighborhood of Japan.

Coal, as well as nuclear energy, is used as an alternative to oil and the government is encouraging R&D on new technologies. For example, R&D in such fields as coal liquefaction technology and coal hydro-gassification technology are being encouraged as a part of the Sunshine Project.

Since natural gas also ais being used as an alternative to oil, and especially is a clean source of energy that has minimal negative effect on the environment, the government encourages R&D on this resource.

3.4.1.2.2.4 R&D for More Efficient Use of Energy

From the viewpoint of securing stable supply of energy, coping with global environmental issues, and the effective use of limited energy resources, it has become essential to bolster R&D for more efficient usage of energy at each stage from its supply to end use and promote R&D for the optimum usage of energy for society as a whole.

The Government is actively promoting R&D on a network system using a wide range of energy sources (Eco Energy City: the New Sunshine Project), the conversion and efficient use of energy, and national construction techniques for saving resources and energy.

Moreover, the New Sunshine Project is bolstering R&D on high thermal efficiency ceramic gas turbines that can be used in cogeneration systems, and R&D into fuel cell technology for clean and highly efficient power generation, superconducting materials and technology for superconducting power generation systems, technology for decentralized battery power storage, and technology for an international clean energy system using hydrogen.

In addition, progress is being made in developing the practical applications of technology for rationalizing energy uses.

3.4.1.2.3 Development and Recycling of Resources

For R&D on the development and management of natural resources, R&D for a manganese nodule mining system designed to mine the manganese nodules found at the bottom of deep seas which contain important metals such as nickel, copper, cobalt and manganese is being promoted through MITI's Industrial Science and Technology Frontier Program. The Ministry of Agriculture, Forestry and Fisheries is promoting the development of next-generation agricultural systems maintaining harmony with the ecosystem, and the development of recycling techniques for wood waste materials, based on their policy of encouraging the high-level recirculation of materials. The Ministry of Construction is developing construction technology R&D, such as suppressing the occurrence of by-products during construction as well as reproducibility techniques.

3.4.1.2.4 Continuous Production of Foods

The following are some of the R&D activities which are important to contribute to the continuous production of foods: the development of the technology for plant breeding and animal rearing and their propagation, improvement of the productivity and development of the facilities of farming and forestry lands, improvement of the management technology for cultivation, plant breeding and animal rearing, rationalization of the storage and distribution systems, the collection and preservation of gene resources, and the development of uses for unused or under-used resources. Other work being promoted includes research to develop new agricultural, forestry and fishery techniques through the clarification and control of biological information by the Ministry of Agriculture, Forestries and Fisheries; research to elucidate and ecological order in the agricultural, forestry and fishery systems and develop optimal controls; and R&D into MITI's technology using the tropical life form functions and the Ministry of Agriculture, Forestry and Fisheries' Gene Bank Project.

3.4.1.3 Encouraging Science and Technology for Enriching Life and Society

Japanese society is maturing and the proportion of old people in the population increases and The Japanese are increasingly seeking mental or psychological fulfillment by leading comfortable, relaxed lifestyles. In this context, it is even more important than ever to maintain and improve health, secure safety and improve life environment and the socioeconomic foundation. With this understanding, the 18th Recommendation of the CST (submitted in January 1992) indicates the importance of encouraging science and technology for the enrichment of individual life and society, and the Japanese government established the *"Basic Policy for Science and Technology"* at the cabinet meeting in April 1992 in response to this recommendation. The related ministries and agencies are encouraging R&D to maintain and improve the health, improve the life environment, the socioeconomic foundation and perfect disaster prevention and safety measures.

3.4.1.3.1 Maintaining and Improving the Mental and Physical Health of the People

Maintaining and improving the mental and physical health of the people is the cornerstone to enabling everyone to live comfortable and prosperous lives.

For this purpose, it is important to encourage R&D on various technologies to maintain and improve physical and mental health on a dally basis, and R&D on technologies to prevent the generation of and for processing various materials harmful to human body, techniques for decreasing their influences on human body. It is also necessary to advance and integrate medical technologies by developing diagnosis and treatment methods and the medicines for diseases to be perfectly cured, and for diseases taken up as social issues. In this case, it is important to take into account the discussion concerning the dignity of men and bioethics from many aspects.

A number of government organizations have formulated policies and published recommendations that have established government priorities for R&D in health-related areas. Some of the key documents which have been drawn up include the following.

- *Opinions on Basic Guidelines for Promoting Neurological Science and Technology*, submitted in August 1987 by the CST
- *Opinions on Basic Guidelines for Promoting Immunological Science and Technology*, submitted in August 1987 by the CST
- *Guidelines for General Anti-AIDS Policies*, submitted in February 1987 by the Cabinet Council for AIDS-Counter Measures
- *Opinions on Basic Guidelines for Promoting Cancer Research*, submitted in July 1983 by the CST
- *Ten-year General Anti-cancer Strategy*, submitted in June 1983 by the Cabinet Council for Cancer-Counter Measures
- *Promotion of Basic Scientific Research for Formulating Drugs* (recommendation submitted in October 1990 by the National Scientific Research Institute)

The Science and Technology Agency, the Ministry of Health and Welfare, the Ministry of Education and the Ministry of International Trade and Industry are undertaking R&D programs in the following areas.

- Studies on disabilities
- Development of Techniques for the Evaluation and Application of Functions of Agricultural, Forest, and Fishery Products that Contribute to Health
- Technology for the diagnosis and treatment of cancer, AIDS, diseases of the circulatory system and current incurable diseases
- Development of medical treatment systems
- Formulation of original and revolutionary drugs
- Development of diagnostic and therapeutic equipment and artificial organs
- R&D into the elucidation of the causes of food allergies, and into their prevention and treatment

3.4.1.3.2 Improvement of the Life Environment

Dealing with issues such as improving the quality of life, the proportional increase of old people in population structure and making adjustments to the decline in the birthrate, are primarily the responsibilities of the local community, the family and the individual. Therefore, it is important to promote R&D on the life technologies of food, clothing, housing, etc., and the technologies to give a mental satisfaction and to support the formation of communities in order to create an affluent life environment which allows men to exhibit their characteristics and a cultural life. It is also important to encourage R&D on welfare technologies to delicately meet diverse needs so that the old, the handicapped can live without feeling largely inconvenience and actively participate in social activities.

The CST has addressed these issues and set out R&D priorities in *Opinions on Basic Guidelines for Promoting Science and Technology Appropriate to Long-lived Populations,* submitted to the Prime Minister in May 1986. Based on this, the government is encouraging R&D in areas related to lifestyle improvement, support for various cultural activities, the fostering of safe, livable communities and adjustment to a prolonged demographic shift toward an aging population.

In this regard, the Science and Technology Agency, the Ministry of Health and Welfare, the Ministry of International Trade and Industry, the Ministry of Transport and the Ministry of Labor are encouraging R&D in the following areas.

- Development of technology applied to measuring the human senses
- Research into establishing comprehensive safety measures to cope with the changes in the traffic environment
- Comprehensive research into the sciences of long life
- R&D into the technology for developing the medical welfare equipment designed especially for the needs of the elderly
- R&D into expanding the work available for the elderly and into equipment for ensuring their safety
- R&D into the construction and effective utilization of lifestyle information systems for the health preservation and medical treatment required by an aging society

3.4.1.3.3 Improvement of Socioeconomic Foundation

The improvement of a social and economic foundation is being sought domestically and abroad as society as a whole advances and becomes complicated through progressive urbanization and the development of traffic, transport and telecommunication systems. Therefore, it is important to encourage the following.

- Technologies for comprehensive utilization of national land
- Technologies for civil engineering and construction of public facilities
- R&D concerning traffic and transportation
- Technologies aimed at the establishment of an advanced information communication system
- Technologies for the construction of a data base
- R&D of waste treatment technologies

Furthermore, with attention to the decrease of load on the environment, it is also important to promote R&D on the technologies concerning production activities to respond to the diversification of consumer demands and the shortage of labor force.

A number of government organizations have formulated policies and published recommendations that establish priorities for furthering R&D in these areas. Some of these documents are as follows.

- *Long-term Perspectives on R&D of Construction Technology,* published in April 1988 by the Ministry of' Construction.
- *Basic R&D Programs at the Ministry of Transport,* published annually by the Ministry of Transport.
- *Research and Development Guidelines for Telecommunications Technology,* published in May 1992, partly revised in August 1993, by the Ministry of Posts and Telecommunications.
- *Transportation Technology Policy Prospect for the 21st Century* published in June 1991 by the Council for Transportation Technology.
- *Emphasis on Priorities and the General Promotion of Experimental Research Related to Pollution Prevention,* published annually by the Environment Agency.

R&D of the following are being encouraged by the National Police Agency, Environmental Agency, Ministry of Agriculture, Forestry and Fisheries, Ministry of Transportation, Ministry of Posts and Telecommunications and the Ministry of Construction, and other ministries:

- Development of planning and construction technologies for cities and rural communities
- Development of technology to maintain and control city functions and a new traffic transportation system

- Development of a new information telecommunication system

3.4.1.3.4 Substantialization of Disaster Preventive and Safety Measures

In constructing a charming society where people can live with peace of mind, it is important to remove or reduce the following anxiety and danger factors which effect life and society.

- Natural disasters such as volcanic eruptions and earthquakes, etc.
- Disasters or accidents caused by fire, explosives and combustibles, etc.
- Crimes committed in computer and telecommunication networks
- Accidents in large-scale systems

Therefore, it is necessary to encourage R&D on the elucidation of the mechanism of disaster-causing natural phenomena and prediction of natural disaster and R&D of prevention and restoration technology as well as encourage R&D of technology to respond to fire and disasters caused by fire, explosives and combustibles and technology to operate, maintain and manage large structures and systems. It is also necessary to encourage R&D of technology to deal with new dangers which are increasing in daily life and in the work environment as a result of their becoming more technologically sophisticated and information-oriented.

In this field, *The Basic Plan on R&D Concerning Disaster Prevention* (decided by the Prime Minister in July 1981), etc. were established.

The Science and Technology Agency, the Ministry of Education, the Ministry of Transport, the Ministry of Construction and other organizations are promoting R&D on the elucidation, prediction, prevention and recovery techniques related to the mechanism of disaster-causing natural phenomena such as earthquakes, volcanic eruptions and weather-caused disasters. In addition, National Police Agency, Ministry of Labor, Ministry of Home Affairs and other organizations are promoting R&D in such fields as the technology for countermeasures in response to disasters involving fires and dangerous materials, and the preservation of hygiene and safety in the workplace.

3.4.2 Research Activities by Organization

3.4.2.1 Research Activities at the National Research Institutes

The national research institutes conduct specific research activities under the auspices of the ministry or agency with which they are affiliated. In FY1993, expenditures by the national research institutes for experimental research costs, personnel costs and facility costs were 366.5 billion yen up 7.2% from the previous year. Table 3-4-9 lists these expenditures by ministry and agency. A total of 14,573 people were employed including 9,612 researchers. This was down 64 from the previous year, including 29 fewer researchers.

3.4.2.1.1 Ordinary Research and Special Research

Ordinary research consists principally of research activities in comparatively basic fields that is conducted on a regular basis to provide the foundation for other research activities.

Special research, unlike ordinary research, consists of planned research activities that must be conducted expeditiously within a fixed time period to meet societal or governmental requirements.

3.4.2.1.2 Guidelines for Promoting Basic Research at Research Institutes

Looking forward to the 21st century, Japan is committed to promoting creativity in science and technology and especially in basic research for the betterment of society at home and abroad.

For the promotion of basic research the national institute are highly expected as well as universities.

In this context, a number of highly promising basic research projects are currently underway at the national research institutes, national universities, etc. Since this basic research provides the impetus for development of innovative technologies, the Science and Technology Agency utilizes the Special Coordination Funds for Promoting Science and Technology in the following ways to support R&D

Table 3-4-9 Breakdown of expenditures for national research Institutes by ministry of agency

(million yen)

Ministry or agency	FY 1992	FY 1993
National Police Agency	1,209	1,305
Hokkaido Development Agency	150	158
Defense Agency	125,880	136,038
Economic Planning Agency	930	965
Science and Technology Agency	41,875	46,861
Environment Agency	8,383	8,901
Ministry of Justice	1,063	1,141
Ministry of Finance	1,434	1,542
Ministry of Education	8,559	8,757
Ministry of Health and Welfare	19,367	19,420
Ministry of Agriculture, Forestry and Fisheries	64,707	67,352
Ministry of International Trade and Industry	44,574	46,491
Ministry of Transport	9,825	10,141
Ministry of Posts and Telecommunications	5,289	7,298
Ministry of Labor	1,862	2,374
Ministry of Construction	6,130	7,113
Ministry of Home Affair	631	658
Total	341,870	366,515

Notes: I. Since amounts have been rounded, the sum of the amounts for each column and the totals shown above do not necessarily agree.
2.Amounts include expenditures for the humanities.

in national research institutes in accordance with the directives of the CST:

- Encouragement of Basic Research at national research institutes to create the seeds of innovative technologies (since FY1985)
- International Core System for Basic Research to promote international research exchanges (since FY1988)

Also, since FY1993 this latter system has provided a research environment to bring together excellent researchers from different countries and it has also set up the "Center of Excellence (COE)" to announce the results of the excellent research to the world, and to provide COE support centering on the national research institutes and other similar organizations.

In FY1990, the science and technology special researcher system was established and implemented for activities in national research institutes by accepting young researchers in these institutes as part-time employees.

3.4.2.2 Research Activities at Public Research Corporations

In addition to the national research institutes, important government-sponsored research activities are conducted at public research corporations. Funding for these corporations is provided by government investments and subsidies as well as by private sector investment. They are effective measures for research since they allow for flexible management, are able to recruit researchers from a wide range of government and private-sector organizations and can finance their activities with investments from the private sector.

Public research corporations are destined to play an important role in Japanese R&D as they are capable of sustaining the comprehensive efforts required to accommodate the growing volume of large-scale, complex projects.

Table 3-4-10 lists the main purposes and research activities provided by the principal public research corporations.

3.4.2.3 Research Activities at Academic Institutions

Academic institutions conduct research with the goal of extending knowledge. At these institutions, innovation and creativity are fostered in an environment that encourages independence, inquisitiveness and the free dissemination of ideas.

Japan's national and private universities and colleges lie at the center of this activity and are charged with maintaining and raising the standard of the nation's academic worth. The universities and colleges promote academic development by paying high regard to the independence of researchers and encouraging education and research to mature together in studies that are focused around the humanities, social sciences and natural sciences.

The Ministry of Education supports research activities in graduate schools, departments of universities and colleges, their attached laboratories and research institutes and in inter-university research institutes. Although education and research activities are basically treated as two parts of an inseparable whole, for accounting purposes, expenditures designated for research can be classified into the following categories.

- Expenditures for ordinary research
- Expenditures for separately accountable research granted on the basis of research content and need
- Expenditures for research on specific projects
- Expenditures for installment and maintenance of research facilities and equipment

Expenditures for ordinary research to provide the foundation to conduct research independently, consist, at the national universities and colleges, of personnel expenses, research expenses by faculty members and research-related travel expenses by faculty members. The Ministry of Education supports personnel expenses and overall education and research costs for private universities and colleges through subsidies for working expenditures.

There are a number of expenditures allocated to cover the cost of special research, one of which is the Ministry of Education's Grant-in-aid for Scientific Research to promote advanced scientific research in fields that contribute to the furtherance of the sciences in Japan. This grant-in-aid covers the cost of independently planned research projects by a researcher or group of researchers affiliated with an academic institution which are deemed to be in the national interest for the furtherance of academic knowledge and for which outstanding results may be obtained. This grant-in-aid has been instrumental in furthering scientific research in Japan by encouraging creative and innovative scientific research and by nurturing the formation of distinguished research groups.

In FY1993, the following researches are being promoted.

- "High-Priority Research" for promoting innovative research in areas which Japan is competing on a cutting-edge level in international community
- "Priority Research" for promoting research in areas with strong scientific and social demands
- "General Research (A), (B), (C)" for encouraging creative and innovative basic research and for developing social sciences and humanities
- "Commendatory Research (A)" to promote research

Table 3-4-10 Public research corporations

Organization	Purpose and activities
Japan Atomic Energy Research Institute (JAERI)	To carry out comprehensive, efficient research on nuclear energy development; conduct basic and applied research on nuclear energy; nuclear reactor design, construction and operation; R&D of nuclear-powered ships; and to disseminate information and technologies.
Institute of Physical and Chemical Research (RIKEN)	To develop original, innovative technologies, conduct broad-ranging, advanced experimental basic and applied research level in physics, chemistry, agricultural science, biology and other fields; to disseminate information and technologies to the academic and industrial sectors.
Research Development Corporation of Japan (JRDC)	To commission development of new technologies, and basic research deemed necessary to develop new technologies, to disseminate information and technologies; grant concessions for the development of new technologies; promote communication among the international research community; facilitate technology transfer; Supply information pertinent to the international research community.
Power Reactor and Nuclear Fuel Development Corporation (PNC)	Primary development work is to establish key elements of the nuclear fuel cycle, including fuel development, uranium prospecting and mining, reprocessing of spent fuel, development of autonomous technology for fast breeder reactors, and new types of conversion reactors.
National Space Development Agency of Japan (NASDA)	To contribute to space science and technology and the utilization of the space environment for peaceful purposes, conduct general development of satellites and the launch vehicles to launch them, and to manage launching and tracking operations.
Japan Marine Science and Technology Center (JAMSTEC)	To further science and technology useful in ocean development; conduct general experimental research, including R&D of technologies for deep-sea surveys, R&D of technologies for Ocean observation; to commission and manage large, joint-use facilities for experimental research, conduct training programs, information gathering and dissemination.
New Energy and Industrial Technology Development Organizations (NEDO)	To improve Japan's industrial technologies and to further international exchange in the field of industrial technology; conduct R&D of technologies for industrial use; establish a research infrastructure; promote joint international research.

by capable young researchers

- "Fellowship for encouraging special researchers"
- "Experimental Research" for promoting both experimental and applied research
- "International Scientific Research" for promoting international joint research projects
- "Research Reporting Expenditures"
- "Original Basic Research Expenditures" for promoting new scientific programs (Table3-4-11).

Training and securing a large number of creative young researchers who can flexibly respond to developments in new research is also an issue of critical importance in strengthening the infrastructure for scientific research and for its development. In FY1985, the Ministry of Education addressed this issue by establishing the "Special Researcher Fellowship Program," a full-fellowship program under the auspices of the Japan Society for the Promotion of Science (JSPS). The program enables students to attend the later period of doctor degree programs in graduate schools and those who have obtained the doctorate degree to devote themselves to independent creative research. In FY1993 the amount of the fellowship fund was greatly increased so that the total of research fellows was expanded to 1,700.

