NISTEP REPORT No.52

THE SIXTH TECHNOLOGY FORECAST SURVEY -- Future Technology in Japan Toward The Year 2025 --

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June 1997
Fourth Policy-Oriented Research Group
National Institute of Science and Technology Policy
(NISTEP)
Science and Technology Agency
JAPAN

CONTENTS(PDF)

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When quoting our data, please specify clearly that the data are quoted from "The Sixth Technology Forecast Survey" published by NISTEP

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CHAPTER 3 SURVEY RESULTS (FINDINGS BY FIELD)

Translation from Japanese Version

Notes on English translation of the original Japanese version

(1) Chapter1 and Chapter2 were fully translated.

(2) Chapter3 was translated partially by applying the following approach to each field

- “Trends in note worthy domains”: translated fully
- “Topics with high degree of importance”: Survey results summaries focused on domains and objectives as shown in the framework omitted
- “Forecasted realization times” and ”Current leading countries etc.”: Survey results summaries focused on domains and objectives as shown in the framework and typical examples of topics omitted
- Other questionnaire reply analysis results omitted
- “Examples of respondents’ comments on each of topic” and “Chronological table of future technologies” omitted completely

(3) The list of topics proposed by respondents for high future advancement prospects was omitted from the “Reference”.

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Foreword

The Science and Technology Agency has traditionally conducted a technology forecast survey to ascertain the future direction of science and technology in Japan from a long-term viewpoint. The latest survey, the sixth in the series, was conducted primarily by the National Institute of Science and Technology Policy (NISTEP).

This report is a comprehensive overview of the future of science and technology and the kind of society it will generate as seen by experts engaged in various fields of research and development in Japan.

Incorporating more than a thousand topics, the survey covers an extensive range of fields from basic to applied technology. In addition to the analyses presented in this report, we at NISTEP believe much more analytical work is required from a variety of perspectives, and our intention is to continue working toward this goal. Similar surveys have also been conducted in other countries over the past several years, and we will be comparing and analyzing the results of these surveys with those of our own. This comparative research is expected to yield some interesting results.

We hope this report will be used widely, and can contribute to the promotion of science and technology in Japan.

This survey would not have been possible without the cooperation of many people. I should like to express my sincere thanks to the Technology Forecast Committee and the members of the various subcommittees, who examined the survey guidelines, set the survey topics and analyzed the results, the more than 4,000 experts in related fields who took part in the survey, and the staff at the Institute for Future Technology (IFTECH) who actually conducted the survey.

June 1997

Masayasu Miyabayashi
Director General
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1. Objectives

The National Institute of Science and Technology Policy (NISTEP) has to date conducted technology forecast surveys, generally every five years, since 1971 to ascertain the future direction of technology in Japan from a long-term viewpoint. This is the sixth survey conducted.

The promotion of science and technology is pivotal to the sound growth of Japan's business community, so it is crucial that we fully grasp the future direction of technological development from a long-term viewpoint.

In this light, we conducted a technology forecast survey that took in the next 30 years to ascertain the future of technology in Japan, and through this, contribute to the formulation of science and technology policy, and provide a basic reference point for technology strategies in the private sector.

2. Implementation structure

For the survey, NISTEP established a technology forecast committee to examine the overall survey plan and implementation guidelines, and IFTECH established 13 subcommittees[note 1] headed by members of the technology forecast committee to set the survey topics in each field, select the survey participants, and analyze the survey results. NISTEP conducted an analysis of all fields handled by the survey, and the technology forecast committee prepared a comprehensive report based on these analysis results.

3. Outline

(1) Survey fields

The survey covered the following 14 fields.

i) Materials and processing
ii) Electronics
iii) Information
iv) Life science
v) Space
vi) Marine science and earth science
vii) Resources and energy
viii) Environment
ix) Agriculture, forestry and fisheries
x) Production and machinery
xi) Urbanization and construction
xii) Communication
xiii) Transportation
xiv) Health, medical care and welfare

The fifth survey contained 16 fields (see Ref. 3), but the following changes were made for this survey.

- "Information and electronics" was divided into "Information" and "Electronics".
- "Mineral and water resources" and "Energy" were combined into "Resources and energy".
- "Particles" and "Lifestyle and culture" were removed as independent fields and incorporated into other fields.

[note 1] Of the 14 fields covered, "Resources and energy" and "Environment" are closely related, and were handled by a single subcommittee.

- “Production” and “Health and medical care” were changed to, respectively, “Production and machinery” and “Health, medical care and welfare”.

(2) Forecast period

The forecast period is 30 years from 1996 (the year the survey was conducted) to 2025.

(3) Survey method

Like the previous survey, this survey was conducted using the Delphi method, and responses were consolidated through two questionnaires.

Delphi method: The Delphi method is a method of consolidating respondents’ views by repeatedly giving the same questionnaire to a large number of people. In the second and subsequent questionnaires respondents receive a feedback of the results of the previous questionnaire so that they can reassess their answers to the questions in the light of the overall trend of views. This is the major characteristic that sets the Delphi method apart from ordinary survey methods. Respondents who are not confident in their answers will generally tend to support the majority view, so it is possible to consolidate their views. The Delphi method, developed by the U.S. Rand Corporation, was named after the site of the oracle of Apollo in ancient Greek mythology, and according to legend, many gods used to gather there to foretell future events.

(4) Setting the topics

The topics were set by the various subcommittees. The process began with the subcommittees determining the scope of the survey in each of the field, categorizing the future direction of technological development, and preparing a framework that would ensure important topics were not omitted. They then drew up a list of topics. This was done within the following parameters set by the technology forecast committee.

- Review the topic framework of the 5th survey in view of recent technological trends.
- The number of topics should generally be the same as the previous survey, with identical topics, revised topics and new topics each accounting for roughly 1/3 of the topics.
- Set the forecast topics with consideration given to an intersection of technological fields (four axes of aging countermeasures, safety, environmental preservation and recycling, and common base technologies, whose integration with technologies in a large number of fields is considered necessary when looking at future technological trends).
- In principle, topics that have no technological elements and are connected only to socioeconomic conditions should not be included in the survey.
- In principle, survey topics should be those thought to be realizable by 2025. Where necessary though, topics that are realizable after 2026 may also be included.
- In principle, the technological stage of each topic should be expressed by one of the four keywords of “elucidation”, “development”, “practical use” and “widespread use.”
- As for the place of realization, unless specifically mentioned the topic should assume realization anywhere in the world, that is the country or region where realization is earliest.
- Two or more forecast particulars should not be included in one topic.
- Topics should include specific objective values and champion data wherever possible, and should present an image of specific use and application.
- Where necessary, identical forecast topics should be surveyed in more than one survey field.