In addition, scientific investigators at universities have been besieged with requests by private industry and other sectors of society. To address this, the Ministry of Education has implemented a number of

Table 3-4-11 Research classifications for scientific research grants

Research classification	Purpose/Description
High-priority research	Promotion of pioneering scientific research in international leading-edge fields: 42 research themes are being promoted during FY 1992.
Priority research	Dynamic, intensive promotion of scientific research in areas or fields where strong scientific and social demands exist: Research projects for FY 1992 cover 77 different fields including environment, earth and space science, energy science, substance and material science, information and electronic science, life sciences, and social sciences and humanities as well as a special cancer-related research.
General research, commendatory research A, etc.	Support for research aimed at strengthening the foundations and maintaining or improving the level of scientific research and research conducted by university and other young researchers.
Experimental research	Greater promotion of experimental or applied research projects with the potential for research results to find commercial use as well as promoting social interaction with the private sector.
International scientific research	Promotion of foreign academic studies and joint research
Commendatory research B	Support for scientific research being conducted by elementary school, middle school, high school, and other school teachers and by private sector researchers.
Special researcher grants	Support for research conducted by special researchers of the Japan Science Promotion Association.
Research publishing promotion expenditures	Promote the publishing of scientific research results
Original basic research expenditures	Promote research themes decided by the Science Committee (Promotion of research according to the new program format)

measures that enable them to cooperate with private industry on joint research projects that meet the needs of society in an appropriate manner, while protecting the autonomy of the universities.

In FY1983, the Ministry of Education established the "University-Private-Sector Joint Research Program" to allow national universities and other institutions to accept researchers and research funding from private industry. These researchers collaborate equally with university researchers on joint research projects of common interest.

Researchers, both at universities and in the private sector, have expressed strong interest in this program. As of FY1992, 1,241 joint projects had been conducted under this program for the development of materials, equipment, software and other technology. From FY1987, the Ministry has commissioned "Joint Research Centers" at national universities for joint research projects and other areas of academic and private-sector cooperation. The Ministry also is promoting private-industry and university cooperation on joint research by making it easier for colleges and universities to undertake contract research and accept contract researchers. Funds for this are provided through the Grant-in-Aid for Scientific Research. The Japan Society for the Promotion of Science also is encouraging academic-private sector cooperative activities through its General Liaison Committee.

Academic research is an all-encompassing intellectual endeavor that helps further knowledge regarding ourselves and our universe. Thus, expanding the frontiers of academic research requires cooperation and a free exchange of' ideas across national boundaries. Over the last few years, the need for international effort to deal with resource and energy problems and global environmental problems has intensified. Moreover, many fields of scientific research, such as high-energy physics and nuclear fusion, require large-scale facilities and advanced equipment that are often beyond the capital resources of any single nation.

To address these issues, Japan is encouraging international cooperation in scientific research in the following areas.

- Invitation of researchers from overseas to conduct research in Japan under the Special Overseas Researcher Fellowship Program
- Dispatch of Japanese researchers to participate in R&D activities overseas
- Encouragement of joint bilateral and multilateral research projects

Japan is involved in large-scale, international joint research projects under various agreements, both at the international and inter-organization levels. Research activities also are conducted under multilateral agreements with the International Council of Scientific Union (ICSU), the United Nations Educational, Scientific and Cultural Organization (UNESCO) and other international bodies. The Ministry of Education also is actively encouraging university exchange programs with developing countries.

The Ministry of Education is working on various measures to complete preparations for the condition and structure to accept foreign researchers in order to encourage these kinds of international scientific exchanges.

In July 1992, a recommendation was given by the Science Council of Japan regarding "Comprehensive Promotion Measures for Academic Research in Prospect of the 21st Century" to respond to significant changes in the various situations surrounding academic research in recent years. In this recommendation, the basic concept for promoting academic research is proposed as follows.

1) Academic research as an intellectual and creative activity worth to all over the world
2) Consolidation of the research infrastructure with paying attention to academic research trends
3) Respect for the independence of researchers and demand for their social contributions
4) Comprehensive promotion of research and education

The recommendation also proposes that it is necessary to raise the standard of academic research infrastructure up to those of Europe and the United States. For this purpose, the recommendation prioritizes a consolidation of infrastructure with a plan, and establishment of academic research system open to the world and responding flexibly to developments in academic research.

3.4.3 Strengthening the Infrastructure for Science and Technology Promotion

A strong promotional infrastructure is a prerequisite for the smooth and efficient progress of R&D in science and technology toward meeting various needs in and out of the country.

The government is addressing this issue through its implementation of the following measures.

- Investment on R&D
- Nurturing of research personnel and improving their treatment
- Management and supply of equipment and facilities, materials and genetic resources
- Promotion of the research exchange
- Dissemination of science and technology information
- Promotion of regional science and technology

3.4.3.1 R&D Expenditures

In FY1991, R&D expenditures for the public sector invested 2,700 billion yen on R&D, up 6.2% over the previous year. The money was spent primarily in areas deemed to be of national importance, such as conducting basic research, encouraging large-scale research projects and improving the infrastructure of R&D. The public sector's share of research expenditures relative to Gross National Product was 0.47%, lower than in the U.S. and European countries. Only 12.9% of the total R&D expenditures in Japan was spent on basic research (Figure 3-4-12). Given this record, a continued increase in R&D investments by the government is desired.

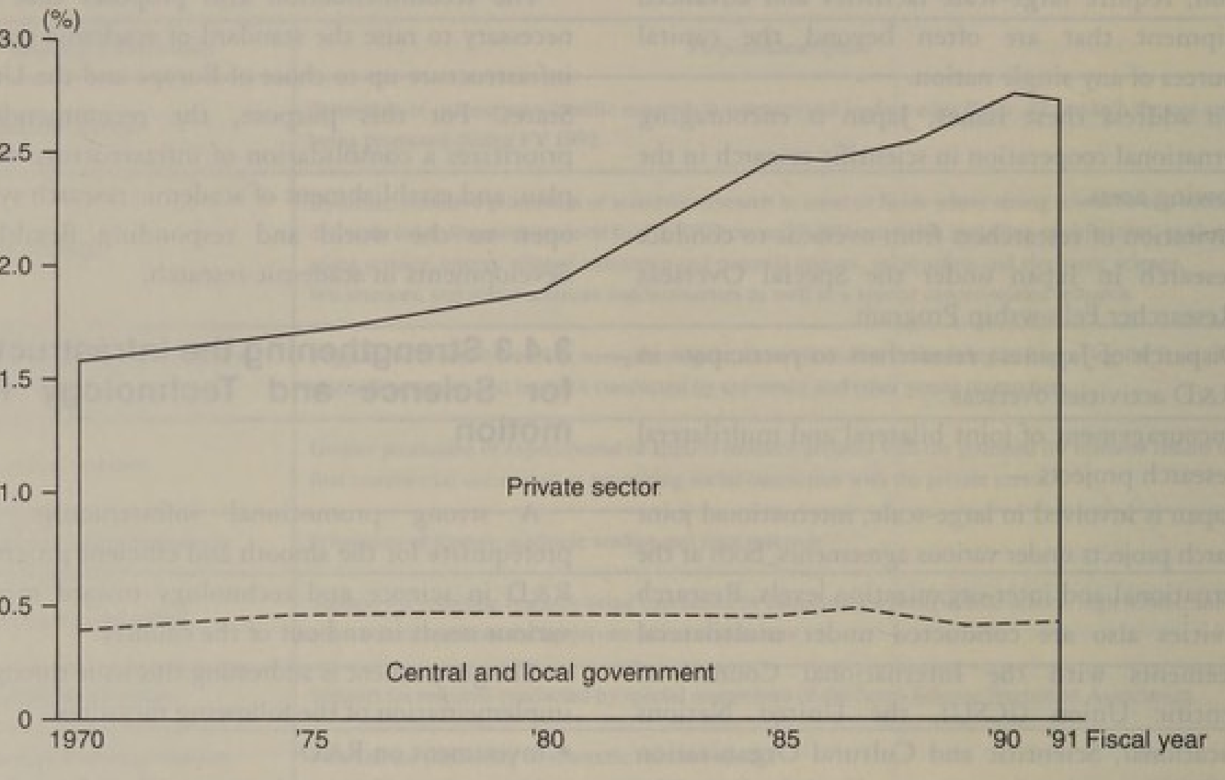


Figure 3-4-12 Research expenditures by sector as a percentage of GNP

Based on current trends, private sector investments in R&D are expected to rise. In light of this, the government is making it more attractive for the private sector to increase investments through the implementation of the following tax measures and programs.

- *Tax Deductions on Experimental and Research Expense Increments*
- Exemptions under *The Tax Program for Promoting R&D of Basic Technologies*
- *Cooperative Development for Industrial Technology* for the development and commercial application of new technologies
- Credit guarantee programs

3.4.3.2 Nurturing of Research Personnel and Improvement of Their Treatment

Progress and development of science and technology is heavily dependent on the abilities and creativity of those involved in R&D work. Accordingly, efforts to nurture, sustain and improve scientific and technically-trained personnel are prerequisites for the effective promotion of science and technology development.

As part of its efforts, the Science and Technology Agency (STA) has implemented programs designed to raise the quality of work done by researchers and to stimulate research work at the national research institutes through study-exchange activities both at home and abroad. In FY1989, the STA supplemented these programs by establishing the Special Researcher Program for the Basic Sciences at the Institute of Physical and Chemical Research where capable young researchers could engage in self-initiated, independent research, and in FY1990, by inaugurating the National Institute Post Doctoral Fellowship Program to accept young investigators with abundant creativity in national research institutes.

The Ministry of Education also has been nurturing highly capable, young researchers by consolidating and expanding programs and facilities at graduate schools and other institutions of higher learning. The Ministry established the Special Researcher Fellowship Program in FY1985 under the direction of the Japan Society for the Promotion of Science.

STA has recognized that good treatment of research personnel is a prerequisite for retaining capable researchers and for allowing them to reach their full potential. Since 1961, STA has coordinated the opinions of the various ministries and agencies and has made an annual request to the National Personnel Authority regarding the employment conditions of government researchers. As a result of the FY1992 request, the starting salaries of researchers with university bachelor is degrees were improved by 5.4%, those with master's degrees by 4.4%, and those with doctoral degrees by 3.8%. The percentage improvements in salaries for researchers with the respective degrees in private institutions were 4.8%, 3.8% and 4.9%, respectively. The average salaries of young researchers with research staff grade 2 on the Salary Scale for Research Staff and teaching staff grade 2 on The Salary School for Teaching Staff were improved by 3.6% and 3.0% respectively, placing the average salaries for research staff higher than the average salaries of teaching staff. Since FY1993, moreover, researchers have been able to use the "flextime" method of choosing their working hours.

The first measure for FY1993, stated the desirability of revising the salary scales for research workers in view of the actual state of the salary scales for researchers in private institutions (especially those of newly appointed researchers and young researchers from the viewpoint of securing talented staff) to bring them into line with The Salary Scale 1 for Teaching Staff (applicable to tenured staff at national universities and other institutions), which itself has been specially upgraded to keep in step with the salaries being paid to teachers at compulsory education schools as part of the policy on securing human resources.

The second measure stated the desirability of improving the salaries of researchers assigned to Tsukuba Science City.

As a result of these requests, the starting salaries of researchers with bachelor is degrees were improved by 2.3%, those with master's degrees by 2.4%, and those with doctoral degrees by 2.5%. Also, the National Personnel Authority recommended that the rates should be made higher than the average raises awarded to middle-leading researchers. The average salaries of young researchers (research staff grade 2) and teaching staff grade 2 on The Salary Scale1, for Teaching Staff were revised by 2.5% and 2.3% respectively, placing the average salaries for research staff grade 2 higher than the average salary of teaching staff on grade 2.

3.4.3.3 Management and Supply of Equipment and Facilities, Materials and Genetic Resources

In accordance with *The Basic Directives for Consolidating the Infrastructure for Science and Technology Promotion,* approved by the Prime Minister in January 1990, the various ministries and agencies are promoting measures to implement the following:

- Establishment of a system to ensure a more complete system of supply for the materials and genetic resources used in research
- Replacement of obsolete and outdated equipment and facilities at national universities and the national research institutes
- Development of the world's most advanced equipment and consolidation of core research functions
- Creation of favorable work environments at national universities and at national research institutes to conduct more joint research projects with outside researchers

In the area of biological research materials and genetic resources, the Institute of Physical and Chemical Research (RIKEN) has established a gene bank program for the collection, storage and distribution of the animal and plant cell cultures and genes required for research in the life sciences. Other

RIKEN programs include the development of an information system for experimental data in the biological sciences, the development of test animals, and the collection, storage and apportionment of microorganism strains.

The Ministry of Education is setting up animal testing facilities as a part of the overall reorganization of its research support infrastructure at the national universities.

The Ministry of Health and Welfare is operating a Research Resources Bank that collects, stores and distributes human and animal cell cultures needed for the cancer research carried out under the 10-year comprehensive anti-cancer strategy.

The Ministry of Agriculture, Forestry and Fisheries is promoting the operation of the MAFF Gene Bank, which collects and stores genetic resources from all types of agricultural, forestry and fishery resources, including plants and trees, animals, marine life and microorganisms. The gene bank also supplies genetic resources and information in stock to researchers.

The Ministry of International Trade and Industry at its Fermentation Research Institute Patented Microorganism Depository, deposits and distributes microorganisms related to patent research as well as conducts research on preservation technologies for use with plant and animal cells.

As one of its projects for improving research and development infrastructure, the Science and Technology Agency is constructing the Next-Generation Synchrotron Radiation Facility "SPring-8" in the Harima Science Garden City, Hyogo Prefecture. RIKEN and the Japan Atomic Energy Research Institute (JAERI) are jointly implementing the enterprise. It will be the largest synchrotron radiation facility in the world with 8GeV stored electron energy. It also will perform as a source with higher brilliance and harder X-rays than conventional synchrotron radiation facilities. This facility can be used for research carried out in a wide range of science and technology fields, including materials science, electronics and life sciences. It will be a joint use facility opened to researchers both at home and abroad.

This SPring-8 is a R&D infrastructure facility vital for promoting basic and creative R&D, and is expected to not only help further basic research in Japan, but also play a key role in international research cooperation.

R&D activities and manufacturing of instruments are to be continued as in 1992, and construction of the facility is being done at the Harima Science Garden City, Hyogo Prefecture. It is scheduled to be completed and ready for partial use in 1997.

This facility has been targeted as one of the facilities for COE research using synchrotron radiation, and in its role as a facility open to researchers both from Japan and overseas, it will be important to consolidate operations. Organizational restructuring is also needed in order to promote its use. In a similar vein, the High-Energy Physics Research Institute (KEK) of the Ministry of Education, one of the core organizations in the field of accelerator physics, is carrying out research at the highly advanced synchrotron radiation facility using the "TRISTRAN" injection accumulation ring in order to become the first in the world to break into new fields of research.

Based on the Act for Construction of R&D Structures concerning Industrial Technologies, the Ministry of International Trade and Industry, under the Research Foundation Construction Project, is constructing those research facilities which are necessary for sophisticated R&D that should be promoted in this country in the future but which are difficult to construct only by the efforts of the private sector. In this project, a third-sector enterprise, to be established with investment from the New Energy Comprehensive Research and Organization for the Comprehensive Development of Industrial Technology will construct and operate the facilities which are to be provided for common use to researchers both at home and abroad.

3.4.3.4 Promotion of Research Exchange

In recent years, scientific R&D have become increasingly advanced, complex and interdisciplinary in nature. To promote creativity in science and technology, Japan must commit itself to developing the organizational infrastructure for R&D that will allow for the free movement of researchers, as well as for dissemination of research findings and materials. This will ensure that the limited resources that can be made available for research are used as efficiently and effectively as possible.

In the past, the legal restrictions placed on civil servants and the strict asset control measures applied by the government made it difficult for researchers to interact and cooperate with the private sector, or other countries. The government has moved to remove impediments in the relevant laws by enacting ***The Law for Facilitating Governmental Research Exchange*** in November 1986. In March 1987, the cabinet approved ***The Fundamental Policy for the administration of institutions to promote governmental research exchange between industry, universities and foreign countries*** to help ease the implementation of the aforementioned law.

Seven years have passed since this law was established and the situation surrounding science and technology in Japan has greatly changed since then. There is a greater need for Japan to make international contributions in science and technology and strong domestic and foreign demands for it to promote basic and creative research. Under these circumstances, this law was amended in July 1992 to further relax the various restrictions surrounding Japan's research activities of national research institutes (Table 3-4-13).

In addition, the Research Development Corporation of Japan has accumulated abundant experience concerning performance of basic research by collecting together researchers from industry, universities and the national research institutes. The result of the partial amendment of the Research Development Corporation of Japan Law, (effective March, 1993) was to promote increased interaction between researchers and consolidate a system to comprehensively promote exchanges between researchers.

3.4.3.5 Distribution of Scientific and Technological Information

Scientific and technological information is the result of the distillation of highly specialized knowledge obtained through R&D and supported by major financial investments. Scientific and technological information also is a major component of the infrastructure for promoting R&D.

As science and technology develops, the annual volume of research information continues to increase, making it difficult for researchers to access needed information swiftly. It is, therefore, increasingly important to gather and organize information into easily referenced systems, which can then be supplied on demand to individual users in the requested format.

Also, research information should be disseminated to a much greater extent, and a basic infrastructure is needed for the distribution of research information, including the consolidation of computer networks to promote an advanced form of R&D.

3.4.3.5.1 Basic Policies for the Promotion of Scientific and Technological Information-related Activities

The CST Recommendation pursuant to Inquiry No.4, *Basic Guidelines Regarding the Distribution of Scientific and Technological Information,* submitted in October 1969, makes the basis for the promotion of scientific and technological information-related activities using the concept of a National Information System for Science and Technology (NIST).

In December 1989, in its Recommendation pursuant to Inquiry No. 16, ***Basic Guidelines for Managing the Infrastructure for Science and Technology Promotion,*** the CST outlined the importance of a healthy promotional infrastructure, including scientific and technological information. To facilitate this, the CST proposed implementation of the following measures.