After the subcommittees evaluated previous topics, examined new topics and prioritized topics according to importance, they finally settled on 1,072 topics for the survey.

(5) Selecting survey respondents

For the most part, members in each of the subcommittees were asked to recommend experts in their respective fields as potential respondents. Our intention was to obtain as large a list as possible of experts with extensive knowledge in the relevant topics or technological fields, keeping in mind the need for a good cross-section of representatives from industry, the government and academia. In some cases however, rather than recommendations of individual names, the Secretariat chose respondents at random from a list put forward by the subcommittees.

The main people we were looking for as respondents were "people in research and development, research managers and others in corresponding positions who have expert knowledge in the relevant survey fields." We also considered people with the following attributes.

i) Sector (occupation)

The overall percentage breakdown of respondents across all fields in the fifth survey was company-related 37%, university-related 36%, public research institutions 15%, and others 12%, and for the sixth survey we aimed at a similar industry-academia-government mix.

ii) Age composition

For this survey we tried to increase the number of relatively younger respondents in their 30s and 40s (in the previous survey, most respondents were in their 50s, followed by those in their 40s, then 60s). We also tried to increase the proportion of female respondents (only 1% in the previous survey).

We asked potential respondents identified through the above process whether they would be prepared to cooperate in the survey, then chose those who were prepared to cooperate to take part in the first questionnaire. For the first part of the survey we sent questionnaires to 4,868 respondents, of whom 4,196 were sent questionnaires for the second part. We excluded those who decided to withdraw from the survey after the first questionnaire.

The breakdown of final respondents by sector for this survey is generally the same as it was for the fifth survey. By age, the number of respondents in their 30s and 40s increased over the previous survey, though only slightly. An increase was also recorded in female respondents, but here too, the increase was quite small (see Tables 3-1 and 3-2).

(6) Survey items

We drew up the questionnaires in question form covering the survey items listed below for each of the topics set at (4) above (for details see 4. Reading the survey results)

Degree of expertise

Degree of importance to Japan

Expected effect

Forecasted realization time

Current leading countries etc.

Effective measures the government should adopt in Japan

Potential problems in Japan

(7) Implementation of the questionnaires

The questionnaires were sent to respondents as follows.

First questionnaire: August 1996

Second questionnaire: December 1996

For the survey we asked the respondents to give their responses assuming that over the next 30 years there would be no wars of a global scale or natural calamities to cause socioeconomic upheaval. In the second questionnaire we included the results of the first questionnaire for reference by the respondents.

The second questionnaire questioned respondents on the same topics as the first, though the wording of some topics was reviewed and revised in the light of comments by the respondents in the first questionnaire.

(8) Response assumptions

- In principle, this technology forecast covers what are considered to be key R&D topics over the roughly 30-year period from 1996 to 2025.
- There will be no wars of a global scale or natural calamities that would cause socioeconomic upheaval over the next 30 years.
- Unless expressly indicated in the topics with such terms as “in Japan,” topic realization means realization anywhere in the world.

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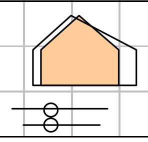
4. Reading the survey results

Questionnaire results are shown as follows.

Division	Topic serial no.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%) High	Medium	Low	Importance (index, %) Index	High	Medium	Low	Unnecessary	Expected effect (%) Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources
	1	Development of technology capable of manipulating single atoms and single molecules.	1	290	12	38	50	71	48	42	10	0	62	6	7	75
			2	258	12	34	54	71	46	46	7	0	62	2	1	79
			X	30	100	0	0	91	83	13	3	0	67	3	0	93

i ii iii iv v vi

Forecasted realization time	Will not be realized (%)	Do not know (%)	Leading countries (%) USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%) Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%) Natural environment	Safety	Morals, culture or society	Others
	1	4	85	26	0	63	0	9	60	40	45	5	53	1	1	8	2	8	2
	1	3	92	22	0	69	0	3	64	36	47	2	55	0	0	5	2	6	2
	0	3	100	37	0	77	0	0	80	47	47	0	63	0	0	0	0	0	0

vii viii ix x

i) Topics

In some cases the two questionnaires differed slightly in the wording of the topic, but here we have used the wording contained in the second questionnaire. The definitions of the keywords used in the topics are as follows.

Elucidation	:	To scientifically and logically identify principles or phenomena.
Development	:	To attain a specific goal in the technological aspect (e.g. completion of a No.1. prototype).
Practical use	:	To be practically used after being proved economically viable (e.g. completion of the first object that can be actually presented for practical use).
Widespread use	:	To be widely and commonly used after an object is put to practical use.

ii) Questionnaire rounds

The terms 1, 2 and X are used to indicate the following.

1 : First round of the questionnaire (results from respondents indicating a “high,” “medium” or “low” degree of expertise)

2 : Second round of the questionnaire (results from respondents indicating a “high,” “medium” or “low” degree of expertise)

X : Aggregate results from respondents indicating a “high” degree of expertise in the second round of the questionnaire.

iii) Number of respondents

The number of respondents in rounds 1 and 2 of the questionnaire shows the total number of respondents indicating a “high,” “medium” or “low” degree of expertise (the number who indicated “none” is not shown).

The number in X shows the number who indicated a “high” degree of expertise in the second round of the questionnaire. Normally the number of respondents in the second round is lower than the number in the first (on average about 85% of the first round number), but there are a few cases where the number has increased because some who did not respond in the first round responded in the second.

iv) Degree of expertise

The degree of expertise shows a percentage breakdown of respondents in iii). above who indicated a “high,” “medium” or “low” degree of expertise. Respondents were asked to select one of the expertise degrees defined below.

High : Has considerable specialist knowledge about the topic through current research or work related to the topic (including research based on literature).

Medium : Was once engaged in research or work related to the topic; or has some specialist knowledge about the topic through research or work in an adjoining field.

Low : Has read technical books or literature about the topic or has listened to experts connected with the topic.

None : Has no expertise.

v) Degree of importance to Japan

The degree of importance to Japan shows a percentage breakdown of respondents who indicated “high,” “medium,” “low” or “unnecessary” for the topic’s importance. The index was worked out from the following equation; the index is 100 when all respondents indicate “high” and 0 when all indicate “unnecessary”.

Degree of importance index = (number of “high” responses × 100 + number of “medium” responses × 50 + number of “low” responses × 25 + number of “unnecessary” responses × 0) ÷ total number of degree of importance responses.

Respondents were asked to select one of the importance degrees defined below.

High : Extremely important

Medium : Important

Low : Somewhat important

Unnecessary : Not important

vi) Expected effect

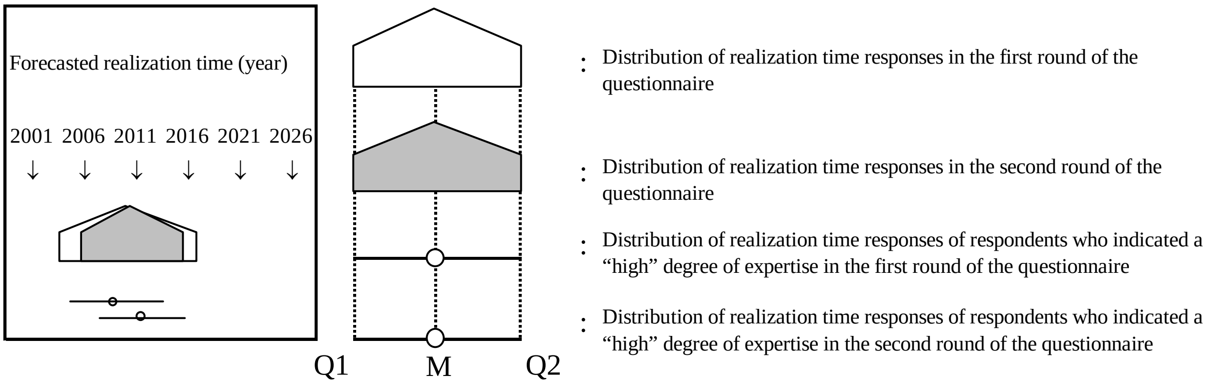
The figures here show the percentage of the respondents at iii) who selected each of the four expected effects of the topic's realization, listed below. For this, respondents were allowed to select more than one effect (or none if nothing was applicable).

Contribution to socioeconomic development	:	Development of innovative products, creation of new industries, expansion of economic frontiers, development of the socioeconomic base, etc.
Resolution of various problems of a global scale	:	Global environment, food, energy, resources, etc.
Response to people's needs	:	Prevention and cure of disease, improvement of the living environment, support for elderly people and people with disabilities, disaster prevention and safety, etc.
Expansion of human intellectual resources	:	Discovery of new laws and principles, construction of original theories, etc.

vii) Forecasted realization time

The forecasted realization time graph shows the distribution of responses of "1996–2000" through "2026-", and was calculated according to the method explained below. Responses of "will not be realized" or "do not know" were excluded.

(Forecasted realization time graph)



Distribution of realization time responses in the first round of the questionnaire; Distribution of realization time responses in the second round of the questionnaire; Distribution of realization time responses of respondents who indicated a "high" degree of expertise in the first round of the questionnaire; Distribution of realization time responses of respondents who indicated a "high" degree of expertise in the second round of the questionnaire

Q1	: Realization time corresponding to the response at the 25th percentile of all responses after they were arranged in chronological order from the earliest to the latest realization time.
M	: Realization time corresponding to the response at the 50th percentile.
Q2	: Realization time corresponding to the response at the 75th percentile.

The width of the pentagon (distance between Q1 and Q2) shows the range of realization time distribution for the half of all respondents who were positioned around the middle of the realization time responses.

A narrow width represents a strong consensus among respondents.

The M value is used in cases where the topic realization time in the chronological table is expressed as a numerical value. The number of respondents who selected “will not be realized” or “do not know” are shown as a percentage of respondents at iii). above.

viii) Current leading countries etc.

This shows the percentage of respondents at iii) who selected each of the six countries or regions below as a world leader in the topic in question. Respondents were allowed to select more than one country or region.

- USA
- EU
- Former Soviet Union and Eastern European countries
- Japan
- Other countries (enter specific country in the response column)
- Do not know

(As of May 1996 the EU comprises the 15 countries of Germany, UK, France, Spain, Netherlands, Greece, Belgium, Portugal, Sweden, Austria, Denmark, Finland, Ireland and Luxembourg.)

ix) Effective measures the government should adopt in Japan

This shows the percentage of respondents at iii). who selected each of the seven items below as effective measures that the government should adopt in Japan to promote R&D aimed at the realization of the topic in question. Respondents were allowed to select up to three separate measures. No selection was made where it was believed no measures were appropriate considering the nature of the topic; for example, realization was best left up to market forces.

- Foster researchers, engineers and research assistants
- Enhance systems to promote personnel exchanges among the industrial, academic and government sectors and cooperation among different fields of science and technology
- Upgrade advanced R&D facilities and equipment and make them available for more widespread use (covers facilities and equipment at national research institutions, universities and other public research institutions)
- Develop a research base comprising data bases, standard reference material, genetic resources and the like
- Increase the government’s funding for research (including research subsidies for private companies etc.)
- Adjust relevant regulations (relax/toughen/establish/abolish; including such tax measures as promoting the widespread use of electric cars by introducing a carbon tax)
- Others (enter specific measures in the response column)

x) Potential problems in Japan

This shows the percentage of respondents at iii) who selected each of the four items below as potential problems that realization of the topic in question could create in Japan. Respondents were allowed to select up to two items (none if nothing was applicable).

Adverse effect on the natural environment	:	Increased destruction of the natural environment, including air and water pollution, destruction of ecosystems, etc.
Adverse effect on safety	:	Adverse effect on disaster prevention, health, security, privacy etc. (occurrence of natural disasters, increase of crime, improper use of personal information etc.).
Adverse effect on morals, culture or society	:	Adverse effect on life ethics, human psychology, traditional culture, human relations, regional communities etc.
Other adverse effects	:	(enter specific effects in the response column)

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5. Presentation of information

The way this report presents the data and topics is described below.

- For questionnaire totals in each of the topics, forecasted realization times (year) are whole numbers with any decimals discarded, and degree of importance and other survey items with percentages or indices are rounded off to the nearest whole number.
- Average values for survey fields are, in principle, rounded off to the first decimal point, but where this is too cumbersome for graphs and the like, values are rounded off to the nearest whole number.
- For topic descriptions in tables etc., in principle we have used the wording used in the questionnaire (text of topics in the table of aggregate results for each field at Chapter 3), however where this may become too cumbersome, we have used a shortened form of the topic.