- Reinforcement of the information distribution infrastructure with an emphasis on improving the quality of information and ensuring easy access to

Table 3-4-13 Summary of the law for facilitating governmental research exchange

Item	Legal system before enforcement of this law	Special measures under this law
Term adoption as public research officials (Article 3)	Within the National Civil Servant Law, it is a general rule that employment is based on a lifetime system and no period of employment is set.	* According to the guidelines determined by the National Personnel Authority based on the National Civil Servant Law, it became possible to establish a period of employment for research civil servants.
Appointment of foreigners as public research officials (Article 4)	In principle, foreigners can be appointed as researchers, but their work is limited to testing and research.	* Foreigners can be appointed even as research division managers or research section managers.
Participation in research meetings (Article 5)	As part of official duties (business trips, outside duties) or on holidays.	* One can be released from the obligation to carry out one's duties.
Exceptions to the law of Retirement Allowances for Government Officials concerning public research officials (Article 6)	For leave to devote oneself to research at a school, institute, hospital and other public facilities (research leave), half of the period is used for calculating the retirement allowance according to the length of service.	* For leave necessary for carrying out research entrusted, by or joint research with, a national research institute, 100% of the period is credited.
Transfer of patent rights, etc. relating to the results of government-commissioned research (Article 7)	National research institutes apply for patents, etc.	* Part of the patent rights can be assigned to a trustee who has borne the cost.
Use of patented inventions, etc. relating to international joint research conducted by the government (Article 8)	It is often requested to use patents, etc. of national institutes free of charge or at low cost in case of international joint research. To realize this, some legal basis should exist.	* For joint research with public organizations of foreign countries or international organizations conducted by the national government, it was arranged so that patents and other rights held by the national government related to these results can be used at no cost or minimal cost.
Handling of patent rights, etc. relating to the results of international joint research commissioned by the government (Article 9)	For consignments from the national government, patent rights and other such results belong to the national government and it is necessary to collect an appropriate fee for usage.	* For the results of international joint research involving consignment from the national government, the following treatment is permitted. (1) Sharing the patent rights or other rights related to the subject research results with the consignee. (2) Allowing the consignee to use the patent rights or other rights related to the subject research results at no cost or minimal cost.
Relinquishment of the right to claim for damages relating to international joint research conducted by the government (Article 10)	It is often requested in international joint research to waive governmental compensation claims. To realize this, some legal basis should exist.	* For joint research with public organizations of foreign countries or international organizations conducted by the national government, it is possible for the national government to dispose its right to request compensation for damages.
Use of the government-owned facilities at low cost (Article 11)	To permit the use of national property at little expense, some legal basis should exist.	* Researchers, who are conducting research which is closely related to research being undertaken by the national government or may be of special value to the subject government research and will supply the results of such research to the national government, can use test and research facilities at a minimal cost.

(Table 3-4-13)

Item	Legal system before enforcement of this law	Special measures under this law
What should be considered (Article 12)		* To conduct international research exchanges using special measures under this law, special attention shall be paid to fulfilling the obligation to execute treaties and other international promises and to maintain international peace and security.

information by users

- Further international distribution of information and the dissemination of information among regional areas in Japan
- Intensified and broader information collection
- More advanced information dissemination capabilities

The Recommendation pursuant to Inquiry No.18 General Basic Policies on Science and Technology for the Next Century submitted in January 1992 proposes the following.

- Facilitation of the distribution of document information
- Preparation of an information distribution system to promote the construction of a fact data base and its usage
- Strengthening the mutual distribution function of international information
- Regional development of a science and technology information network

In response to this recommendation, The General Guideline on Science and Technology Policy proposed expansion in production of science and technology information and its distribution domestically and overseas, and the regional development of a science and technology information network.

3.4.3.5.2 Scientific and Technological Information Activities in Japan

The following sections summarize science and technology information activities in Japan. Table 3-4-14 lists scientific and technological information distribution activities by government ministry and agency in FY1993.

3.4.3.5.2.1 Primary Information Services

Libraries and several other information service organizations make primary literature available for reading, photocopying or loan. According to the National Diet Library (NDL) Law, all unclassified publications issued in Japan are to be deposited in NDL. The library has created a database of its collection and has made this available for use on-line.

The Ministry of Education's National Center for Science Information Systems (NACSIS), in cooperation with national and local governments and private universities and colleges, has created a database that catalogs the location of books and magazines available in university libraries nationwide and made this information available for referencing.

3.4.3.5.2.2 Secondary Information Services

The use of computers to edit and build databases allows researchers to search large volumes of data quickly, accurately and with relative ease.

Recently, the creation and utilization of databases in science and technology fields has increased sharply worldwide, a typical example being the text databases used to store the contents of large numbers of academic theses. However, there is also an increasing demand for factual databases that store numerical and image data.

The Japan Information Center of Science and Technology (JICST) produces the comprehensive bibliographic database, inputting approximately 690,000 science and technology documents annually,

Table 3-4-14 Distribution of science and technology information measures in FY1993

Ministry or Agency	Organization	Activity
National Diet Library		* Collecting domestic and foreign scientific and technical publications, building indexing databases and supplying information services
Science Council of Japan		* Compilation of data on international cooperative activities of the International Council of Scientific Union (ICSU)
Science and Technology Agency	Science and Technology Promotion Bureau	* Research concerning construction of sell-organizing information base systems for supporting development of creative research and other projects funded by the Special Coordination Funds for Promoting Science and Technology
	National Research Institute for Metals	* Creating data sheets
	National Research Institute for Disaster Prevention	* Collecting, compiling and providing science and technology material on disaster prevention
	National Institute for Research in Inorganic Materials	* Collecting documentary data, etc.
	National Institute of Science and Technology Policy	* Construction of a data processing system concerning science and technology policy research
	Japan Information Center of Science and Technology (JICST)	* Building and maintaining databases of scientific and technical literature and reference databases, including English-language databases. Providing domestic and overseas information services * International dissemination of Japanese government publications of science and technology
	Japan Atomic Energy Research Institute	* Cooperative work on an international system of networks and databases for information on nuclear energy
	Power Reactor and Nuclear Fuel Development corporation	* Compilation of information on nuclear fuel resources
	National Space Development Agency of Japan	* Design and operation of comprehensive system of networks and databases for information on space development
	Research Development Corporation of Japan	* Compilation of a directory of research on the global environment
	The Institute of Physical and Chemical Research	* Development of a data system on experimental living organisms
	National Center for Oceanic Research	* Collecting, processing and providing information on oceanic science and technology
Environment Agency	National Environment Research Institute	* Collecting data on the environment and building databases
	National Minamata Disease Research Center	* Collecting information and cataloguing literature on mercury poisoning

(Table 3-4-14)

Ministry or Agency	Organization	Activity
Ministry of Education	National Center for Science Information Systems (NACSIS)	* R&D, planning and coordination of systems for scientific information * Establishing networks, building databases, and providing information services * Electronic mail services
Ministry of Health and Welfare	Medical Information Systems Development Activities	* Development and promotion of information systems for medical use and improvement of information support systems for public health centers
	Pharmaceutical Product Safety Investigations	* Collection of data on the side effects of pharmaceutical products
	National Institute of Hygienic Sciences	* Evaluation of the effects of chemical substances on health
Ministry of Agriculture, Forestry and Fisheries	Office of the Agriculture, Forestry and Fisheries Research Council	* Management of the Agriculture, Forestry and Fisheries Research Information Center, collection of information and maintenance of databases on genetic resources
Ministry of International Trade and Industry	Agency of Industrial Science and Technology (AIST)	* Participation in a network for exchange of information on international standards
	Patent Agency	* Development of a databases retrieval system for reference materials used in patent investigations * Building patent information databases
	Small-and Medium-Enterprise Agency	* Collecting, cataloguing and supplying of technical literature relevant to small- and medium-size enterprises
Ministry of Transport	Maritime Safety Agency	* Operating of the Japan Ocean Data Center
	Meteorological Agency	* Operating the Global Warming Information Center
Ministry of Posts and Telecommunications	Communications Research Laboratory	* Operation of the Ionosphere Data Center
Ministry of Labor	Harmful Substances Investigations	* Investigation of potentially harmful substances and formulation of corrective action
Ministry of Construction	Geographical Survey Institute	* Research concerning the development of technology to electronically publish maps

and provides this by on-line. The center also provides factual databases such as Chemical Dictionary Database of Chemical Substances.

NACSIS creates databases for use in scientific research, providing this information nationwide over a scientific information network that links national, local governments' and private universities and related organizations.

The Japan Patent Information Organization (JAPIO) has created a database of patent information that is available on-line.

3.4.3.5.2.3 Clearing Services

Clearing services provide information on specific research topics. JICST supplies on-line information on a variety of research topics from public research institutes.

NACSIS has created an on-line database containing abstracts of research funded by Grant-in-Aid for Scientific Research.

3.4.3.5.2.4 International Dissemination of Scientific and Technological Information

Overseas demand for Japanese scientific and technological information has increased as the nation's science and technology has progressed.

In November 1987, the three organizations of JICST, the Chemical Abstracts Service (CAS) of the United States and FIZ Karlsruhe of Germany set up the Scientific and Technical Information Network International (STN International) which currently provides a service well exceeding a hundred different types of databases.

NACSIS also has been disseminating internationally Japanese scientific information. In January 1989, the Center established a link with the United States National Science Foundation (NSF). This was followed by establishing ties with the United States Library of Congress(LC) in the same year and with the British Library (BL) in 1990.

Since FY1990, JICST has been disseminating government documents in science and technology fields which had hitherto been difficult for overseas researchers to obtain. In March 1993, JICST held an explanatory meeting on Japanese scientific and technological information in the United States.

3.4.3.5.2.5 Advancement of R&D Related to Scientific and Technological Information

A program titled "Investigations for Building a Self-Organizing Information-Based System to Assist Creative R&D", which began in FY1990, has been financed using the Special Coordination Funds for Promoting Science and Technology, and was designed to support researchers' creative R&D activities. Both the basic and detailed design of the program were carried out in FY1992.

Further, JICST has been working on a full-text database development program to implement a practical full-text Japanese language database.

3.4.3.5.2.6 Basic infrastructure for disseminating research information

In consideration of the increasing necessity for a basic infrastructure for the dissemination of research information, supercomputers and an local area network (LAN) were installed in the research institutions of the various government Ministries and agencies using the FY1993 supplementary budget. In the future, there are plans to further consolidate the research information infrastructure, through such measures as upgrading the network connecting these research institutions. On the basis of the situations in foreign countries and the needs of researchers and research institutions, the concerned ministries and agencies will cooperate together to investigate the matters further.

3.4.3.6 Science and Technology Promotion at Regional Level

The Cabinet in its *Fourth Nationwide Comprehensive Development Plan,* approved in June 1987, and the *General Guidelines for Science and Technology Policy,* approved in April 1992, identified the strengthening of regional R&D capability as a strategic issue.

Given this, more and more of Japan's regional areas have been attempting to improve their R&D capabilities over the last few years.

Japan's regional areas held councils and meetings deliberating measures for development of science and

Table 3-4-15 Establishment state of science and technology council by regional public organizations

Prefecture/city	Name of science and technology Council	Established	Chairman	Composition
Hokkaido	Hokkaido Science and Technology Council	September 1952	Toichiro Koike, Dohto University	30 experts from industries, universities and government
Kyoto	Kyoto Science and Technology Council	September 1961	Takeo Saegusa, Kyoto University Professor Emeritus	15 scholars
Ishikawa	Ishikawa Technology Promotion Council	August 1982	Takeshi Yasui, Kanazawa University Engineering Professor	20 experts from industries, universities and government
Toyama	Toyama Science and Technology Council	November 1983	Tomomichi Yanagida, University of Tokyo Professor Emeritus	20 experts from prefectural industries, universities and government
Hyogo	Hyogo Science and Technology Council	July 1986	Nobuaki Kumagai, Osaka University Professor Emeritus	21 experts from industries, universities and government
Osaka	Osaka Science and Technology Deliberations Committee	December 1986	—	7 experts from industries, universities and government
Kanagawa	Kanagawa Science and Technology Council	June 1988	Shinroku Saito, Tokyo Institute of Technology Professor Emeritus	15 experts from industries, universities and government
Yamaguchi	Yamaguchi Science and Technology Council	May 1991	Yoshihira Tanaka, Tokyo Institute of Technology Professor Emeritus	12 experts from industries, universities and government
Yamanashi	Yamanashi Science and Technology Council	September 1991	Satoshi Omura, Kitazato Research Center Head	15 experts from industries, universities and government
Hiroshima	Hiroshima Science and Technology Promotion Conference	May 1992	Noriyasu Yoshida, Hiroshima University Assistant Dean	17 experts from industries, universities and government

technology and formulated general principles and guidelines for science and technology policy and have begun actively developing science and technology (Table 3-4-15 and 3-4-16).

Hitherto, R&D advances in regional areas have been centered on the work of public research organizations. More recently, with improvement in the technological development capability of regional industries, many local governments are considering reorganization and rearrangement of public research institutes.

New measures for development of science and technology at the local government level have been appearing. These include the determination of a science city concept in the region and the establishment of a public corporation as a core organization for promoting comprehensively scientific and technological development.

Here, we will various measures taken by the central government to develop science and technology in the regions (Table 3-4-17).

Table 3-4-16 Enactments of science and technology promotion policies by regional public organizations

Prefecture	Science and technology promotion policy	Date of enactment
Osaka	Osaka Research and Development Charter	March 1988
Shizuoka	Basic Direction of Science and Technology Promotion Policies in Shizuoka Prefecture	January 1990
Saitama	Saitama Technology Policy for the 21st Century	February 1990
Kanagawa	General Guideline for Kanagawa Science and Technology Sixth Plan	May 1990
Hyogo	General Guideline for Hyogo Science and Technology Sixth Plan	March 1991
Hokkaido	Basic Direction of Science and Technology Promotion Policies in Hokkaido	April 1991
Toyama	General Guideline for Toyama Science and Technology	October 1991
Yamanashi	Yamanashi Science and Technology Sixth Plan	March 1992

3.4.3.6.1 Measures for Interaction Within and Outside Regional Areas

3.4.3.6.1.1 Adviser Meeting on Local Science and Technology Policy and Forum on Local Science and Technology Policy

To better promote regional and national science and technology through the science and technology policy, the Council for Science and Technology, in cooperation with the science and technology committees set up in each prefecture, began Adviser Meetings on the Science and Technology Policy in FY1991 between the members of the Council's Committee on Policy Matters and the chairmen of prefectural science and technology committees to exchange opinions on science and technology policy. Also, to discuss questions of regional science and technology policy and include not only experts directly involved in formulating regional science and technology policy, but also experts related in some way to such policy, and researchers themselves, The Forum on Local Science and Technology Policy was started in FY1992.

3.4.3.6.1.2 Regional Science and Technology Promotion Conference

As a part of the measures to promote science and technology in regional areas, the Science and Technology Agency has divided the entire country into eight separate blocks and has held Regional Science and Technology Promotion Conferences for each block. The conferences seek to encourage an environment for closer cooperation among science and technology organizations, the industrial community and the academic community and to contribute to stabilizing, the science and technology promotion infrastructure in regional areas. At these conferences, representatives from the various sectors, especially those related to science and technology, come together and look at differences in national and regional opinions concerning science and technology and the issues surrounding the promotion of science and technology in that region.

3.4.3.6.1.3 Japan Association for the Advancement of Research Cooperation (JAREC)

The Japan Association for The Advancement of Research Cooperation was established in June 1992 with funds provided by the prefectures to engage in various activities that contribute to promoting regional science and technology. An office is located in the Tsukuba Science City. This association conducts

Table 3-4-17 Regional science and technology promotion measures

Ministry or Agency, related organizations	Item	Outline of measures
Science and Technology Agency	Lifestyle and regional movement research (Special Coordination Funds for Promoting Science and Technology)	Outstanding researchers from inside and outside the region representing regional research organizations related to industry, universities and government are gathered and research for the improvement of the quality of life and research for the activation of regions are conducted.
Science and Technology Promotion Bureau	Regional research exchange promotion project (Regional high-tech network)	Promotion of information distribution and new technology corporations centering on the new technology coordinator for regional research information networks in order to advance regional research and development functions.
Institute of Physical and Chemical Research	Frontier research and regional development	Joint research is conducted with the cities and prefectures on new technology issues with activities centering around regional research organizations.
Japan Marine Science and Technology Center	Regional joint research and development projects	Joint research is conducted with the cities and prefectures on technology issues that must be overcome in order to promote the comprehensive use of regional ocean territory.
Environmental Agency, Planning and Coordination Bureau	Research Funds for the National Organization for Pollution Prevention (Research to meet regional needs)	Public facility joint research is conducted with national testing and research organizations concerning research issues matched to specific regional needs.
Ministry of Agriculture, Forestry and Fisheries, Agriculture, Forestry and Fisheries Research Council Secretariat	Regional biotechnology research and development promotion	Public facility testing joint research with regional agricultural testing sites of the Ministry of Agriculture, Forestry and Fisheries in high-tech areas of research and development.
	Joint research with prefectural agricultural testing sites	In terms of important research issues stemming from the demands of agricultural testing sites, in addition to public facility testing joint research conducted with the national research facilities of the Ministry of Agriculture, Forestry and Fisheries, the nation's researchers enter the local areas directly and, through close links with public facilities testing, conduct technological development necessary for securing the large-scale high-productivity agricultural industry needed to meet the actual regional conditions.
	Joint research system for public and private exchange (regional technology joint research)	In terms of special research issues that need to be immediately resolved, regional agricultural testing sites and local public facilities testing are linked and research is conducted.
Ministry of International Trade and Industry, Agency of Industrial Science and Technology	Important regional technology research and development system	Joint research is conducted on important technology issues that meet specific regional needs.

various research support activities and research exchange promotion activities nationally when regional areas begin research in advanced or basic research areas.

3.4.3.6.2 National Research System for Research and Development in Regional Areas

The relevant ministries and agencies have set up a variety of research systems in order to conduct R&D in regional areas. The following section introduces some of the main examples.

3.4.3.6.2.1 Science and Technology Agency

The Science and Technology Agency, using Special Coordination Funds for Promoting Science and Technology from FY1990, has initiated a regional research program. The program assembles at regional research organizations, top researchers from within and outside the region and employs the special characteristics of the region to conduct basic and leading research which contributes to improving Japan's level of science and technology. Since FY1992, contributing to the improvement of the living standards of local people has been added as a theme. This program is being expanded under the title of Joint Research Utilizing Scientific and Technological Potential in Region.

This research takes place under a central regional organizer who guides research efforts. Researchers from national research institutes, universities, local government research institutes and private companies are brought together to strongly encourage research.

The Japan Marine Science and Technology Center (JAMSTEC) has implemented a joint research and development program since 1988. It involves joint research with prefectures to advance marine science and technology, to disseminate knowledge on these and to promote the usage of sea areas in regions.