  (Example) Development of precision polymerization processes that can freely control stereoregularity, chain structure and molecular weight and distribution of polymer in supplementary polymerization reactions at the molecular level.

  ↓

  Development of precision supplementary polymerization processes for polymer controlled at the molecular level.

- In some cases, survey questions were preceded by two, three or six-digit numbers. Each number signifies the following:

  (Two or three-digit number) The topic number of the topic concerned within the field to which it belongs

  (Six-digit number) The first digit, which is 6, indicates that the topic concerned is a 6th Survey topic. The following two digits signify the field to which the topic concerned belongs (for field number assignment, see the table below). The last three digits signify the topic number of the topic concerned within its field.

• The following shortened forms have been used for field names.

Field	Shortened form	No. of field
Materials and processing	Materials	01
Electronics	Electronics	02
Information	Information	03
Life science	Life science	04
Space	Space	05
Marine science and earth science	Marine science	06
Resources and energy	Resources	07
Environment	Environment	08
Agriculture, forestry and fisheries	Agriculture etc.	09
Production and machinery	Production	10
Urbanization and construction	Urbanization	11
Communication	Communication	12
Transportation	Transportation	13
Health, medical care and welfare	Health	14

• The following shortened forms have been used for survey items.

Survey items	Shortened form
Degree of importance to Japan	Importance
Expected effect	Expected effect
Contribution to socioeconomic development	Socioeconomic development
Resolution of various problems of a global scale	Resolution of global problems
Response to people’s needs	People’s needs
Expansion of human intellectual resources	Expansion of intellectual resources
Current leading countries etc.	Leading countries
USA	USA
EU	EU
Former Soviet Union and Eastern European countries	Former Soviet Union and Eastern Europe
Japan	Japan
Other countries	Others
Do not know	Do not know
Effective measures the government should adopt in Japan	Measures the government should adopt
Foster researchers, engineers and research assistants	Foster human resources
Enhance systems to promote personnel exchanges among the industrial, academic and government sectors and cooperation among different fields of science and technology	Promote exchanges among industrial, academic and government sectors and different fields
Upgrade advanced R&D facilities and equipment and make them available for more widespread use	Upgrade advanced facilities and equipment
Develop a research base comprising data bases, standard reference material, genetic resources and the like	Develop a research base
Increase the government’s funding for research	Increase government research funding
Adjust relevant regulations (relax/toughen/establish/abolish)	Adjust regulations (relax/toughen)
Others	Others
Potential problems in Japan	Potential problems
Adverse effect on the natural environment	Natural environment
Adverse effect on safety	Safety
Adverse effect on morals, culture or society	Morals, culture or society
Other adverse effects	Others

Table 3-1 State of questionnaire responses and breakdown of respondent numbers

Field	No. of topics	Responses						Attributes (round 2 questionnaire)																		Unit ; persons
		R1			R2			Gender			Age							Occupation						Occupational category		
		Sent	Returned	Response rate	Sent	Returned	Response rate	Male	Female	Did not indicate	20s	30s	40s	50s	60s	70s or above	Did not indicate	Company employee	University-related	Public servant	Other non-company employee	Other	Did not indicate	Research-related	Other	Did not indicate
01. Materials	109	441	366	83%	364	300	82%	299	1	0	1	14	71	156	53	5	0	99	158	27	10	6	0	264	36	0
02. Electronics	74	407	351	86%	350	312	89%	309	3	0	0	20	141	124	23	4	0	175	99	26	9	3	0	284	28	0
03. Information	79	295	242	82%	241	194	80%	188	6	0	0	29	92	60	12	0	1	118	59	7	8	1	1	167	26	1
04. Life science	94	380	337	89%	334	274	82%	268	6	0	0	21	99	110	40	4	0	38	185	33	15	3	0	259	15	0
05. Space	51	384	342	89%	339	305	90%	300	5	0	4	29	122	124	25	1	0	95	71	65	72	2	0	259	46	0
06. Marine science	74	335	294	88%	292	248	85%	242	6	0	1	21	93	89	37	5	2	36	131	52	24	3	2	210	36	2
07. Resources	88	495	433	87%	432	363	84%	358	5	0	0	22	106	177	51	6	1	138	115	39	58	12	1	275	88	1
08. Environment	39	411	351	85%	348	294	84%	283	11	0	11	35	108	90	42	7	1	82	107	60	32	12	1	239	53	2
09. Agriculture, etc.	84	384	355	92%	355	311	88%	300	11	0	1	13	90	131	70	6	0	49	111	120	26	5	0	280	30	1
10. Production	71	224	188	84%	186	154	83%	152	2	0	0	13	59	58	22	2	0	81	65	3	4	1	0	113	40	1
11. Urbanization	73	287	252	88%	251	219	87%	213	6	0	0	16	85	94	23	1	0	110	52	27	28	2	0	152	67	0
12. Communication	78	325	279	86%	278	242	87%	237	5	0	2	27	102	94	16	1	0	174	46	7	13	1	1	186	56	0
13. Transportation	60	276	255	92%	253	238	94%	238	0	0	1	17	81	106	33	0	0	99	57	35	44	3	0	154	84	0
14. Health	98	224	175	78%	173	132	76%	128	4	0	0	4	48	44	35	1	0	9	85	31	4	3	0	87	45	0
Sixth survey total	1072	4868	4220	87%	4196	3586	85%	3515	71	0	21	281	1297	1457	482	43	5	1303	1341	532	347	57	6	2929	650	8
Fifth survey	1149	3334	2781	83%	2781	2385	86%	2312	27	46	8	111	724	1054	410	32	46	879	864	349	203	42	48	1834	498	53

Table 3-2 State of questionnaire responses and percentage breakdown of respondents