3.4.3.6.2.2 Environment Agency

Since FY1993, the Environmental Agency has been performing environmental research closely related to local regions as joint research together with national research institutes and public research institutes into issues which are of strong concern to regions and which should be examined as a result of the characteristics of the regional environment.

3.4.3.6.2.3 Ministry of Agriculture, Forestry and Fisheries

Since FY1984, the Ministry of Agriculture, Forestry and Fisheries has been carrying out joint research with the Ministry's research institutes and public research institutes into important research issues on the basis of requests made by public agricultural research organizations. In addition, since FY1986 the Ministry's regional agricultural research institutes and public research institutes have been promoting regional biotechnology R&D in the form of joint R&D activities in the field of biotechnology.

The Ministry has implemented regional, concentrated, cooperative, technology research since FY1992. This effort brings together regional agricultural testing plants, local government research institutes and private companies to cover research themes related to regional research needs.

3.4.3.6.2.4 Ministry of International Trade and Industry (MITI)

Since FY1982, the Ministry of International Trade and Industry has implemented the Priority Regional Technology Research and Development System. In this program, the Agency of Industrial Science and Technology's (AIST) regional testing laboratories, local government research institutes and private companies join together to conduct research and development on priority research and development themes which meet regional needs or take advantage of regional research and development potential.

3.4.3.6.3. Support for Concentrating Research and Development Functions

In the past, policies for industrial promotion in regional areas have focused on attracting or relocation of plants. The importance of attracting research facilities and advanced industrial technologies is being recognized now as a more effective approach. It is now felt that comprehensive development, in which organizations to support research are provided and living and recreational environments are improved, is also necessary.

3.4.3.6.3.1 Technopolis Development Plans

Technopolis development plans are based on the Promotion Act for Accelerating the Development of High-Tech Industry Integrated Region (Technopolis Act). They seek to promote the concentration of advanced technology industry in regional areas and the creation of urban areas which assemble industry, academia, and living facilities around an advanced technology. These plans are a new type of regional development proposed by the local area and tailored to regional particularities.

3.4.3.6.3.2 Key Facilities' Siting Law–Law to Promote the Group-Siting of Designated Types of Business Contributing to More Sophisticated Local Industrial Structures

With the increasing shift to software and service in economic activities, the Key Facilities' Siting Location Law has two purposes. It is intended to attract to regions special operations, defined as natural science research institutes, software industry, information service industry, and other non-manufacturing departments as well as to promote the regional distribution of plants.

3.4.3.6.3.3 Multi-Polar Act–Act on the Promotion of Multi-Polar Pattern National Land Formation

The development of regional research bases in line with the Multiple-Polar Act is designed to develop and establish wide-ranging regional promotion bases in a comprehensive and strategic manner by concentrating industrial, cultural, scientific, research and exchange functions which are distinct to the region and to strongly support regional development led by regional forces.

3.4.3.6.3.4 Private Sector Resources Utilization Law–Temporary Law for Promoting the Strengthening of Specific Facilities by Utilizing Private Sector Business Capabilities

The Private Sector Resources Utilization Law was passed in May 1986. It is designed to promote utilization of the capabilities of the private sector in providing facilities which strengthen the economic and social infrastructure. The facilities related to research and development are grouped in four categories: research core facilities which are dedicated to research and development and commercialization of industrial technologies; telecommunications research park facilities which are designed for research and development of telecommunications technologies; agriculture, forestries and fisheries research and development and commercialization infrastructure facilities; and the coastal regions revitalization facilities.

3.4.3.6.4 Consolidation of Information and Communications Infrastructure

3.4.3.6.4.1 Activities for Promotion of Regional Research Exchange–Regional High-Tech Network

The Science and Technology Agency started a research information network in regional areas in FY1988. Based on this, the Agency has striven projects to promote research exchange, information exchange within the region and between regional areas and the Tsukuba Science City and to encourage the development of new technologies. Also, these various regional research information networks are connected with the Tsukuba Science City Tsukuba Network, thus contributing to interaction between regional areas and Tsukuba.

3.4.3.6.4.2 Other National Information Networks

The Japan Information Center of Science and Technology (JICST) has created a comprehensive database of documents on science and technology and provides this on-line through the JICST network. Branch offices are located in 10 locations nationwide and are used by regional researchers.

National and International Networks of Science Information centered on the National Center for Science Information are connecting national, public and private universities nationwide is being developed.

Since August 1993, an information retrieval service and other services have been made open to the public for use by researchers outside universities and other people.

The on-line Patent On-Line Information System provided by the Japan Patent Information Organization started service in 1978. In addition, the Japan Technomart Foundation which distributes technical information has branch offices in 10 regions.

3.4.3.6.5 Consolidation of R&D bases

The fourth Nationwide Comprehensive Development Plan calls for the consolidation of Tsukuba and the hilly area of Kyoto, Osaka and Nara as a base for cultural, academic and research activities. It also calls for a research institute city to be established in the regions making use of the characteristics of each region, and for the creation of a network to link these to R&D and other activities.

3.4.3.6.5.1 Tsukuba Science City

Tsukuba Science City has been created as a base to provide a high level of research and education in addition to contributing to the well-balanced development of the entire Tokyo metropolitan area. It is being constructed as part of the national policy to respond to the needs of the age as regards science, academic research and advanced education.

In this city, currently, 47 national research institutes, educational organizations and the like have been established and are operating. Private research organizations are also moving into the city.

The city is developing in this manner, and is promoting the establishment of facilities from both within Japan and overseas which are fostering its development as an R&D base.

3.4.3.6.5.2 Kansai Science City (Kyoto, Osaka and Nara Prefectures)

Kansai Science City seeks to take advantage of the abundant culture, science, and research cultivated by the Kinki area over many years as the foundation of a new base for international, interdisciplinary, and interactive culture, science, and research. It is being developed based on the Kansai Science City Construction Promotion Law.

3.4.3.7 "Cooperative Technology Development" and "Technology Transfer Facilitation"

The Research Development Corporation of Japan (JRDC) surveys and compiles experimental research results at universities, national research institutes and other research organizations to pick out promising results, and under "Cooperative Technology Development" System contacts with companies to develop those results which otherwise would be difficult to be commercialized. In this way JRDC actively promotes the commercialization of new technologies. JRDC also makes available the developed technology so that it can be used by companies in the private sector.

For new technologies which can be developed on a commercial basis with relatively small risks, JRDC promotes their transfer to companies through "Technology Transfer Facilitation" activity. JRDC promotes technology transfer to foreign countries by publishing an English-language magazine introducing new technologies possible for licensing overseas.

By the end of FY1992, 277 "Cooperative Development of Industrial Technology" projects were successful and 489 experimental research results were transferred to 784 companies.

3.4.3.8 Promotion of Research in the Private Sector

3.4.3.8.1 Promotion through Preferential Taxation and Financial Provisions

The government is promoting the smooth development of research activities and the advancement of new technology through preferential taxation and financial provisions for private-sector research expenditures.

Tax benefits within the national taxation system include *The Tax Deduction on Experimental and Research Expense Increments,* instituted in FY1976. This program has been a major factor in encouraging the expansion of private-sector research activities based on independent and innovative efforts. This allows corporations to deduct from their tax assessment 20% of the incremental increase over their previous highest expenditure for research.

Another preferential tax measure, adopted in FY1985, is *The Tax Program for Promoting R&D of Basic Technologies* which exempts businesses from 7% of the acquisition cost of assets, such as equipment and facilities, purchased for the purpose of conducting R&D in the basic technology areas.

Another measure of this type adopted in the same year is *The Tax Deduction for Strengthening the Technological Foundation of Small - and Medium-scale Enterprises.* This program, which may be selected as an alternative to *The Tax Deduction on Experimental and Research Expense Increments,* allows small-and medium-sized enterprises to deduct from their assessment a maximum of 6% of their overall research expenditures every tax year.

Similar preferential tax provisions to *The Tax Program for Promoting R&D of Basic Technologies* and *The Tax Deduction for Strengthening the Technological Foundation of Small- and Medium-scale Enterprises* were adopted as special measures in local taxation structures and provide for reductions in the standard taxation determined by the corporate residential tax rate. See also Table 3-4-18 for a summary of the main tax provisions for promoting science and technology.

3.4.3.8.2 Promotion through funding and loans

A variety of organizations have provided assistance in the forms of funding and loans in order to promote R&D activities in the private sector. The following section introduces some of the main examples.

3.4.3.8.2.1 Japan Key Technology Center

Japan Key Technology Center was established in October 1985 with the aim of promoting experimental research in the private sector concerning fundamental technology in the mining, engineering, telecommunications and broadcasting industries. Using funds from the Industry Investment Special Account, the Japan Development Bank and private sources, the Center provides conditional interest-free loans and funds, and encourages joint research activities. In FY1993, funds from the Industry Investment Special Account totaled 26,000 million yen.

3.4.3.8.2.2 Bio-oriented Technology Research Advancement Institution

This institution was established in October 1986 with the aim of promoting experimental research in the private sector concerning designated industrial technology of biological systems. Using funds from the Industry Investment Special Account and private sources, the institution provides conditional interest-free loans and funds, and encourages joint research activities. In FY1993, funds from the Industry Investment Special Account totaled 3,300 million yen.

3.4.3.8.2.3 Drug Fund for Adverse Reaction Release and Research Promotion

This Found started operating in October 1987 with the aim of promoting experimental research in the private sector concerning medical products technology and similar matters. Using funds from the Industry Investment Special Account and private sources, the Found provides conditional interest-free loans and funds, and encourages joint research activities. In FY1993, funds from the Industry Investment Special Account totaled 2,300 million yen.

Table 3-4-18 Major preferential for science and technology promotion (as of April, 1993)

Item	Purpose	Description	Applicable law	Date of enactment / validity
Tax Deduction on Experimental and Research Expense Increments	Promotion of technological development	[National Taxes] 1. Corporations can deduct 20% of the incremental increase in research expenditures form their tax assessment (with an upper limit of 10% of their tax assessment) provided that the research expenditures for the applicable tax year (the amount debited against income) exceed the maximum annual research expenditure for all tax years falling between the standard tax year (defined below) and the immediately preceding business tax year. In addition, corporations may treat 20% of investments in approved experimental research companies as a research expenditure. Notes: Applicable tax years: All business years starting between June 1, 1967 and March 31, 1995 Standard tax years: Business tax years immediately preceding the business tax year in which January 1, 1967 falls 2. Identical provisions apply to individuals	Special Taxation Measures Law, Article 10, Item 1 (personal income tax), Article 42-4, Items 1,6 (corporate income tax)	Enacted in FY 1967, effective through FY1994
Tax Program for Promoting the R&D of Basic Technologies	Promotion of technological development	[National taxes] 1. In addition to the current Deductions on Experimental and Research Expense Increments, corporations may deduct from their tax assessment 7% of the acquisition cost of assets to be used for R&D of basic technologies, including special materials, advanced electronics technology, telecommunications technology, and space-development, with an upper limit of 15% of their tax assessment. 2. Identical provisions apply to individuals	Special Taxation Measures Law, Article 10, Item 2 (personal income tax), Article 42-4, Item 2 (corporate income tax)	Enacted in FY 1985, effective through FY 1994
		[Local taxes] 3. Corporations may deduct 7% of the acquisition cost if assets to be used for R&D of basic technologies from the standard taxation determined by corporate residential tax rate, with an upper limit of 15% of the standard taxation.	Local Taxation Law, Supplementary Provisions, Article 8, Item 1	Enacted in FY1985, effective through FY1994

(Table 3-4-18)

Item	Purpose	Description	Applicable law	Date of enactment / validity
Tax Program for Strengthening the Technological Foundation of Small and Medium-scale Enterprises	Promotion of technological development	[National taxes] 1. As an alternative to taking the Deductions on Experimental and Research Expense Increments, small and medium-scale enterprises paying corporate income taxes may choose to take a tax deduction of 6% of their research expenditures with an upper limit of 15% of their tax assessment. In addition, they may treat 20% of investments in approved experimental research companies as a research expenditure. 2. Identical provisions apply to individuals	Special Taxation Measures Law, Article 10, Item 3 (personal income tax) Article 42-4, Items 3,6 (corporate income tax)	Enacted in FY 1985, effective through FY 1994
		[Local taxes] 3. Small and medium-scale enterprises opting for the 6% deduction above may deduct this amount from the standard taxation determined by the corporate residential tax rate, with an upper limit of 15% of the standard taxation.	Local Taxation Law, Supplementary Provisions, Article 8, Item 2	Enacted in FY 1985, effective through FY1994
Tax Deduction on Special Experimental and Research Expenses	Promotion of technological development	[National Taxes] 1 For experimental research expenses related to joint research with national testing and research organizations and for experimental research expenses related to technology involving technology for the rationalization of energy use and specific substance use, the following totals are recognized as tax deductions. (However, this is limited to corporate taxes of 10%, or 15% if (2) applies). (1) 6% of the relevant amount for special experimental research expenses for the applicable fiscal year. (2) 7% of the acquired amount in cases where there is acquisition of capital for basic technology research and development. (3) 20% of the least relevant amount if either the amount for (a) or (b) below are added. (a) Amount of testing research expenses for the applicable fiscal year – Amount of comparative experimental research expenses. (b) (Amount of testing research expenses for the applicable fiscal year – amount of special testing research expenses for the applicable fiscal year) – (amount of comparative testing research expenses – amount of special testing research expenses for the business year in which the amount of comparative testing research expenses has been paid) In cases where there is investment in special testing research companies, it is possible to add 20% of the relevant amount for investment to the amount of testing research expenses for the applicable fiscal year in (3) (a) and (b) above. 2. Identical provisions apply to individuals	Special Taxation Measures Law, Article 10, Item 4 (personal income tax), Article 42, Item 4,5,6 (corporate income tax)	Enacted in FY 1993, effective through FY 1994

(Table 3-4-18)

Item	Purpose	Description	Applicable law	Date of enactment / validity
Special Exemption of Income Associated with Overseas Transactions Related to Technology Transfers	Promotion of diverse types of overseas transactions and the promotion of technology transfers and domestic technology development	1. Corporations receiving income from overseas transactions related to technology transfer are exempt from a portion of this income (not to exceed 40% of applicable tax year's income) as a debit against taxable income. Specifically, they are exempt from: * 8% of income from the supply or transfer of industrial property rights (excluding trademark rights) and know-how. * 16% of income from consulting activities. 2. Identical provisions apply to individuals	Special Taxation Measures Law, Article 21 (personal income tax) Article 58, (corporate income tax)	Enacted in FY 1964, effective through FY 1993
Exemption of Donations and Contributions				
1. Donations to specified public-service promotion corporations. See note.	Promotion of education, science and technology	1. Corporations Corporations may enter the amount of their donations as a separate item of debits-against-income and distinct from general donations. The upper limit is the same as that for general donations.	Corporate Taxation Law, Article 37, Item 3	Enacted in FY 1961
		2. Individuals The income tax exemption corresponding to each donation to a specified public benefit corporation is calculated as the amount of the donation less 10,000 yen. The total amount of donations used in these calculations may not exceed 25% of income.	Personal Income Taxation Law, Article 78, Item 1,2	Tax exemption method enacted in FY 1962 and revised in FY 1967
2. Contributions to specified public-service trusts	Promotion of education, science and technology	Corporations and individuals can apply exemptions for donations to approved public-service trusts by including the amounts of these donations in the totals for donations to specified public-service promotion corporations. Corporations should then calculate debits against income, while individuals calculate income tax exemption. Note: Approved public-service promotion corporations include corporations whose main purpose is research in science and technology, and certain public-service trusts whose purpose is to aid research in science and technology.	Corporate Taxation Law, Article 37, Item 5 Personal Income Taxation Law, Article 78, Item 1,3	Enacted in FY 1987
3. Specific donations	Promotion of education, science and technology	Corporations may deduct the entire amount of donations allocated for urgently needed education or science promotion expenditures in debits against income. Individuals may treat these donations to specified public-service promotion corporations as described above	Corporate Taxation Law, Article 37, Item 3, Personal Income Taxation Law, Article 78, Item 1,2	Enacted in FY 1960

(Table 3-4-18)

Item	Purpose	Description	Applicable law	Date of enactment / validity
Measure for Exceptional Treatment of Fixed Asset Acquisitions for Experimental Research by the Mining and Industrial Technology Research Cooperatives	Promotion of technological R&D	Members of the Mining and Manufacturing Technological, Research Association may apply special depreciation to payments levied by the Association to acquire fixed assets for experimental research.	Special Taxation Measures Law, Article 18 (personal income tax), Article 52 (corporate income tax)	Enacted in FY 1961, effective through FY1992
		The Mining and Industrial Technology Research Cooperatives may enter the value of fixed assets acquired for experimental research by levy on members in its account books as 1 yen	Special Taxation Measures Law, Article 66- 10	Enacted in FY 1961, effective through FY1992
Measure for Tax Exemptions on Research Assets of Scientific Research Corporations	Promotion of science and technology	Assets provided to corporations established under Civil Law Article 34 for the purpose of scientific research are exempt from the real estate acquisition tax, fixed assets tax, special land holding tax and urban planning tax on investments used directly for- that research.	Local Taxation Law, Article 73-4, Item 1, Article 348, Article 586, Article 702-2	Fixed asset tax enacted in FY 1951, real estate acquisition tax, in FY 1954, urban planning tax, in FY 1956, special land holding tax in FY 1973
Fixed Asset Tax Reduction Measure for Machines and Equipment for Research Acquired by the Mining and Industrial Technology Research Cooperatives	Promotion of technological development	The standard of assessment for the machinery and equipment fixed assets approved under the regulations of the Mining and Industrial Technology Research Cooperatives Law, Article 14 and additionally acquired between April 1, 1991 and March 31, 1993 is valued at five-sixth of the standard value for period of three years from the year in which tax was first levied on the asset.	Local Taxation Law, Supplementary Provisions, Article 15, Item 26	Enacted in FY 1962, from FY1991,applicable for the first two years after acquisition

3.4.3.8.2.4 Other financial provisions

There are also a number of financial provisions designed to help raise the nation's level of technological development through the provision of low-interest loans. These include the Financing for Development and Promotion of Technology administered by the Japan Development Bank's Domestic Technology Promotion Funding System. The Technology Promotion Funding System provided loans totaling 149,800 million yen during FY1992.

Further, Japan Finance Corporation for Small Business has established the Loan for the Development of New Industries and Technology to stimulate new technology development and further technological advancement at small- and medium-scale enterprises.