Field	No. of topics	Responses						Attributes (round 2 questionnaire)																	Unit : %	
		R1			R2			Gender			Age							Occupation						Occupational category		
		Sent	Returned	Response rate	Sent	Returned	Response rate	Male	Female	Did not indicate	20s	30s	40s	50s	60s	70s or above	Did not indicate	Company employee	University-related	Public servant	Other non-company employee	Other	Did not indicate	Research-related	Other	Did not indicate
01. Materials	109	441	366	83%	364	300	82%	100%	0%	0%	0%	5%	24%	52%	18%	2%	0%	33%	53%	9%	3%	2%	0%	88%	12%	0%
02. Electronics	74	407	351	86%	350	312	89%	99%	1%	0%	0%	6%	45%	40%	7%	1%	0%	56%	32%	8%	3%	1%	0%	91%	9%	0%
03. Information	79	295	242	82%	241	194	80%	97%	3%	0%	0%	15%	47%	31%	6%	0%	1%	61%	30%	4%	4%	1%	1%	86%	13%	1%
04. Life science	94	380	337	89%	334	274	82%	98%	2%	0%	0%	8%	36%	40%	15%	1%	0%	14%	68%	12%	5%	1%	0%	95%	5%	0%
05. Space	51	384	342	89%	339	305	90%	98%	2%	0%	1%	10%	40%	41%	8%	0%	0%	31%	23%	21%	24%	1%	0%	85%	15%	0%
06. Marine science	74	335	294	88%	292	248	85%	98%	2%	0%	0%	8%	38%	36%	15%	2%	1%	15%	53%	21%	10%	1%	1%	85%	15%	1%
07. Resources	88	495	433	87%	432	363	84%	99%	1%	0%	0%	6%	29%	49%	14%	2%	0%	38%	32%	11%	16%	3%	0%	76%	24%	0%
08. Environment	39	411	351	85%	348	294	84%	96%	4%	0%	4%	12%	37%	31%	14%	2%	0%	28%	36%	20%	11%	4%	0%	81%	18%	1%
09. Agriculture, etc.	84	384	355	92%	355	311	88%	96%	4%	0%	0%	4%	29%	42%	23%	2%	0%	16%	36%	39%	8%	2%	0%	90%	10%	0%
10. Production	71	224	188	84%	186	154	83%	99%	1%	0%	0%	8%	38%	38%	14%	1%	0%	53%	42%	2%	3%	1%	0%	73%	26%	1%
11. Urbanization	73	287	252	88%	251	219	87%	97%	3%	0%	0%	7%	39%	43%	11%	0%	0%	50%	24%	12%	13%	1%	0%	69%	31%	0%
12. Communication	78	325	279	86%	278	242	87%	98%	2%	0%	1%	11%	42%	39%	7%	0%	0%	72%	19%	3%	5%	0%	0%	77%	23%	0%
13. Transportation	60	276	255	92%	253	238	94%	100%	0%	0%	0%	7%	34%	45%	14%	0%	0%	42%	24%	15%	18%	1%	0%	65%	35%	0%
14. Health	98	224	175	78%	173	132	76%	97%	3%	0%	0%	3%	36%	33%	27%	1%	0%	7%	64%	23%	3%	2%	0%	66%	34%	0%
Sixth survey total	1072	4868	4220	87%	4196	3586	85%	98%	2%	0%	1%	8%	36%	41%	13%	1%	0%	36%	37%	15%	10%	2%	0%	82%	18%	0%
Fifth survey	1149	3334	2781	83%	2781	2385	86%	97%	1%	2%	0%	5%	30%	44%	17%	1%	2%	37%	36%	15%	9%	2%	2%	77%	21%	2%

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1. Topics with a high degree of importance

1.1 Overall trends

Here we shall look at forecasts for those of the 1,072 topics in all fields (referred to as all topics) that were assessed as having a high degree of importance. Respondents were asked to classify the importance of each topic as "high", "medium", "low" or "unnecessary". We calculated importance indices for the topics based on the total number of respondents and weighted values of 100, 50, 25 and 0, respectively, for the degrees of importance. Where all respondents indicated "high" the index is 100, and where all indicated "unnecessary" it is 0. Unless otherwise specified, from now on all data used are from the second round questionnaire.

$$I_{index} = (100 * N_{high} + 50 * N_{medium} + 25 * N_{low})/N_{all}$$

I_{index}: Degree of importance index

N_{high}: Number of "high" responses

N_{medium}: Number of "medium" responses

N_{low}: Number of "low" responses

N_{all}: Total number of degree of importance responses ($N_{high} + N_{medium} + N_{low} + N_{unnecessary}$)

The average index for all topics is 62.1, slightly down from the 65.3 recorded in the fifth survey. By fields, environment has the highest average index with (72.0), followed by electronics (67.7) and life science (66.1), while the lowest is urbanization and construction with (56.0), then space (56.2).

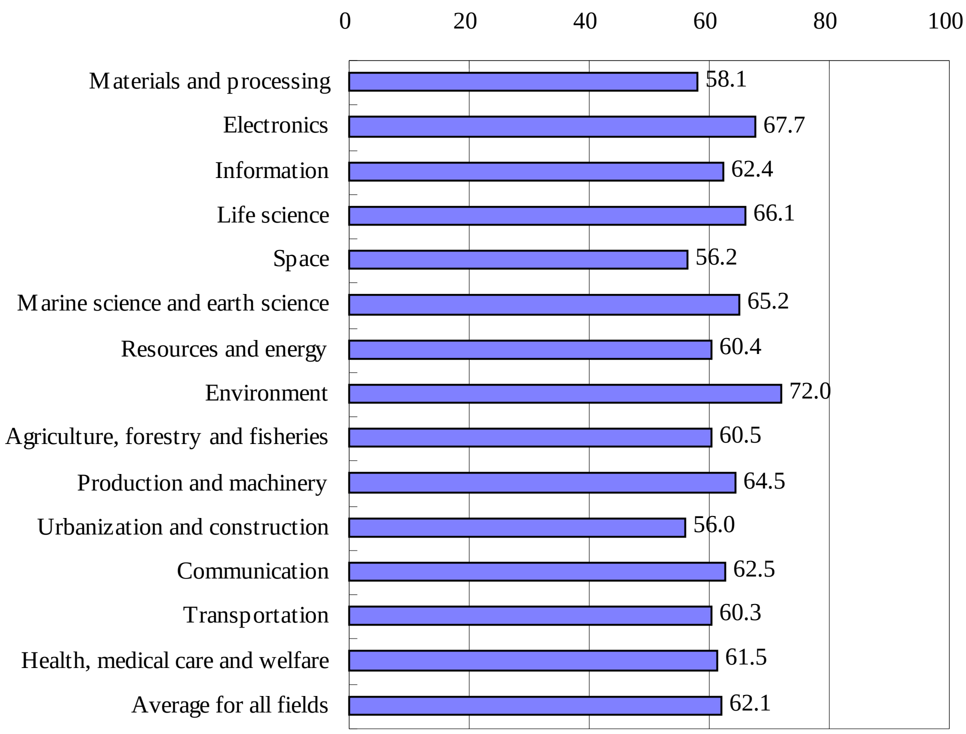

Figure 1.1-1 Importance index by field

Fields with the largest number of topics in the list of top 100 topics in degree of importance (see Table 1.1-1) are:

Electronics	15
Life science	13
Marine science and earth science	9
Environment	9
Materials and processing	8

From this we can see that while “environment” has the highest average index, it does not have the largest representation in the top 100 topics list. So although overall the environment is considered to be the most important field, relatively speaking there is not a large number of topics that are given particular prominence.

To determine any distinctive features about the top 100 topics in this survey, we compared them with the top 100 topics in the fifth survey (see Reference 3).

First we divided the 100 topics into five classifications:

i) Environment-related technologies ranging from global environmental issues to local waste disposal

ii) Information-related technologies such as memory and semiconductors, and the internet and other networks

iii) Life-related technologies such as gene technology and treatment of illness

iv) Disaster-related technologies such as prediction and prevention of earthquakes and other natural disasters

v) New energy technologies connected with the use of solar energy and other non-fossil fuel energy

This resulted in the following breakdown.

Classification	6th survey	5th survey
Environment-related technologies	25	28
Information-related technologies	24	10
Life-related technologies	17	37
Disaster-related technologies	11	9
New energy technologies	11	6
Others	12	10

What stands out here is that information-related technologies increased and life-related technologies decreased significantly. New energy technologies also recorded a considerable rise. Next we shall discuss the results for each classification in more detail.

i) Environment-related technologies

Overall, the number of topics has changed little, though the number connected with recycling, such as the greater acceptance of product design concepts that facilitate recycling and the practical use of technologies for recycling plastics has jumped from four in the fifth survey to nine in the sixth. On the other hand, topics related to the global environment, such as the practical use of CO_2 fixing technology and fluorocarbon and halon substitutes, dropped from thirteen to seven, indicating that greater importance is given to the more familiar and tangible environmental technologies.

ii) Information-related technologies

Network systems topics, such as practical use of a high-security next-generation internet and widespread use of networks that protect privacy and confidential information, jumped from two to twelve; and semiconductor-related topics, such as practical use of 256Gb memory chips and practical use of technology for mass production and processing of 10nm patterns, also jumped, from six to eleven. Thought to be behind these rises is a much greater awareness about the diversification of services and need for safety and security with the phenomenal rise in interest in the internet in Japan and throughout the rest of the world over the five years since the last survey.

iii) Life-related technologies

While little change was seen in cancer-related topics, such as practical use of means of preventing the spread of cancer, dropping to nine from ten in the fifth survey, brain-related topics, such as treatment etc. of Alzheimer's disease, dropped from eight to one this survey. This can be put down partly to the fact that the total number of related topics were consolidated from six topics in the previous survey, of which five made the top 100 list, to three topics in this survey. The number of topics dealing with the treatment of diseases such as arterial sclerosis also dropped. The average importance index value for the life science field was high in this survey as well, so the fact there were comparatively few life-related topics in the top 100 does not necessarily mean that the degree of importance fell, rather it should be seen to be attributed to the greater importance given to information technology.

iv) Disaster-related technologies

The number of earthquake-related topics rose from four in the previous survey to eight in this survey, so overall the number of topics were up as well.

v) New energy technologies

Topics dealing with solar cell technology rose from two to four, and all are ranked in or near the top ten. There was little change in topics dealing with other technologies, such as nuclear power.

Table 1.1-1 Top 100 topics in the sixth survey

Ranking	Field	Topic	Degree of importance index	Forecasted realization time	Notes; Classification of topic	
1	Production	42 Widespread use of non-fossil energy sources (wind, geothermal, solar (photovoltaic/solar thermal) and waste heat) in all areas of life including household, industry and transportation.	94	2018	New energy	
2	Electronics	06 Practical use of VLSI with as much as 256 Gbits of memory per chip.	94	2014	Information	Semiconductors etc.
3	Electronics	30 Practical use of solar cells which make the cost of power generation facilities less than 100 yen/watt.	93	2012	New energy	Solar cells
4	Electronics	05 Practical use of technology which allows mass processing of patterns with minimum line width as low as 10 nanometers.	93	2013	Information	Semiconductors etc.
5	Space	25 The cost of rocket thrusted space transportation will be reduced to less than 1/10 current levels.	93	2014		
6	Production	50 Widespread use of designing, producing, collecting and recycling systems which make it possible to recycle most used materials through legally establishing manufacturers' responsibilities for collection and disposal of disused products.	92	2012	Environment	Recycling
7	Marine science	60 Development of technology capable of forecasting the occurrence of major earthquakes (magnitude 7 or above) several days in advance.	92	2023	Disasters	Earthquakes
8	Communication	01 Practical use of a highly secure next-generation internet that allows the transmission of real-time information, leading to the implementation of internet-based telephone services and motion video broadcasts.	92	2003	Information	Networks
9	Electronics	18 Development of solar cells capable of maintaining 15% efficiency for at least 10 years without light convergence.	92	2010	New energy	Solar cells
10	Urbanization	13 Practical use in Japan of a safe and rational demolition technology for decommission of commercial nuclear power plants.	92	2009	New energy	Nuclear energy
11	Materials	84 Practical use of multi-layer solar cells with a conversion efficiency of more than 50%.	91	2016	New energy	Solar cells
12	Materials	85 Practical use of large-area amorphous silicon solar cells with a conversion efficiency of more than 20%.	91	2011	New energy	Solar cells
13	Life science	49 Practical use of effective means to prevent metastasis of cancer.	91	2013	Life	Cancer
14	Marine science	01 Practical use of Tsunami forecasting systems based on tide and Tsunami observation through satellites and on other data including shelf topography.	91	2007	Disasters	Natural disasters
15	Environment	32 Wide acceptance of LCA-style product design concepts that encourage recycling and reuse.	91	2007	Environment	Recycling
16	Information	22 Widespread use of highly reliable network systems capable of protecting the privacy and secrecy of individuals and groups from the intrusion of ill-intentioned hackers.	91	2007	Information	Networks
17	Materials	34 Establishment and practical use of plastic recycling technology.	91	2007	Environment	Recycling
18	Production	44 Practical use of technologies that enable the direct storage of electricity (superconducting magnets, flywheels and capacitors).	90	2016	New energy	
19	Information	18 Realization of an environment in which the unlimited utilization of high-capacity networks (150 Mbps) for around 2,000 yen/month is possible.	90	2008	Information	Networks