3.4.4 International Exchange of Science and Technology

3.4.4.1 Bilateral Cooperation

3.4.4.1.1 Cooperation with Industrialized Nations

Cooperation between Japan and other industrialized nations is conducted mainly on the basis of bilateral agreements. Cooperative goals include solutions to problems common to the nations related to natural resources development, energy development, nuclear energy, space development, ocean development, biotechnology and environmental protection.

Japan and the United States have been cooperating in this area since the Japan-U.S. Science and Technology Cooperation Agreement was concluded in June 1988.

So far, an active exchange of opinions has taken place on a variety of levels, including three meetings of the Joint High-Level Committee chaired at the ministerial level, four meetings of the Joint Working-Level Committee that laid the groundwork for the Joint High-Level Committee, and three meetings of the Joint High-Level Advisory Panel of experts from the two countries. In addition, two Task Forces met to investigate issues of the participation of researchers in R&D and access to scientific and technological information of each country.

In May 1993, the Joint High-Level Committee was convened in the United States, the first since the inauguration of the Clinton Administration. The Clinton Administration had declared the importance of securing American industrial competitiveness in the fields of science and technology. The Committee vigorously examined a wide variety of issues, including the science and technology policies of both countries, cooperative activities between the two countries, and global environmental issues. Both sides were agreed on recognizing the importance of fully securing mutual trust between member nations when advancing international cooperation in large-scale projects such as space stations. In terms of extending this agreement which was to remain in effect until June 1993, the two countries were satisfied that the agreement acted as a framework contributing to the advancement of technological cooperation, and the agreement was extended for a further five years.

In 1993, 60 U.S. graduate students joined Japan's public and private research institutes for approximately 2 months from June to August. This program, the 4th Summer Institute was carried out by Task Force on access to R&D (TFA) which has established under the framework of the Japan-U.S. Agreement on Cooperation in Research and Development in Science and Technology and sponsored by National Science Foundation (NSF) and the Center for Global Partnership of the Japan Foundation.

The Japan-U.S. Energy R&D Agreement was revised in February 1990, primarily to keep up with the changes made in the Japan-U.S. Science and Technology Cooperation Agreement.

Japan-U.S. cooperation in research and development of space have been carried out based on the arrangement concerning cooperation in research and development of space which was concluded in July 1969, or under the supervision of the Standing Senior Liaison Group (SSLG) which was established in July 1979 based on the mutual agreement between the Space Activities Commission and the National Aeronautics and Space Administration (NASA).

Further, cooperation in the area of science and technology is being encouraged in a wider range through the Japan-U.S. Conference on Development and Utilization of Natural Resources (UJNR), Japan-U.S. Cooperation Agreement on Nuclear Energy and Japan-U.S. Committee on Scientific Cooperation, etc.

At the Japan-United States summit of April 1993, instead of the Japan-United States Structural Impediments Initiative, a new framework, the Japan-United States Framework for new Economic Partnership, was established to discuss such issues as active mutual cooperation with the new structural problems, economic problems in various fields, and technological and environmental matters.

In June 1991, the new Japan-France Science and

Technology Cooperation Agreement, a revision of the old agreement concluded in 1974, was concluded in order to advance further scientific and technological cooperation between both countries. The agreement was revised because of recent progress in science and technology made in both countries. Under the new agreement, three types of meetings will be held: a meeting of high-level representatives at the cabinet level, a joint working committee of concerned experts and a joint committee of business people working in the field. At the first Joint Committee, convened in June 1993, participants reached agreement on various cooperative issues contained in the agreement, and exchanged opinions about such matters as the science and technology policies of the two countries.

Concerning the Cooperation with Canada, the Japan-Canada Science and Technology consultation began in 1972. This was superseded by the Japan-Canada Science and Technology Cooperation Agreement to further strengthen bilateral cooperation in science and technology, which was signed in May 1986.

In July 1989, the Report on Japan-Canada Complementary Study was completed by experts of both countries to explore the priorities for future scientific and technological cooperation. Based on this study, cooperative activities have been promoted through bilateral workshop program in which researchers from both countries can discuss and exchange views on specific research theme.

Further, the "Japan-Canada Forum 2000" report, initiated by an agreement reached at the Japan-Canada summit in May 1991, was published in December 1992, advocating scientific and technological cooperation with environmental problems in the North Pacific region.

Japan and Germany cooperate in the areas of nuclear energy, life sciences, ocean science and technology, etc. based on the Japan-Germany Science and Technology Cooperation Agreement concluded in October 1974 between Japan and West Germany. After the integration of East and West Germanies in October 1990, the Agreement was confirmed to be effective under the entire territory of integrated Germany. Progress in cooperation with integrated Germany is expected in the future.

Japan has concluded science and technology cooperation agreements with Italy and cooperative activities in a variety of fields are underway based on these agreements. Cooperation with other countries is also underway through working-level staff activities, including Anglo-Japanese Science and Technology Cooperation Talks between Japanese and UK officials and the Japanese-Finish Meeting on Cooperation in Science and Technology, as well as through Trade and Economic Consultations with Sweden and Norway.

The Japan-EC Ministerial Meeting and the Japan-EC High Level Consultation have also been taking up issues for science and technology cooperation. Japan suggested and is currently preparing for the Japan-EC Meetings on Science and Technology Cooperation with the purpose of promoting cooperation on science and technology between the two parties.

3.4.4.1.2 Cooperation with Asian and Pacific Rim countries

Based on the Japan-Republic of Korea Science and Technology Cooperation Agreement concluded in December 1985, Japan is cooperating with South Korea in such fields as ocean science, resources and energy, and the preservation of health and the environment.

Japan is also cooperating with China based on the Japan-China Science and Technology Cooperation Agreement concluded in May 1980 in carrying out information exchanges, exchanges of specialists and joint research with the aim of promoting cooperation in the fields of science and technology. The two countries have established a Japan-China Science and Technology Cooperation Committee to further advance cooperation.

In addition, Japan is cooperating with Australia, Indonesia, India and Brazil in various fields on the basis of science and technology cooperation agreements. Also, Japan is cooperating with the nations of Asia and the Pacific Rim, both in multilateral and bilateral forms of cooperation, under the terms of the Association for Science Cooperation in Asia (ASCA).

3.4.4.1.3 Cooperation with the FSU, Central and Eastern European Countries

Cooperation with the Former Soviet Union (FSU) has been promoted based on the Japan-U.S.S.R. Agreement on Cooperation in Science and Technology, concluded in October 1973. Under this agreement, seven joint committees have been formed and the first joint committees with Russia was held in February 1993. Cooperation has been promoted in the form of exchange of information and researchers, holding seminars, etc. in the fields of nuclear fusion, agriculture, etc.

In addition to the above, investigator exchanges have increased under the Japan-U.S.S.R. Researcher Exchange Arrangement.

Although the U.S.S.R. collapsed at the end of 1991, the Japan-U.S.S.R. Agreement on Cooperation in Science and Technology, etc. is effective with Russia since it has taken over the same authority.

At the first meeting of the Japan-Russia Science and Technology Cooperation Committee held in February 1993, agreement was reached to continue and expand cooperation in the fields agreed upon at the previous 7th Japan-U.S.S.R. Science and Technology Cooperation Committee. Also, the two countries agreed to start cooperation in the three fields of new high energy physics and accelerator science, communications technology, and energy R&D.

Japan has been cooperating with the Central and East European countries through exchange of researchers, etc. according to science and technology cooperation agreements with Poland and Yugoslavia and science and technology cooperation arrangements with Romania, Bulgaria, Czechoslovakia and Hungary (former Yugoslavia has collapsed as a nation, and cooperation with former Yugoslavia has ceased except with Croatia and Slovenia).

The former state of Czechoslovakia has separated into The Czech Republic and The Slovak Republic, and discussions are now in progress about reaching agreements.

3.4.4.2 Multilateral Cooperation

3.4.4.2.1 International Cooperation Based on the Economic Summit of the Heads of State or Government of Seven Major Industrial Nations and the President of the Commission of the European Communities

The leaders of the industrialized nations have been discussing science and technology issues at Summits every year since French President Mitterand first raised the subject at the 8th Summit at Versailles in June 1982.

In 1989, the Arch Summit initiated cooperation in global environmental problems which have become of increasing concern in recent years. Further efforts were required in expanding global observation and monitoring activities, performing scientific surveys about the global weather conditions, and developing and disseminating energy and environmental technology.

In July 1992, at the Munich Summit, various countries requested that the seven advanced nations of the world take action about global environmental problems. In terms of the issue of scientists and engineers leaking intelligence out of the former U.S.S.R., it was confirmed that an International Science and Technology Center would be established to support the employment of scientists and engineers who had been involved in the production of weapons of mass destruction in work for peaceful objectives.

At the Tokyo Summit in July 1993, the necessity of countries cooperating to support nuclear non-proliferation and increase the safety of nuclear power stations in the former U.S.S.R. was reconfirmed. Also, it was declared that among the policies of the seven advanced nations, global environmental problems would continue to be given highest priority.

3.4.4.2.2 Cooperation with the United Nations

United Nations committees and organizations are addressing important issues related to natural resources, energy, food, climate, environment and natural disasters, since these problems require solutions derived from a global perspective.

They are making an effort to contribute to a long-term solution of the North-South problem by strengthening the science and technology capabilities of developing nations as these nations suffer the most from the above-mentioned problems.

The United Nations Conference on Environment and Development (UNCED: Global Summit) was held in Rio de Janeiro.

Participants from 140 nations attended against the backdrop of the increasing worldwide interest in global environment problems in recent years. The Global Summit produced abundant results: over 150 nations signed the "Rio Declaration on Environment and Development" which provided the action principles for nations and individuals in preparation for the 21st century, "Agenda 21" and "Declaration on Forest Principles", which comprised concrete action plans for this Rio Declaration, and the "Framework Treaty on Climate Variations" and "Biological Diversity Treaty". Follow-up discussions to the Global Summit took place at the 47th United Nations General Assembly, and resolutions were passed to establish a "Sustainable Development Committee" and a "Government Negotiating Committee to Formulate a Treaty to Prevent the Spread of Deserts".

Based on these United Nations resolutions, the "Sustainable Development Committee" was established in February 1993, and held its first meeting in June of that year. The "Government Negotiating Committee to Formulate a Treaty to Prevent the Spread of Deserts" held its first meeting in May 1993.

3.4.4.2.3 Cooperation within the Organization for Economic Cooperation and Development

Cooperation in science and technology related activities within the Organization for Economic Cooperation and Development (OECD) framework has been conducted through the Committee for Scientific and Technological Policy (CSTP), Committee for Information, Computer and Communications Policy (ICCP), Industry Committee, Environment Committee, Nuclear Energy Agency (NEA), International Energy Agency (IEA). Activities include exchanging opinions, useful experiences, information and personnel, compiling of statistical information and being involved in joint research projects.

Recently, Policy Statement on Technology and the Economy was appended to the communique which was adopted by the Council of the OECD at Ministerial level in June 1991. It includes the result of the Technology and Economy program (TEP) which was conducted with the aim to acquire a comprehensive picture of the influence of science and technology on the world's socioeconomic situation.

In March 1992, OECD Committee for Scientific and Technological Policy at Ministerial level was held with the theme "Science and Technology Policies in the 1990s - The Interrelatedness of the National and International Dimensions". In this meeting, the following were agreed on.

1) Establish a forum so that necessary information can be exchanged and debates conducted from the initial stages of megascience projects (major facility projects and large scale geographically distributed programs)
2) Establish a forum to support improvement in science and technology capabilities in Central and East European countries, to expand exchanges between researchers, etc. and to exchange information on the cooperation situation
3) Conduct follow-ups on TEP and take coordinated activities in science and technology, industrial trade and competition policies

The Megascience Forum, established according to an agreement of the Meeting of the Science and Technology Conference, began activities from the time of the first meeting in July of 1992. In addition to the main meeting, activities have been promoted through specialist meetings in the areas of astronomy, deep earth excavation and global change research.

3.4.4.2.4 Promotion of the Human Frontier Science Program

The Human Frontier Science Program (HFSP) is an international program which promotes, through international cooperation, basic research focused on the elucidation of the sophisticated and complex mechanisms of living organisms. The Japanese government proposed the program at the Venice Economic Summit in June 1987, as a means for the government to contribute to the development of international science and technology in a manner appropriate to its economic standing. The HFSP also can help to increase international public assets through the promotion of basic research and to make the research results available to all humankind.

The program and the Japanese initiative behind it have been lauded by the Economic Summit member countries. In October 1989, the organization for the implementation of the HFSP, the International HFSP Organization (HFSPO), was established in Strasbourg, France.

The Program offers support for the following activities.

- Research grants: Subsidies for international joint research teams
- Long-term and short-term fellowships: Travel and accommodation subsidies for researchers who wish to do research in foreign countries
- Workshops: Subsidies for international workshops

The fields eligible for support fall into two basic research areas—the elucidation of brain functions and the elucidation of biological functions through a molecular level approach. On the basis of recommendations by the International Scientific Committee, consisting of eminent scientists, these research areas were agreed to by the countries concerned.

On January 1992, government representatives of countries which support the HFSP agreed to continue the program on a full phase after April 1992.

The HFSPO reported in March 1993 that 343 researchers had been selected as the award recipients for the fourth fiscal year.

3.4.4.2.5 Association for Science Cooperation in Asia (ASCA) cooperation

In November 1970, agreement was reached on the establishment of ASCA. With the aim of exchanging information on science and technology policies and research and development plans in Asia, shedding light on areas of common interest, and investigating and strengthening policies for the promotion of international science and technology cooperation projects within the region, ASCA has met 12 times to bring together the ministers in charge of science and technology from each nation. At the 12th meeting held in November 1992 and the high-level meetings held in Tokyo in March 1993, members agreed to consider policies for cooperation in the Asia-Pacific region and policies for the future expansion of ASCA and its activities, and to strengthen cooperation at ASCA through the exchange of information and development of human resources. In addition to sending a representative to each meeting, Japan has conducted seminars focusing on areas of high interest to the countries of ASCA. Since 1980, Japan has been implementing ASCA science and technology information cooperation projects that provide information on science and technology from Japan to the other members of ASCA.

3.4.4.2.6 International Science and Technology Center (ISTC) Cooperation

In November 1992, Japan, the United States, the European Community and the Russian Federation signed an agreement to set up the International Science and Technology Center (ISTC) in order to provide an opportunity for former-U.S.S.R. scientists and engineers with expertise in the area of weapons of mass destruction to steer their talents toward peaceful activities, and to help contribute to the resolution of domestic issues faced by the former-U.S.S.R. as well as issues faced by the international community. The establishment of this center is being deferred until Russia finishes the necessary procedures.

Japan intends to actively contribute personnel and use its past experiences toward cooperation in future endeavors. Japan will continue to strive to see that the activities of this center are implemented smoothly and developed effectively.

Sweden, Canada and Switzerland have also indicted their intentions to participate.

3.4.4.3 Promoting International Research Exchange

For many years, Japan has been cooperating with other countries in a wide range of fields within the framework of bilateral and multilateral scientific and technological cooperation agreements. However, Japan needs to extend its international research exchange to meet worldwide expectations regarding the nation's role and to stimulate Japanese science and technology within the context of international cooperation.

Since FY1987, the government has carried out the bilateral international joint research within the framework of bilateral science and technology cooperation agreements, by using the Special Coordination Funds for Promoting Science and Technology. To promote effectively international research exchanges in important areas of cooperation in view of policy issues related to science and technology cooperation agreements, etc. the government started in 1991 the International Workshops Support Program to hold international workshops in which researchers may exchange opinions directly.

In FY1993, taking a global perspective in terms of issues that need to be addressed in the wide geographical region of which it is part, Japan built a network of people and information, established a global research network to conduct joint research and initiated "global science and technology cooperation" as the theme for the first year.

In FY1988, to further promote the existing exchange programs among researchers.

- The Science and Technology Agency Fellowship Program, which provides for the acceptance of young researchers from overseas at the national research institutes
- The Japan Society for the Promotion of Science (JSPS) Fellowship for Research in Japan, which provides for the acceptance of overseas researchers at Japanese academic institutions
- The Foreign Researcher Invitation Program of the Agency of Industrial Science and Technology (AIST), which provides for the acceptance of overseas researchers in its research institutes
- Inviting of researchers as an operation of Institute for Transfer of Industrial Technology
- TARC Fellowship Program of Tropical Agriculture Research Center, Ministry of Agriculture, Forestry and Fisheries (TARC, reorganized into Japan International Research Center for Agricultural Sciences in October 1993)

In October 1989, the Research Development Corporation of Japan (JRDC) started the following new programs to expand international research exchanges.

- Administration of the Science and Technology Agency Fellowship Program.
- The Support Program, which includes operating dormitory facilities and providing practical assistance for overseas researchers and their families.
- Constructing of facilities for international research exchange.
- Research Cooperation Promotion Program which send researchers from national research institutes to Asian Pacific countries to promote research cooperation and exchange.
- The Research Information Program, which disseminates scientific and technological information required to increase the exchange .
- International Joint Research Program, which initiates joint research with overseas research organizations.

In addition, other ministries and agencies have taken measures to promote international research cooperation.

3.4.5 Principal R&D Programs

Following paragraphs summarize important R&D programs by government ministries and agencies.

(1) Science and Technology Agency

The Special Coordination Funds for Promoting Science and Technology were first appropriated in FY1981, superseding the previous Special Coordination Funds for Promoting Research. In accordance with the policy set forth by the CST, the funds are intended to support comprehensive coordination of R&D promotion. For example, the funds are used for comprehensive R&D which cuts across the boundaries of existing research organizations.

The funds are administered on the basis of the following six guiding principles.

- Promoting advanced and basic/generic research
- Promoting R&D requiring cooperation among several research institutes
- Strengthening organic ties among industry, the government and academia
- Promoting international collaborative research projects
- Responding flexibly to urgent research needs
- Conducting research evaluation, as well as investigation and analysis of research and development

This coordination fund provides for general research, ministerial based research, research on lifestyles and regional trends, research on priority areas of international exchange, international joint research in areas of individual importance, basic research on priority areas, surveys and analyses and urgent research. In FY1993, this fund also began to develop COE by providing appropriate assistance for national testing and research organizations that are making self-help efforts to maintain a competitive research environment while aiming to bring the level of their expertise to a high international level. This coordination fund amounted to 13.3 billion yen in FY1993.

Special Funds for Investigation and Research of Earth Science and Technology was initiated in FY1989 in order to conduct research to explain global phenomena. The budget for this research in FY1993 was 600 million yen.

For Japan to establish itself as a mature science and technology-based nation, it needs to discover the scientific and technological seeds that become the starting points for the original development of innovative new technologies.

In FY1981, this consideration led the Research Development Corporation of Japan to set up the Exploratory Research for Advanced Technology (ERATO) Program to provide for comprehensive research promotion organized around the most creative people. This is accomplished by appointing distinguished scientists as overall managers with administrative authority over research activities within a designated area of research in a humanistic system which utilizes creativity. It also provides for the procurement of researchers from industry, government, academia and overseas.

Currently, 22 projects are underway with budgets totaling 6.9 billion yen in FY1993. Each project has a limited duration of five years and involves approximately 20 researchers.

The Precursory Research for Embryonic Science and Technology (21 pioneering project) System, set up by its parent organization, the Research Development Corporation of Japan, in 1991, recruits researchers from throughout Japan, selects the top researchers with the most creative ideas and let's the individuals freely conduct their research for a certain period. In FY1993, this system provided a budget of 1.4 billion yen for research on 48 different topics in three different regions.

The Institute of Physical and Chemical Research (RIKEN) initiated the Frontier Research Program in FY1986. This internationally open program brings together researchers in many fields outside the framework of existing research organizations. The program aims at developing new knowledge that will become the foundation for technological innovations in the next century.

Currently, there are three groups active as international frontier research program and two groups active as regional frontier research program. The budget for FY1993 is 2.7 billion yen.

(2) Environmental Agency

In FY1990, the Environmental Agency set up the Comprehensive Promotion Fund for the Promotion of Global Environmental Research to bring together researchers from national testing and research organizations as well as universities and other organizations to promote global environmental research. The budget for this promotion fund was 2.1 billion yen in FY1993.

(3) Ministry of Health and Welfare

In FY1979, the Ministry of Health and Welfare established the Research Grant for Health Sciences to promote research in the areas of health, medical care, sanitation, etc., and had budgets of 9.5 billion yen in FY1993.

(4)Ministry of Agriculture, Forestry and Fisheries

In 1978, the Ministry of Agriculture, Forestries and Fisheries began to implement separate large-scale research to combine the research and development strength of industry, universities and the Government and conduct large-scale research and development. In 1983, the Ministry started to conduct research and development on leading biotechnology in order to promote research related to agriculture, forestries and fisheries. In addition, the Ministry is also conducting comprehensive research and development and separate general research. The budget for these in FY1993 were 1.3 billion yen, 2.2 billion yen, 900 million yen and 600 million yen (total of 5 billion yen), respectively.

(5) Ministry of International Trade and Industry

In FY1993, the Ministry of International Trade and Industry integrated the National Research and Development Program (Large-scale Project), Research and Development Program on Basic Technologies for Future Industries, and National Research and Development Programs for Medical and Welfare Apparatuses to form the Industrial Science and Technology Frontier Program. This system conducts research and development that emphasizes basic, creative areas as well as public, social and welfare areas and implements leading research in the areas of pre-project research and basic research. The budget for this system was 25.3 billion yen in FY1993.

In FY1993, the Ministry integrated the former new energy technology (Sunshine Plan), energy conservation technology Moonlight Plan), and global environmental technology research and development structures and established the Comprehensive Research and Technology Program on Energy and Environmental Technologies (New Sunshine Plan). The budget for this plan was 52.3 billion in FY1993.

(6) Ministry of Transport

In 1982, the Ministry of Transport began to conduct an investigation on R&D of transport technology in regards to topics which need to be carried out with emphasis and urgency and integrated in many research areas. The budget for this investigation in FY1993 was 300 million yen.

(7) Ministry of Posts and Telecommunications

Since FY1988, the Ministry of Posts and Telecommunications has been conducting Research on the Frontier of Telecommunications. The program consists of basic and leading R&D that incur high financial risks and long-term commitments far beyond the capacity of the private-sector. The budget for this program in FY1993 was 800 million yen.

(8) Ministry of Construction

The Ministry of Construction has been implementing since 1972 its Comprehensive Technological Development Project for those issues of urgent need which cover wide-ranging areas of R&D. This program had budgets of 900 million yen in FY1993.

(9) Ministry of Labor

Since FY1990, the Ministry of Labor has been conducting research and development on equipment for expanding the occupational realm and securing the safety and hygiene of elderly citizens. The budget for this research and development was 200 million yen in FY1993.

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In FY1993, the Ministry integrated the former new energy technology (Sunshine Plan), energy conservation technology (Moonlight Plan) and global environmental technology research and development programs and established the Comprehensive Research and Technology Program on Energy and Environmental Technologies (New Sunshine Plan). The budget for this plan was 55 billion yen in FY1993.

(6) Ministry of Transport

In 1982, the Ministry of Transport began to conduct an investigation on R&D of transport technology in regards of topics which need to be dealt with with emphasis and urgency and are related to each research area. The budget for this investigation in FY1993 was 300 million yen.

(7) Ministry of Posts and Telecommunications

Since FY1988, the Ministry of Posts and Telecommunications has been conducting Research on the Frontier of Telecommunications. The program consists of basic and leading R&D that poses high financial risks and long-term commitments far beyond the capacity of the private sector. The budget for this program in FY1993 was 800 million yen.

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APPENDIX

Appendix

1. Changes in R&D expenditures, etc., in Japan

Item / Fiscal Year	Gross national product	National income	R&D expenditures	Government financed R&D expenditures	Defense-related R&D expenditures	A	B	C	D	Number of researchers	Population
	Trillion yen	Trillion yen	100 Million yen	100 Million yen	100 Million yen	%	%	%	%	Persons	10 Thousand Persons
1970	75.1520	61.0297	11,953.28	3,014.13	110.65	1.59	1.96	25.2	24.5	172,002	10,372.0
71	82.8063	65.9105	13,459.19	3,690.25	123.05	1.63	2.04	27.4	26.7	194,347	10,514.5
72	96.5391	77.9369	15,867.08	4,320.68	140.96	1.64	2.04	27.2	26.6	198,084	10,759.5
73	116.6792	95.8396	19,808.96	5,226.84	155.75	1.70	2.07	26.4	25.8	226,604	10,910.4
74	138.1558	112.4716	24,213.67	6,410.77	161.56	1.75	2.15	26.5	26.0	238,179	11,057.3
75	152.2094	123.9907	26,218.27	7,207.55	169.49	1.72	2.11	27.5	27.0	255,202	11,194.0
76	171.1525	140.3972	29,413.73	8,003.86	188.25	1.72	2.10	27.2	26.7	260,250	11,309.4
77	190.0348	155.7032	32,335.43	8,861.15	218.26	1.70	2.08	27.4	26.9	271,956	11,416.5
78	208.7809	171.7785	35,699.53	9,995.02	242.72	1.71	2.08	28.0	27.5	273,102	11,519.0
79	225.4018	182.2066	40,636.27	11,138.22	276.49	1.80	2.23	27.4	26.9	281,920	11,615.5
80	245.3600	199.5902	46,837.68	12,095.57	295.99	1.91	2.35	25.8	25.4	302,585	11,706.0
81	260.3343	209.7489	53,639.86	13,403.20	325.73	2.06	2.56	25.0	24.5	317,487	11,790.2
82	273.4615	219.3918	58,815.39	13,888.12	364.87	2.15	2.68	23.6	23.1	329,728	11,872.8
83	285.9973	230.8057	65,037.37	14,407.17	394.52	2.27	2.82	22.2	21.7	342,237	11,953.6
84	305.7253	243.6089	71,765.11	14,945.46	446.07	2.35	2.95	20.8	20.3	370,045	12,030.5
85	325.3705	259.5898	81,163.99	15,739.53	586.77	2.49	3.13	19.4	18.8	381,282	12,104.9
86	339.6853	269.3947	84,149.93	16,516.80	661.33	2.48	3.12	19.6	19.0	405,554	12,167.2
87	356.2636	281.7375	90,161.86	17,982.70	741.35	2.53	3.20	19.9	19.3	418,337	12,226.4
88	379.2300	299.5894	97,751.65	18,013.73	827.00	2.58	3.26	18.4	17.7	441,876	12,278.3
89	406.0129	319.7384	109,093.35	18,679.36	930.68	2.69	3.41	17.1	16.4	461,634	12,325.5
90	436.9275	344.3293	120,895.93	19,901.47	1,042.68	2.77	3.51	16.5	15.7	484,346	12,361.1
91	460.4451	–	–	–	1,150.45	–	–	–	–	504,966	12,404.3
92	470.6730	–	127,882.21	23,058.68	1,269.89	2.72	–	18.0	17.2	518,869	12,445.2
93	–	–	–	–	1,371.75	–	–	–	–	541,139	–

Notes: 1. A = R&D expenditures as a percentage of gross national product, B = R&D expenditures as a percentage of national income, C = the ratio of R&D expenditures financed by government and D = the ratio of R&D expenditures financed by government excluding defense R&D expenditures.

2. R&D expenditures and the number of researchers are for natural sciences only. Including social sciences and humanities, R&D expenditures in FY1991 were 13,909,493 million yen (government-financed R&D expenditures of 2,696,717 million yen), A=2.96%, B=3.80%, C=19.4%, D=18.6% and the number of researchers in 1993 was 622,410 persons.

3. The numbers of researchers is as of April 1 in each year.

4. Defense-related R&D expenditures are appropriations to the Defense Agency in the science and technology budget of the government.

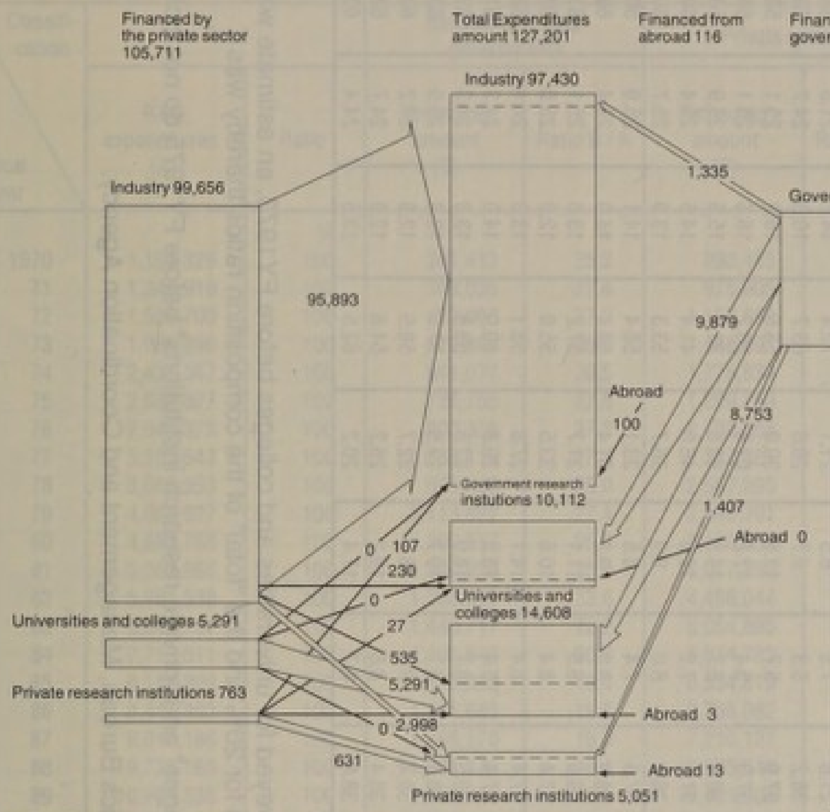
5. The numbers of population are those of national censuses and estimations as of October 1. The population of Okinawa Prefecture is not included in 1970 and 1971.

Sources: 1. Gross national product and national income:"Annual Report of National Accounts" by Economic Planning Agency.

2. R&D expenditures, government-financed expenditures and the number of researchers: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

3. Population: "Population Estimation Material" by the Statistics Bureau, Management and Coordination Agency.

2.Flow of R&D expenditures in Japan (in FY1991)



(%)

Classification / Sector	Financing ratio	Performing ratio
Industry	78.3	76.6
Government	16.8	7.9
Universities and colleges	4.2	11.5
Private research institutions	0.6	4.0
Abroad	0.1	
Total	100.0	100.0

Notes: 1. R&D expenditures are for natural sciences only

2. R&D expenditures are the funds spent by research institutions themselves for research. There are two concepts of R&D expenditures on a performing basis: disbursement and cost. Japan considers R&D expenditures to be disbursements. Disbursement includes expenditures on labor, materials, tangible fixed assets, and so on. In case of cost, it is computed by adding the depreciation of tangible fixed assets instead of expenditures on the tangible fixed assets.

3. Coverage of each sector is as follows:

(1) Financing sector

1)Industry: companies and public corporations whose major purpose is not in research activities

2)Government: national and local governments, national, local government-owned research institutions, research-centered public corporations, and national and public universities and colleges (including junior colleges, same as in the following)

3)Universities and colleges: private universities and colleges (including junior colleges, same as in the following)

4)Private research institutions: nonprofit private research institutions

(2)Performing sector

1)Industry: coverage is the same as in the financing sector

2)Government research institutions: national and local government-owned research institutions and research-centered public corporations

3)Universities and colleges: national public and private universities and colleges

4)Private research institutions: coverage is the same as in the financing sector

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

3. Changes in composition ratios of R&D expenditures by character of work in Japan

(%)

Classification / Fiscal Year	Industry			Government research institutions			Universities and colleges			Private research institutions			Total		
	Basic research	Applied research	Development	Basic research	Applied research	Development	Basic research	Applied research	Development	Basic research	Applied research	Development	Basic research	Applied research	Development
1970	9.3	27.2	63.5	17.4	42.7	39.9	–	–	–	22.3	35.8	41.9	23.3	27.6	49.1
71	9.1	25.9	65.0	19.6	33.5	47.0	–	–	–	22.2	36.4	41.4	23.9	25.8	50.2
72	8.1	22.3	69.6	15.0	32.5	52.4	–	–	–	22.5	57.0	20.5	22.5	23.6	53.9
73	6.7	19.5	73.8	15.6	29.0	55.4	–	–	–	16.4	53.4	30.1	21.5	21.3	57.2
74	6.3	19.4	74.3	16.5	38.2	45.3	75.4	18.5	6.1	7.2	16.4	76.4	15.0	21.7	63.3
75	5.2	19.1	75.8	15.8	34.3	49.9	70.9	21.6	7.5	6.5	21.1	72.4	14.2	21.5	64.3
76	5.0	18.6	76.3	18.1	34.6	47.3	56.4	38.2	5.3	9.7	26.6	63.7	16.6	24.7	58.8
77	4.7	19.6	75.7	18.1	35.5	46.5	57.4	37.0	5.7	13.5	30.0	56.5	16.2	25.1	58.7
78	4.6	18.2	77.1	18.5	34.9	46.6	57.3	37.3	5.4	12.2	61.6	26.2	16.6	25.1	58.4
79	4.6	19.5	75.9	18.9	37.1	44.0	55.2	38.1	6.7	14.5	63.8	21.7	15.5	25.9	58.7
80	5.0	19.5	75.5	15.8	39.3	44.9	55.8	37.0	7.2	12.6	46.0	41.4	14.5	25.4	60.0
81	5.2	21.8	73.0	14.2	32.2	53.6	55.8	36.3	8.0	9.9	36.7	53.3	13.9	25.7	60.4
82	5.5	21.9	72.6	14.3	31.8	53.9	54.9	37.6	7.4	8.5	33.1	58.4	14.1	25.9	60.1
83	5.7	22.0	72.3	13.9	30.7	55.4	54.9	36.9	8.3	9.2	31.4	59.4	14.0	25.4	60.6
84	5.6	22.0	72.4	13.9	29.9	56.2	54.9	36.6	8.5	11.1	31.7	57.2	13.6	25.1	61.3
85	5.9	21.9	72.1	13.0	28.5	58.4	54.2	37.4	8.4	10.6	33.5	55.9	12.9	25.0	62.2
86	6.1	21.6	72.3	13.6	27.3	59.1	54.2	37.4	8.4	14.1	27.8	58.1	13.3	24.4	62.3
87	6.6	21.7	71.7	14.6	28.3	57.1	54.2	37.4	8.4	18.3	20.8	60.9	14.0	24.3	61.7
88	6.6	21.7	71.7	13.5	26.8	59.7	52.8	38.5	8.7	18.0	22.3	59.8	13.3	24.3	62.4
89	6.4	21.5	72.2	13.1	27.3	59.6	53.2	38.1	8.7	19.7	22.5	57.8	12.8	23.9	63.2
90	6.4	21.8	71.8	14.2	28.6	57.3	52.9	38.4	8.7	18.7	22.7	58.5	12.6	24.2	63.2
91	6.8	22.2	71.1	14.5	29.3	56.2	52.8	38.4	8.8	19.2	26.2	54.6	12.9	24.7	62.4
92	6.9	22.1	71.1	16.5	27.6	55.9	52.7	38.6	8.7	17.4	20.2	62.5	13.5	24.4	62.1

Notes: 1. For natural science only.

2. Because the composition ratios by character or work were not surveyed for universities and colleges before FY1973, an estimate was made that basic research accounted for 80% and applied research for 20% and the "total" of the composition ratios thereby was calculated.

3. Figures of "Government research institutes", "universities and colleges" and "private research institutions" before FY1975 do not include values in the health field.