Ranking	Field	Topic	Degree of importance index	Forecasted realization time	Notes; Classification of topic	
20	Information	64 Establishment of social rules regarding multimedia copyrights, and expanded production and distribution of multimedia information.	89	2005	Information	Networks
21	Resources	63 Practical use of technology for the safe disposal of highly radioactives solid waste.	89	2019	New energy	Nuclear energy
22	Electronics	13 Practical use of TIPS (Tera Instruction Per Second) level microprocessors.	89	2018	Information	Semiconductors etc.
23	Environment	24 Widespread use of control technologies in virtually all types of automobiles, capable of meeting the emission control standard for nitric oxide at the order of 0.1 to 0.2 g/km. (The current level for heavy diesel motorcars is on the order of 4 to 5 g/km, and the standard control value for gasoline passenger cars in 1978 is 0.25 g/km.)	89	2007	Environment	
24	Electronics	08 Practical use of non-volatile, erasable with more than 100 Gbits capacity random access semiconductor memories.	88	2017	Information	Semiconductors etc.
25	Agriculture etc.	84 Practical use of a system of removing almost the entire pollution load on lakes, bays and other closed water bodies that are suffering from water quality degradation by developing environmental restoration technology that utilizes ecosystems and biological functions.	88	2018	Environment	
26	Transportation	31 Achievement of a 90% recyclability for motor vehicle parts and material (scrapped vehicles).	88	2009	Environment	Recycling
27	Marine science	14 Development of a numerical model of the correlation between climatic changes and changes in marine living resources.	88	2013	Environment	Global environment
28	Production	08 Practical use of room temperature superconductors in industrial products.	88	2016		
29	Resources	19 Practical use of economical methods for separating and recycling valuable substances in urban garbage.	88	2009	Environment	Recycling
30	Electronics	49 Production of household-use optical fiber signal tranceiver units at a cost of around 5,000 yen.	88	2009	Information	Networks
31	Resources	17 Practical use of technologies capable of separating useful metals, such as iron, copper and aluminum, from metal-containing wastes, such as scrap cars, discarded electric appliances, to a purity level of more than 99%.	88	2011	Environment	Recycling
32	Life science	74 Identification and classification by the molecular etiology of the genes related to diabetes, hypertension, and arteriosclerosis, typical geriatric diseases which exhibit multiple-factor hereditary traits.	88	2012	Life	
33	Health	05 Elucidation of carcinogenic mutation mechanisms.	88	2013	Life	Cancer
34	Marine science	43 Establishment of scientific methods for long-range weather forecasting (1-6 months in advance).	88	2014		
35	Production	70 Widespread use of earthquake damage alleviation systems for industrial complexes, nuclear facilities, etc. based on the early operation of safety devices in response to initial mild tremors.	88	2009	Disasters	Earthquakes
36	Urbanization	05 Practical use in Japan of a mid-term (5 - 10 years in advance) prediction technique for large-scale (Magnitude 8 or stronger) earthquakes based on analyses of the distribution of strains in the earth's crust and past earthquake records.	87	2017	Disasters	Earthquakes

Ranking	Field	Topic	Degree of importance index	Forecasted realization time	Notes; Classification of topic	
37	Transportation	07 Development of a system that detects the initial mild tremors of an earthquake at appropriate locations, and safely stops trains as necessary to avoid places that have a high risk of collapse (because of the earthquake).	87	2006	Disasters	Earthquakes
38	Electronics	09 Practical use of semiconductor LSIs that operate at a switching speed of 1 ps or less.	87	2015	Information	Semiconductors etc.
39	Agriculture etc.	02 Practical use in Japan of crop varieties having the characteristics (higher yield and more disease- and cold-resistance) improved by gene manipulation.	87	2004	Life	
40	Life science	48 Development of drugs capable of preventing the occurrence of certain types of cancer.	87	2010	Life	Cancer
41	Production	51 Advancements in technological development such as carbon dioxide recovery and detoxification of harmful wastes, leading to the widespread use of global environmental conservation measures throughout the world.	87	2018	Environment	Global environment
42	Communication	72 Development of high performance batteries with an energy density of about 500 Wh/kg, capable of miniaturizing mobile phones in terms of both size and weight.	87	2009		
43	Information	48 Widespread use in all areas of security systems capable of providing emergency information to the general public in the case of a disaster.	87	2007	Disasters	
44	Environment	34 Establishment of assessing socio-economic damage/loss because of the destruction of natural environment by soil contamination and land subsidence (e.g., loss of natural beaches, forests, or fields) and incorporation of its countermeasures in regulatory system.	87	2012	Environment	
45	Health	44 Improvement in the average five-year survival rate for all types of cancer to more than 70% (currently about 40% for stomach cancer).	87	2013	Life	Cancer
46	Electronics	19 Development of processor LSIs with 10 GIPS performance and power consumption of 10 miliwatts or less.	87	2014	Information	Semiconductors etc.
47	Life science	02 Development of anti-cancer agents which target the manifestation functions of cancer genes.	87	2010	Life	Cancer
48	Life science	35 Widespread production of bioplastics using microorganisms and plants, accounting for 10% of the total volume of worldwide plastic production.	87	2013	Environment	Recycling
49	Agriculture etc.	01 Elucidation of the whole DNA sequences of crops (e.g. Rice) to isolate useful genes.	87	2009	Life	
50	Agriculture etc.	20 Widespread use of biodegradable containers and wrapping materials that use bio-oriented materials.	86	2005	Environment	Recycling
51	Marine science	45 Nationwide installation of bore-hole-type observation equipment integrating various types of gauges (e.g., seismometers, tiltmeters, and strain-gauges) for use in earthquake forecasting.	86	2011	Disasters	Earthquakes
52	Life science	01 Identification of multiple genes related to cancer, and elucidation of the relationships between those genes and carcinogenesis.	86	2014	Life	Cancer
53	Health	06 Elucidation of cancer metastasis mechanisms.	86	2012	Life	Cancer
54	Life science	67 Become possible to cure senile dementia of Alzheimer type.	86	2016	Life	Brain