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

4. Changes in R&D expenditures by financing sector in Japan

(million yen)

Classification / Fiscal Year	Total		National and local governments		Private sector		Abroad	
	R&D expenditures (A)	Ratio	Financing amount (B)	Ratio B / A	Financing amount (C)	Ratio C / A	Financing amount (D)	Ratio D / A
		%		%		%		%
1970	1,195,328	100	301,413	25.2	893,485	74.7	428	0.0
71	1,345,919	100	369,025	27.4	975,905	72.5	988	0.1
72	1,586,708	100	432,068	27.2	1,153,560	72.7	1,081	0.1
73	1,980,896	100	522,684	26.4	1,456,891	73.5	1,321	0.1
74	2,421,367	100	641,077	26.5	1,778,834	73.5	1,456	0.1
75	2,621,827	100	720,755	27.5	1,899,293	72.4	1,779	0.1
76	2,941,373	100	800,386	27.2	2,138,368	72.7	2,619	0.1
77	3,233,543	100	886,115	27.4	2,343,681	72.5	3,747	0.1
78	3,569,953	100	999,502	28.0	2,567,390	71.9	3,061	0.1
79	4,063,627	100	1,113,822	27.4	2,946,391	72.5	3,414	0.1
80	4,683,768	100	1,209,557	25.8	3,469,557	74.1	4,655	0.1
81	5,363,986	100	1,340,320	25.0	4,017,752	74.9	5,914	0.1
82	5,881,539	100	1,388,812	23.6	4,486,044	76.3	6,682	0.1
83	6,503,737	100	1,440,717	22.2	5,054,895	77.7	8,125	0.1
84	7,716,511	100	1,494,546	20.8	5,674,783	79.1	7,182	0.1
85	8,116,399	100	1,573,953	19.4	6,534,619	80.5	7,826	0.1
86	8,414,993	100	1,651,680	19.6	6,755,682	80.3	7,631	0.1
87	9,016,186	100	1,798,270	19.9	7,210,127	80.0	7,789	0.1
88	9,775,165	100	1,801,373	18.4	7,965,544	81.5	8,249	0.1
89	10,909,335	100	1,867,936	17.1	9,031,804	82.8	9,595	0.1
90	12,089,593	100	1,990,147	16.5	10,089,311	83.5	10,134	0.1
91	12,720,140	100	2,137,444	16.8	10,571,062	83.1	11,634	0.1
92	12,788,221	100	2,305,868	18.0	10,469,175	81.9	13,178	0.1

Note: Including social sciences and humanities, B/A in FY1992 is 19.4%.
Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

5. Changes in R&D expenditures by performing sectors in Japan

(million yen)

Classification / Fiscal Year	Companies, etc.				Research Institutions						Universities and colleges					Total (D)	
	Companies	Public corporations (a)	Total (A)	Ratio A / D	National	Local government owned	Private	Public corporations (b)	Total (B)	Ratio B / D	National	Public	Private	Total (C)	Ratio C / D		Ratio
				%						%					%		%
1970	785,010	38,255	823,265	68.9	51,560	54,239	14,598	34,222	154,619	12.9	131,760	15,995	69,689	217,444	18.2	1,195,328	100
71	845,790	49,230	895,020	66.5	58,035	63,920	18,721	59,790	200,466	14.9	143,129	18,593	88,710	250,433	18.6	1,345,919	100
72	985,925	59,002	1,044,928	65.9	68,018	72,145	19,424	93,298	252,885	15.9	158,872	19,922	110,102	288,896	18.2	1,586,708	100
73	1,238,444	63,483	1,301,927	65.7	82,266	90,645	24,320	123,509	320,740	16.2	187,809	23,466	146,954	358,229	18.1	1,980,896	100
74	1,524,114	64,939	1,589,053	65.6	102,996	110,142	74,727	99,208	387,073	16.0	245,135	27,052	173,054	445,241	18.4	2,421,367	100
75	1,616,121	68,726	1,684,847	64.3	117,596	111,460	72,684	118,959	420,699	16.0	284,293	29,574	202,414	516,281	19.7	2,621,827	100
76	1,808,210	74,021	1,882,231	64.0	123,403	118,222	84,867	144,997	471,489	16.0	317,986	31,877	237,790	587,654	20.0	2,941,373	100
77	2,019,851	89,649	2,109,500	65.2	140,618	132,141	71,013	150,573	494,345	15.3	351,945	35,745	242,007	629,698	19.5	3,233,543	100
78	2,194,252	96,750	2,291,002	64.2	155,684	137,285	82,447	190,917	566,333	15.9	399,275	35,676	277,667	712,618	20.0	3,569,953	100
79	2,559,917	104,995	2,664,913	65.6	177,704	150,877	76,119	216,331	621,032	15.3	434,641	39,081	303,960	777,683	19.1	4,063,627	100
80	3,032,145	110,111	3,142,256	67.1	185,372	165,966	122,533	243,742	717,612	15.3	461,765	41,374	320,761	823,900	17.6	4,683,768	100
81	3,517,034	112,759	3,629,793	67.7	191,956	177,702	213,394	265,783	848,834	15.8	505,040	45,516	334,803	885,359	16.5	5,363,986	100
82	3,917,089	121,929	4,039,018	68.7	195,747	177,766	244,198	276,599	894,310	15.2	529,884	47,081	371,245	948,211	16.1	5,881,539	100
83	4,435,361	124,766	4,560,127	70.1	200,863	178,222	248,087	288,082	915,254	14.1	561,246	49,491	417,620	1,028,356	15.8	6,503,737	100
84	5,114,631	22,003	5,136,634	71.6	208,062	185,658	274,987	307,396	976,102	13.6	585,463	52,182	426,130	1,063,775	14.8	7,176,511	100
85	5,913,942	26,005	5,939,947	73.2	227,454	193,052	316,461	364,704	1,101,041	13.6	589,212	56,310	429,888	1,075,410	13.2	8,116,399	100
86	6,105,886	14,277	6,120,163	72.7	236,700	193,568	360,436	382,261	1,172,966	13.9	610,800	57,532	453,532	1,121,864	13.3	8,414,993	100
87	6,480,897	13,370	6,494,268	72.0	297,419	201,313	398,324	415,283	1,312,340	14.6	659,914	61,932	487,733	1,209,579	13.4	9,016,186	100
88	7,202,873	16,446	7,219,318	73.9	262,093	208,552	411,511	434,140	1,316,296	13.5	675,343	61,927	502,281	1,239,551	12.7	9,775,165	100
89	8,217,138	16,682	8,233,820	75.5	273,061	226,075	441,818	422,930	1,363,884	12.5	705,507	74,274	531,850	1,311,631	12.0	10,909,335	100
90	9,246,003	21,163	9,267,166	76.7	307,316	252,734	475,391	380,637	1,416,079	11.7	754,426	85,349	566,572	1,406,347	11.6	12,089,593	100
91	9,716,195	26,853	9,743,048	76.6	310,096	265,849	505,077	435,237	1,516,259	11.9	783,564	83,387	593,882	1,460,833	11.5	12,720,140	100
92	9,541,757	18,928	9,560,685	74.8	360,870	266,255	543,439	490,931	1,661,495	13.0	846,905	94,844	624,293	1,566,041	12.2	12,788,221	100

Notes: 1. Public corporations (a) are those which are operated on a self-paying basis and public corporations (b) are those which are not expected to operate on a self-paying basis.

2. In FY1974, research associations based on the Research Associations for Mining and Manufacturing Technology Law were rearranged from public corporations (b) into private research institutions.

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

6. Changes in composition ratios of R&D expenditures by constituent elements in Japan

(%)

Fiscal Year		1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Companies	Labor cost	44.2	43.3	43.5	42.1	40.7	41.3	41.4	40.7	39.4	38.8	38.7	41.1
	Materials cost	19.9	19.8	19.6	20.5	20.5	20.5	20.3	20.9	21.1	21.4	20.8	19.7
	Expenditure on tangible fixed assets	16.0	15.9	15.4	15.5	16.5	15.7	15.6	14.7	15.6	15.5	15.7	13.0
	Other expenses	19.9	20.9	21.4	22.0	22.4	22.5	22.8	23.8	23.8	24.4	24.9	26.2
	Total	100	100	100	100	100	100	100	100	100	100	100	100
Research institutions	Labor cost	34.9	34.8	35.3	35.4	33.1	33.2	30.7	32.5	32.6	34.2	33.4	31.8
	Materials cost	12.6	13.3	12.6	13.6	14.6	17.4	16.2	17.5	17.6	18.8	14.5	16.2
	Expenditure on tangible fixed assets	29.9	28.0	25.8	27.2	29.2	26.9	29.8	26.7	24.2	22.7	21.5	22.4
	Other expenses	22.6	23.9	26.3	23.9	23.0	22.4	23.3	23.3	25.6	24.3	30.6	29.6
	Total	100	100	100	100	100	100	100	100	100	100	100	100
Universities and colleges	Labor cost	58.0	57.8	57.1	59.3	60.4	61.0	59.8	61.0	60.3	61.0	61.9	61.1
	Materials cost	8.9	9.2	8.4	8.8	8.7	8.7	8.5	9.0	9.3	8.9	8.9	9.1
	Expenditure on tangible fixed assets	19.2	18.9	19.4	18.0	16.0	16.0	17.2	15.5	16.0	15.0	14.2	14.8
	Other expenses	13.9	14.0	15.2	14.0	14.9	14.3	14.5	14.5	14.5	15.0	15.1	15.1
	Total	100	100	100	100	100	100	100	100	100	100	100	100
Total	Labor cost	45.0	44.4	44.5	43.7	42.3	42.8	42.3	42.2	41.1	40.8	40.7	42.3
	Materials cost	16.9	17.1	16.9	17.8	18.1	18.5	18.1	18.9	19.3	19.6	18.7	17.9
	Expenditure on tangible fixed assets	18.8	18.2	17.5	17.5	18.1	17.3	17.9	16.4	16.7	16.3	16.2	14.5
	Other expenses	19.3	20.3	21.1	21.0	21.5	21.4	21.7	22.5	22.9	23.3	24.4	25.3
	Total	100	100	100	100	100	100	100	100	100	100	100	100

Source: "Report on the Survey of Research and Development" by the statistics Bureau, Management and Coordination Agency.

7. Changes in number of personnel engaged in R&D activities in Japan

(person)

Year	Number of R&D Performing institutions	Personnel engaged in R&D activities		Researchers		Assistant research workers		Technicians		Clerical and other supporting personnel	
			%		%		%		%		%
1970	12,594	392,236	100	172,002	43.9	75,363	19.2	88,282	22.5	56,589	14.4
71	18,935	429,348	100	194,347	45.3	80,194	18.7	93,581	21.8	61,226	14.3
72	15,753	426,935	100	198,084	46.4	82,308	19.3	86,149	20.2	60,394	14.1
73	13,253	459,239	100	226,604	49.3	80,720	17.6	88,857	19.3	63,058	13.7
74	11,614	468,060	100	238,179	50.9	79,400	17.0	87,516	18.7	62,965	13.5
75	14,445	491,296	100	255,202	51.9	81,934	16.7	90,648	18.5	63,512	12.9
76	14,552	487,999	100	260,250	53.3	79,245	16.2	89,089	18.3	59,415	12.2
77	13,693	492,287	100	271,956	55.2	73,794	15.0	86,698	17.6	59,839	12.2
78	17,289	486,776	100	273,102	56.1	72,479	14.9	83,321	17.1	57,874	11.9
79	16,269	496,030	100	281,920	56.8	72,988	14.7	82,163	16.6	58,959	11.9
80	19,618	521,119	100	302,585	58.1	73,918	14.2	85,882	16.5	58,734	11.3
81	19,103	548,312	100	317,487	57.9	79,889	14.6	89,326	16.3	61,610	11.2
82	18,026	567,235	100	329,728	58.1	83,592	14.7	90,072	15.9	63,843	11.3
83	17,214	587,182	100	342,237	58.3	86,630	14.8	92,224	15.7	66,091	11.3
84	19,367	627,814	100	370,045	58.9	92,826	14.8	96,109	15.3	68,834	11.0
85	16,663	646,299	100	381,282	59.0	97,263	15.0	98,267	15.2	69,487	10.8
86	16,263	676,023	100	405,554	60.0	98,493	14.6	100,850	14.9	71,126	10.5
87	15,449	691,822	100	418,337	60.5	99,569	14.4	101,492	14.7	72,424	10.5
88	16,100	715,337	100	441,876	61.8	98,499	13.8	101,960	14.3	73,002	10.2
89	16,657	740,438	100	461,634	62.3	98,846	13.3	104,497	14.1	75,461	10.2
90	16,625	769,696	100	484,346	62.9	103,077	13.4	103,192	13.4	79,081	10.3
91	15,792	803,733	100	504,966	62.8	103,093	12.8	112,596	14.0	83,078	10.3
92	16,084	812,985	100	518,869	63.8	104,017	12.8	107,050	13.2	83,049	10.2
93	16,367	840,511	100	541,139	64.4	103,944	12.4	107,110	12.7	88,318	10.5

Note: Figures are as of April 1 in each year.

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

8. Changes in number of researchers by sector in Japan

(person)

Classi-fica-tion / Year	Companies, etc.				Research Institutions						Universities and colleges					Total (D)	
	Com-panies	Public corpo-rations (a)	Total (A)	Ratio A / D	National	Local govern-ment owned	Private	Public corpo-rations (b)	Total (B)	Ratio B / D	National	Public	Private	Total (C)	Ratio C / D		Ratio A / D
				%						%					%		%
1970	91,516	2,544	94,060	54.7	8,826	11,149	1,465	1,262	22,702	13.2	34,064	4,536	16,640	55,240	32.1	172,002	100
71	108,593	2,651	111,244	57.2	9,187	11,333	1,534	1,302	23,356	12.0	35,679	4,597	19,471	59,747	30.7	194,347	100
72	100,017	2,746	112,763	56.9	9,231	12,284	1,734	1,569	24,818	12.5	36,168	4,415	19,920	60,503	30.5	198,084	100
73	121,797	2,998	124,795	55.1	9,327	13,012	1,769	2,542	26,650	11.8	43,648	6,940	24,571	75,159	33.2	226,604	100
74	127,536	3,154	130,690	54.9	9,206	13,848	1,824	3,412	28,290	11.9	46,362	6,605	26,232	79,199	33.3	238,179	100
75	143,364	3,240	146,604	57.4	9,341	13,732	1,775	1,842	26,690	10.5	46,771	6,648	28,489	81,908	32.1	225,202	100
76	142,554	2,662	145,216	55.8	9,341	13,698	2,048	1,923	27,010	10.4	50,695	7,120	30,209	88,024	33.8	260,250	100
77	148,741	2,696	151,437	55.7	9,421	13,760	2,654	1,905	27,740	10.2	53,110	7,559	32,110	92,779	34.1	271,956	100
78	150,924	2,782	153,706	56.3	9,712	13,857	2,342	1,997	27,888	10.2	52,019	7,124	32,365	91,508	33.5	273,102	100
79	154,447	2,832	157,279	55.8	9,724	13,737	2,377	2,079	27,917	9.9	54,086	7,154	35,484	96,724	34.3	281,920	100
80	170,279	2,965	173,244	57.3	9,895	13,988	2,512	2,246	28,641	9.5	57,434	7,342	35,924	100,700	33.3	302,585	100
81	181,892	2,997	184,889	58.2	10,073	14,110	3,412	2,411	30,006	9.5	57,523	7,395	37,674	102,592	32.3	317,487	100
82	189,952	2,990	192,942	58.5	10,067	14,257	5,901	2,449	32,674	9.9	58,340	7,612	38,160	104,112	31.6	329,728	100
83	198,132	3,005	201,137	58.8	10,217	13,907	4,514	2,532	31,170	9.1	60,774	8,171	40,985	109,930	32.1	342,237	100
84	220,835	3,047	223,882	60.5	10,179	13,958	5,376	2,467	31,980	8.6	62,906	8,400	42,877	114,183	30.9	370,045	100
85	230,445	652	231,097	60.6	10,037	13,994	5,649	2,487	32,167	8.4	64,657	8,616	44,745	118,018	31.0	381,282	100
86	251,138	633	251,771	62.1	10,169	13,843	5,902	2,545	32,459	8.0	65,926	8,714	46,684	121,324	29.9	405,554	100
87	260,457	389	260,846	62.4	10,016	13,748	6,715	2,688	33,257	7.9	67,590	8,974	47,670	124,234	29.7	418,337	100
88	278,904	394	279,298	63.2	10,174	13,578	7,809	2,908	34,469	7.8	69,787	9,100	49,222	128,109	29.0	441,876	100
89	293,789	413	294,202	63.7	10,225	13,698	8,839	2,948	35,710	7.7	71,614	9,402	50,706	131,722	28.5	461,634	100
90	313,527	421	313,948	64.8	10,195	13,713	9,259	3,098	36,265	7.5	73,471	9,468	51,194	134,133	27.7	484,346	100
91	330,573	423	330,996	65.5	10,220	13,742	9,884	3,238	37,084	7.3	74,890	9,597	52,399	136,886	27.1	504,966	100
92	340,387	422	340,809	65.7	10,247	13,744	10,806	3,346	38,143	7.4	76,686	9,582	53,649	139,917	27.0	518,869	100
93	355,957	449	356,406	65.9	10,386	13,741	11,231	3,484	38,842	7.2	80,896	10,109	54,886	145,891	27.0	541,139	100

Notes: 1. Figures are as of April 1 in each year.
2. Classification of public corporations (a) and (b) is the same as in Appendix 5.

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

9. R&D expenditures and number of researchers of companies, etc. by industry in Japan

(1) R&D expenditures per researcher

(in FY 1991)

Industry	Number of companies, etc. conducting research activities	Research expenditures performed	Number of researchers	Research expenditures per researcher
		million yen	person	million yen
All industries	14,132	9,743,048	330,996	29.44
Agriculture, forestry and fisheries	21	5,472	292	18.74
Mining	28	40,170	798	50.34
Construction	1,272	204,604	7,699	26.58
Manufacturing	12,743	9,195,415	316,350	29.07
Food	1,177	206,411	10,392	19.86
Textiles	684	91,795	4,332	21.19
Pulp and paper products	320	52,372	2,037	25.71
Printing and publishing	36	39,194	1,430	27.41
Chemicals	1,604	1,547,707	53,820	28.76
Petroleum and coal products	111	88,577	2,091	42.36
Plastic products	527	125,970	4,164	30.25
Rubber products	159	129,892	4,942	26.28
Ceramics	615	259,754	8,060	32.23
Iron and steel	145	360,054	6,180	58.26
Non-ferrous metals and products	262	148,988	5,013	29.72
Fabricated metal products	933	137,260	6,919	19.84
General machinery	2,142	674,413	27,887	24.18
Electrical machinery	2,120	3,382,777	125,983	26.85
Transport equipment	565	1,508,671	32,112	46.98
Precision instruments	536	313,969	14,438	21.75
Other manufacturing	807	127,610	6,550	19.48
Transport, communication and public utility	68	297,388	5,857	50.77

Note: The number of companies, etc. conducting research activities is the number of companies, etc. which conducted research activities in FY1991. The number of researchers is as of April 1, 1991.

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

(2) Number of researchers per 10-thousand employees

(in FY 1992)

Industry	Number of researchers	Composition ratio in the number of researchers	Number of employees of companies, etc. conducting R&D activities	Number of researchers per 10-thousand employees
	persons	%	persons	persons
All industries	340,809	100.0	6,858,617	497
Agriculture, forestry and fisheries	254	0.1	18,134	140
Mining	965	0.3	25,059	385
Construction	7,667	2.2	555,809	138
Manufacturing	325,838	95.6	5,494,574	593
Food	10,129	3.0	428,917	236
Textiles	4,300	1.3	140,572	306
Pulp and paper products	2,290	0.7	114,369	200
Printing and publishing	1,380	0.4	80,877	171
Chemicals	55,592	16.3	571,640	973
Petroleum and coal products	2,075	0.6	47,081	441
Plastic products	4,795	1.4	129,539	370
Rubber products	4,957	1.5	113,996	435
Ceramics	8,840	2.6	203,919	434
Iron and steel	6,429	1.9	243,951	264
Non-ferrous metals and products	5,070	1.5	128,964	393
Fabricated metal products	6,432	1.9	237,252	271
General machinery	29,015	8.5	580,180	500
Electrical machinery	129,310	37.9	1,304,699	991
Transport equipment	33,435	9.8	754,813	443
Precision instruments	14,841	4.4	193,941	765
Other manufacturing	6,948	2.0	219,864	316
Transport, communication and public utility	6,085	1.8	765,041	80

Note: Figures are as of April 1, 1992.
Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

10. Changes in ratio of company R&D expenditures to sales figures in Japan

(%)

Industry \ Fiscal year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
All industries	1.78	1.97	1.99	2.31	2.57	2.59	2.60	2.72	2.78	2.81
Agriculture, forestry and fisheries	0.27	0.26	0.24	0.24	0.24	0.31	0.38	0.21	0.50	0.25
Mining	0.64	0.59	0.63	1.03	1.16	1.01	1.27	0.94	1.13	1.41
Construction	0.43	0.53	0.47	0.49	0.55	0.51	0.49	0.52	0.54	0.46
Manufacturing	2.15	2.31	2.34	2.69	3.03	3.14	3.15	3.29	3.36	3.47
Food	0.63	0.70	0.60	0.77	0.85	0.99	0.89	1.07	0.98	0.95
Textiles	1.13	0.90	1.16	1.18	1.23	1.42	1.50	1.71	1.76	1.81
Pulp and paper products	0.52	0.63	0.66	0.71	0.80	0.77	0.87	0.79	0.88	0.87
Printing and publishing	0.39	0.43	0.61	0.68	0.64	0.80	0.63	0.71	0.88	0.91
Chemicals	3.05	3.34	3.46	3.79	4.31	4.53	4.63	4.84	4.89	5.24
Industrial chemicals and chemical fibers	2.17	2.32	2.47	2.80	3.56	3.76	3.92	4.09	4.01	4.19
Oils and paints	2.66	2.83	3.09	3.14	3.42	3.85	3.74	3.93	3.90	4.20
Drugs and medicines	5.56	6.59	6.49	7.04	6.89	6.96	6.94	7.50	8.02	8.66
Other chemicals	3.43	3.40	3.76	3.61	3.87	4.00	4.11	4.11	4.06	4.29
Petroleum and coal products	0.20	0.26	0.27	0.38	0.62	0.64	0.83	0.72	0.64	0.66
Plastic products	–	–	1.94	1.75	2.09	2.16	2.21	2.73	2.37	2.08
Rubber products	2.47	2.40	2.62	2.86	2.92	3.25	3.19	3.25	3.20	3.18
Ceramics	1.64	1.82	1.96	2.61	2.87	2.82	2.73	2.75	2.60	3.00
Iron and steel	1.50	1.60	1.52	1.94	2.54	2.40	2.13	2.21	2.33	2.84
Non-ferrous metals and products	1.57	1.49	1.64	1.92	2.11	1.90	2.00	1.91	1.80	2.17
Fabricated metal products	1.43	1.31	1.46	1.59	1.61	1.50	1.48	1.36	1.60	1.60
General machinery	2.34	2.57	2.59	2.74	2.77	2.99	2.60	2.83	2.99	3.14
Electrical machinery	4.52	4.70	4.55	5.10	5.50	5.61	5.53	5.89	5.86	6.31
Electrical machinery, equipment and supplies	4.17	4.40	4.45	4.82	5.23	5.26	5.25	5.47	5.36	5.66
Communication and electronics equipment	4.72	4.85	4.60	5.25	5.63	5.78	5.66	6.10	6.12	6.63
Transport equipment	2.69	2.66	2.76	2.90	3.21	3.22	3.31	3.40	3.65	3.32
Motor vehicles	3.02	2.89	2.90	2.96	3.20	3.17	3.31	3.48	3.73	3.33
Other transport equipment	1.67	1.86	2.20	2.61	3.28	3.45	3.31	2.93	3.20	3.24
Precision instruments	3.97	4.02	4.08	4.49	4.59	4.91	4.85	5.16	5.94	4.85
Other manufacturing	1.30	1.30	0.92	0.97	1.07	1.12	1.14	1.19	1.21	1.21
Transport, communication and public utility	0.32	0.39	0.84	0.98	0.96	0.84	0.95	1.06	1.07	0.85

Notes: 1. Figures are the ratio of R&D expenditures spent by themselves to sales amount.
2. Figures are for companies only, excluding public corporations.

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

11. Changes in Japan's technology trade amounts

(100 million yen)

Year \ Classification	Export (A)	Import (B)	Ratio A/B
1970	197	1,479	0.13
71	213	1,638	0.13
72	212	1,655	0.13
73	231	1,850	0.12
74	324	2,153	0.15
75	421	2,069	0.20
76	519	2,373	0.22
77	548	2,647	0.21
78	591	2,460	0.24
79	703	2,791	0.25
80	803	3,011	0.27
81	1,063	3,775	0.28
82	1,392	4,369	0.32
83	1,351	4,707	0.29
84	1,651	5,401	0.31
85	1,724	5,631	0.31
86	1,527	5,454	0.28
87	1,870	5,515	0.34
88	2,099	6,429	0.33
89	2,782	7,347	0.38
90	3,590	8,744	0.41
91	3,861	8,158	0.47
92	3,865	9,101	0.43

Note: Figures are values in each calendar year.
Source: The Bank of Japan, "Balance of Payments Monthly".

12. Changes in technology trade amounts by industry in Japan

(1)Technology export amounts

Industry \ Fiscal Year	1982	1983	1984	1985
All industries	184,921	240,887	277,512	234,220
Manufacturing	164,058	209,699	231,860	205,588
Food	4,720	3,640	6,820	6,139
Textiles	6,256	2,189	3,855	4,001
Chemicals	29,409	31,443	37,502	38,233
Ceramics	6,271	9,642	11,238	9,450
Iron and steel	29,047	40,151	32,395	26,195
Non-ferrous metals and products	3,034	2,349	1,924	1,947
Fabricated metal products	1,862	1,529	1,275	2,394
General machinery	5,249	10,717	11,396	11,714
Electrical machinery	35,484	35,551	47,150	59,460
Transport equipment	28,698	28,951	39,784	32,386
Precision instruments	2,418	4,037	1,802	1,725
Other manufacturing	11,611	39,500	36,721	11,946
Construction	19,145	29,955	44,638	26,530
Other non-manufacturing	1,781	1,233	1,014	2,101

(2)Technology import amounts

Industry \ Fiscal Year	1982	1983	1984	1985
All industries	282,613	279,280	281,447	293,173
Manufacturing	278,075	272,838	276,895	288,628
Food	11,286	8,690	9,480	10,422
Textiles	2,821	5,543	9,447	3,287
Chemicals	45,860	42,280	40,765	37,387
Ceramics	10,759	6,731	8,378	32,404
Iron and steel	7,800	17,581	5,562	4,698
Non-ferrous metals and products	3,396	3,651	5,100	5,078
Fabricated metal products	3,057	2,601	3,606	3,922
General machinery	27,405	28,493	23,905	24,483
Electrical machinery	89,158	91,921	94,907	84,197
Transport equipment	56,413	46,916	55,243	59,704
Precision instruments	3,515	4,405	4,386	5,059
Other manufacturing	16,606	14,027	16,116	17,987
Construction	2,298	4,397	2,294	3,476
Other non-manufacturing	2,239	2,045	2,257	1,070

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

(million yen)

1986	1987	1988	1989	1990	1991				
						Composition ratio (%)	Ratio to the previous year	Amounts per one contract (million yen)	Percentage of receipts to R&D expenditures (%)
224,078	215,575	246,255	329,348	339,352	370,552	100.0	1.09	46.0	5.2
193,483	200,772	228,557	316,241	320,707	348,020	93.9	1.09	46.2	5.0
4,945	4,982	5,787	8,337	8,044	9,103	2.5	1.13	32.3	10.6
4,633	4,385	4,361	4,648	3,944	3,618	1.0	0.92	26.0	6.5
38,235	39,295	48,100	53,616	58,173	58,802	15.9	1.01	40.3	5.2
5,468	6,194	5,723	9,025	11,860	11,583	3.1	0.98	44.9	6.6
21,540	9,993	10,798	21,572	9,424	10,527	2.8	1.12	23.3	3.2
3,586	2,614	2,011	7,054	7,239	4,185	1.1	0.58	16.5	3.4
1,525	1,291	1,147	2,004	2,418	2,802	0.8	1.16	11.6	5.0
6,806	8,741	10,818	13,210	14,364	15,113	4.1	1.05	18.2	4.1
53,001	61,126	68,795	86,708	97,017	105,758	28.5	1.09	57.3	3.9
43,840	49,213	58,404	87,126	92,014	102,140	27.6	1.11	91.2	7.3
1,850	2,921	4,611	12,556	4,322	12,094	3.3	2.80	63.7	5.3
8,055	10,017	8,002	10,385	11,888	12,295	3.3	1.03	26.3	3.6
20,835	12,801	16,797	12,448	16,949	21,334	5.8	1.26	45.1	35.1
9,759	2,002	901	659	1,696	1,199	0.3	0.71	24.0	5.4

(million yen)

1986	1987	1988	1989	1990	1991				
						Composition ratio (%)	Ratio to the previous year	Amounts per one contract (million yen)	Percentage of payment to R&D expenditures (%)
260,577	283,245	312,195	329,925	371,907	394,661	100.0	1.06	53.3	5.4
258,393	280,996	309,490	326,901	368,284	393,163	99.6	1.07	54.1	5.5
10,793	9,785	13,397	8,471	8,629	8,826	2.2	1.02	89.2	14.3
3,246	3,683	4,910	4,847	4,722	5,855	1.5	1.24	67.3	13.4
40,583	40,554	50,335	56,866	54,043	67,403	17.1	1.25	59.7	6.0
6,589	6,554	3,735	4,092	3,909	4,744	1.2	1.21	29.7	2.7
5,780	8,013	7,867	4,776	6,489	5,956	1.5	0.92	19.5	1.9
4,158	10,719	14,619	10,702	13,890	10,378	2.6	0.75	51.4	8.4
3,091	2,901	2,166	2,279	2,364	2,399	0.6	1.01	15.0	6.0
25,413	21,298	22,592	32,986	30,533	33,208	8.4	1.09	30.7	9.0
91,264	109,455	113,778	120,553	159,869	161,259	40.9	1.01	73.4	5.4
49,045	48,751	51,955	54,912	52,314	56,540	14.3	1.08	69.1	4.3
4,154	6,677	7,265	8,302	11,389	12,743	3.2	1.12	30.9	5.2
14,275	12,606	16,871	18,115	20,133	23,852	6.0	1.18	38.5	6.3
1,755	934	966	2,043	1,794	687	0.2	0.38	6.0	0.7
428	1,315	1,739	981	1,830	811	0.2	0.44	32.4	1.8

13. Changes in technology trade amounts of Japan by region and country

(1) Technology export amounts

(100million yen)

Region and country \ Fiscal year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	Composition ratio (%)	Ratio to the previous year
Asia (excluding West Asia)	707.67	1,019.20	1,125.16	875.23	864.81	864.35	1,014.12	1,288.62	1,533.17	1,705.46	46.02	1.11
West Asia	56.97	173.00	307.83	141.13	104.85	15.88	22.77	23.60	19.59	36.69	0.99	1.87
North America	408.19	600.34	719.15	587.40	622.88	725.02	769.76	1,151.36	1,081.20	1,171.47	31.61	1.08
South America	108.03	100.68	36.54	87.40	51.61	44.60	44.43	45.80	29.49	30.65	0.83	1.04
Europe	389.63	370.53	407.07	454.61	435.98	402.61	492.62	650.67	614.66	670.91	18.11	1.09
Africa and Oceania	178.72	145.13	179.36	196.44	160.65	103.29	118.84	133.43	115.40	90.35	2.44	0.78
Total	**1,849.21**	**2,408.87**	**2,775.12**	**2,342.20**	**2,240.78**	**2,155.75**	**2,462.55**	**3,293.48**	**3,393.52**	**3,705.52**	**100**	**1.09**
Korea	75	170	149	182	211	275	306	385	465	465	12.54	1.00
China (including Taiwan)	142	292	531	343	282	217	216	244	225	279	7.54	1.24
(Taiwan)	97	108	100	79	85	123	132	163	157	201	5.43	1.28
Indonesia	148	158	136	94	152	85	103	109	197	217	5.86	1.10
Thailand	56	61	83	62	54	73	99	176	246	216	5.83	0.88
Singapore	71	78	91	61	48	66	121	161	185	259	6.98	1.40
USA	356	536	659	518	577	659	711	1,077	995	1,057	28.53	1.06
Brazil	73	79	19	33	38	25	25	33	17	19	0.50	1.09
UK	84	53	68	53	76	106	139	200	201	245	6.62	1.22
Italy	88	73	57	51	72	37	48	39	55	44	1.18	0.80
Former Soviet Union	20	19	11	24	5	27	45	89	16	12	0.31	0.74
Germany	47	51	47	113	78	74	107	137	117	133	3.60	1.14
France	39	45	46	48	59	52	44	71	94	111	3.00	1.18
Australia	46	31	41	119	58	42	52	57	46	47	1.26	1.02

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

(2) Technology import amounts

(100million yen)

Region and country \ Fiscal year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	Composition ratio (%)	Ratio to the previous year
North America	1,885.61	1,940.00	1,939.89	2,102.79	1,745.51	1,792.51	1,981.27	2,107.41	2,578.71	2,751.68	69.72	1.07
Europe	926.62	844.99	866.98	815.67	851.37	1,034.17	1,136.02	1,181.63	1,127.62	1,186.13	30.05	1.05
Others	13.90	7.81	7.60	13.27	8.88	5.78	4.65	10.20	12.73	8.79	0.22	0.69
Total	**2,826.13**	**2,792.80**	**2,814.47**	**2,931.73**	**2,605.77**	**2,832.45**	**3,121.95**	**3,299.25**	**3,719.07**	**3,946.61**	**100**	**1.06**
USA	1,870	1,911	1,930	2,086	1,738	1,786	1,969	2,095	2,553	2,733	69.25	1.07
UK	250	147	132	146	130	103	93	108	99	108	2.74	1.09
Italy	18	12	48	15	22	12	23	25	24	58	1.46	2.39
Netherlands	127	113	141	155	156	208	276	211	202	246	6.24	1.22
Switzerland	157	159	160	163	175	174	184	190	153	156	3.96	1.02
Germany	178	196	178	176	207	214	184	243	270	252	6.39	0.93
France	109	114	104	68	73	221	262	255	228	220	5.58	0.97

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

14. Japan's technology trade amounts by industry and region (in FY1991)

(million yen)

Item	Export amounts							Import amounts			
	Total	Asia (excluding West Asia)	West Asia	North America	South America	Europe	Others	Total	North America	Europe	Others
All industries	370,552	170,546	3,669	117,147	3,065	67,091	9,035	394,661	275,168	118,613	879
Construction	21,334	16,977	x	720	x	877	–	687	280	407	x
Manufacturing	348,020	152,726	905	116,226	3,051	66,091	9,021	393,163	274,831	117,453	879
Food	9,103	5,044	–	2,941	x	935	–	8,826	2,928	5,895	x
Textiles	3,618	2,612	–	450	–	546	x	5,855	459	5,272	x
Pulp and paper products	1,199	290	–	430	x	428	x	446	390	x	–
Printing and publishing	413	121	x	277	x	14	x	1,868	1,699	169	x
Chemicals	58,802	15,688	125	27,301	603	14,414	672	67,403	40,881	26,439	x
Petroleum and coal products	256	130	–	13	–	111	x	3,624	1,691	1,932	x
Plastic products	1,965	1,139	–	419	–	397	x	1,973	1,439	531	x
Rubber products	4,770	2,892	x	939	–	302	260	4,459	1,752	2,707	x
Ceramics	11,583	9,568	x	1,103	127	476	214	4,744	2,821	1,923	–
Iron and steel	10,527	2,034	44	3,549	354	3,573	973	5,956	2,088	3,788	x
Non-ferrous metals and products	4,185	3,066	–	397	x	399	134	10,378	3,659	6,680	x
Fabricated metal products	2,802	1,883	–	679	x	175	66	2,399	846	1,483	x
General machinery	15,113	6,610	x	4,331	104	3,921	106	33,208	25,153	7,907	147
Electrical machinery	105,758	62,195	101	19,464	1,068	21,850	1,081	161,259	123,325	37,891	43
Transport equipment	102,140	34,254	120	48,668	371	13,289	5,438	56,540	45,241	11,118	182
Precision instruments	12,094	3,857	–	3,507	–	4,726	x	12,743	11,562	1,107	74
Other manufacturing	3,692	1,344	–	1,760	x	535	50	11,482	8,898	2,555	29
Others	1,199	844	x	200	x	123	x	811	57	754	–

Note: "–" indicates "none" and "x" shows that values are not expressed because the number of contracts is not more than 4.

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

15. Deflators of R&D expenditures in Japan

Sector / Fiscal year	Natural sciences				Total including social sciences and humanities
	Companies, etc.	Research institutions	Universities and colleges	Total	
1970	53.2	52.3	56.2	53.5	52.6
71	55.2	54.2	59.2	55.6	55.0
72	58.9	57.7	64.0	59.3	59.1
73	66.5	65.4	69.8	66.7	66.2
74	76.4	75.4	77.4	76.4	74.9
75	78.8	77.7	79.2	78.7	76.9
76	82.3	81.2	81.8	82.1	80.1
77	83.5	82.6	83.1	83.4	81.5
78	83.8	83.1	84.2	83.7	82.2
79	89.7	88.7	87.8	89.3	87.2
80	94.6	93.7	89.9	94.0	91.3
81	96.0	95.2	91.3	95.3	92.9
82	97.4	96.5	92.8	96.7	94.5
83	97.0	96.2	92.8	96.4	94.4
84	98.1	97.4	94.0	97.5	95.7
85	97.1	96.5	93.8	96.6	95.3
86	93.9	93.5	93.0	93.7	93.0
87	94.1	93.7	93.8	94.0	93.5
88	95.5	95.1	96.0	95.5	95.3
89	98.4	98.1	98.5	98.3	98.2
90	100.0	100.0	100.0	100.0	100.0
91	100.6	100.8	100.8	100.6	100.7
92	–	–	–	–	–

Source: The Statistics Bureau, Management and Coordination Agency.

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