Ranking	Field	Topic	Degree of importance index	Forecasted realization time	Notes; Classification of topic	
55	Production	49 Widespread use of low entropy-generating eco-factories, which give due consideration to the impact on local ecosystems throughout product life cycles, from manufacture to disposal.	86	2017	Environment	Recycling
56	Marine science	58 Practical use of technology for predicting and forecasting landslides and rockslides caused by intense rainfall in certain locations in Japan.	86	2010	Disasters	Natural disasters
57	Communication	63 Practical use of integrated building management systems and home security systems which are linked to an earthquake detection system and take the necessary safety measures to protect human lives in the event of a non-direct-hit earthquake, taking advantage of the time lag to the arrival of seismic waves.	86	2011	Disasters	Earthquakes
58	Materials	62 Development of memory capacity of 1 terabit per chip.	86	2013	Information	Semiconductors etc.
59	Urbanization	04 Development of a nationwide network for detecting earthquakes, and widespread use in Japan of a disaster prevention system that gives advance warning of earthquakes at a distance of at least 50Km.	86	2011	Disasters	Earthquakes
60	Life science	91 Development of technologies which dramatically improve photosynthetic ability in order to increase food production.	86	2017	Life	
61	Transportation	17 Widespread use of motor vehicles with fuel efficiencies 30% greater than today's vehicles through the introduction of new materials that increase strength and reduce weight and development of element technologies such as one concerning engine thermal efficiency improvements.	86	2007	Environment	
62	Environment	38 Widespread use (e.g., more than 10% in the world) of automobiles as urban transportation system (e.g., electric vehicles) which do not cause air or noise pollution.	86	2013	Environment	
63	Communication	67 Widespread use of electronic commerce carried out via a network based on an electronic funds transfer system and electronic money system.	85	2006	Environment	Networks
64	Materials	107 Practical use of processes for water decomposition by the sunlight.	85	2017	New energy	
65	Environment	23 Introduction of environment tax aiming at global environmental conservation.	85	2006	Environment	Global environment
66	Information	05 Practical use of systems which facilitate multimedia communication from anywhere in the world using pocket-size computers.	85	2003	Information	Networks
67	Marine science	12 Practical use of technologies for predicting and forecasting changes in the ocean currents in the seas adjoining Japan.	85	2011		
68	Agriculture etc.	55 Development of production regulation systems as a step toward management of resources and fisheries once it becomes possible to predict the long term (10 to 20 years) changes major fishery resources.	84	2016		
69	Electronics	24 Widespread use of a portable multimedia wireless terminal operated on the order of 100 Mbits/sec., which can be used throughout the world.	84	2011	Information	Networks
70	Materials	108 Practical use of carbon dioxide fixation technology necessary for protecting global environments.	84	2016	Environment	Global environment

Ranking	Field	Topic	Degree of importance index	Forecasted realization time	Notes; Classification of topic	
71	Space	09 Realization of precision down to less than a centimeter in measurement of crustal movement using VLBI (very long baseline inter-ferometers), satellite lasers, inverse laser ranging, and synthetic aperture radar to improve accuracy in such as earthquake forecasting.	84	2009	Disasters	Earthquakes
72	Transportation	30 Practical use of heavy-duty freight truck exhaust clean-up technologies - such as diesel exhaust catalysts, particulate traps, lean-burn NOx catalysts and high precision combustion technology - to reduce the harmful components of exhaust to 1/10 of present levels.	84	2010	Environment	
73	Transportation	14 Widespread use of traffic control systems on road, for optimal control of the flow of traffic in cities based on identification of vehicles on road, speed, and level of congestion.	84	2007		
74	Communication	08 Development of a super high-speed computer communication protocol capable of achieving a throughput of hundreds of Mbps.	84	2003	Information	Networks
75	Electronics	32 Practical use of ultraviolet, blue, and green, semiconductor lasers.	84	2004		
76	Environment	08 Determination and general understanding of the impact of global warming on world agricultural production.	83	2012	Environment	Global environment
77	Materials	44 Development of superconductive materials with a transition temperature around room temperature.	83	2020		
78	Life science	72 Scientific elucidation of the factors within daily life (eating habits, air quality, etc.) which influence the process of carcinogenesis.	83	2012	Life	Cancer
79	Information	45 Advances in software inspection and verification technology, enabling quick development of error-free, large-scale software.	83	2012	Information	
80	Marine science	22 Development of safe, economically feasible technology for the removal/detoxification of sea-bottom sludges, enabling the widespread application of methods for decontamination and recovery of fishery grounds.	83	2013	Environment	
81	Electronics	67 Development of a magnetic memory hard disk capable of recording 1,000 Gbits density per square inch.	83	2017	Information	Semiconductors etc.
82	Agriculture etc.	42 Establishment of a quantitative assessment technique for the environmental conservation functions of forest ecosystems, and widespread use of a forest management technique that makes the exploitation of timber resources, while still maintaining such functions.	83	2014	Environment	
83	Urbanization	62 Establishment in Japan of a wide-area integrated water management technique covering rivers, dammed reservoirs, etc., leading to widespread use of efficient water resource utilization systems in major urban zones.	83	2009		
84	Electronics	38 Practical use of optical multiplexed communication equipment capable of multiplexing 200 channels of signals with 100 Gbits/sec. and transmitting them over a single optical fiber.	83	2014	Information	Networks
85	Resources	06 Development of a steelmaking technology that requires fossil fuel consumption less than half of the present level.	83	2014		
86	Life science	52 Development of an entirely implantable artificial kidney.	83	2013	Life	

Ranking	Field	Topic	Degree of importance index	Forecasted realization time	Notes; Classification of topic	
87	Communication	09 Widespread use of integrated information wiring and plug socket that incorporate services such as the telephone, Internet, VOD and high-definition TV in homes and offices.	83	2007	Information	Networks
88	Life science	28 Control of signal transduction in the carcinogenesis of cells, and widespread use of treatment methods for dysdifferentiating carcinogenic cells.	82	2020	Life	Cancer
89	Environment	31 Widespread use of power generation using refuse derived fuel (RDF).	82	2006	New energy	
90	Electronics	68 Practical use of optical memories with recording density of 10^{11} b/cm^2.	82	2016	Information	Semiconductors etc.
91	Communication	74 Practical use of biochip devices that have a memory density (10^{12} bit/cm^2) 1,000 times that of current semiconductor devices (10^9 bits/cm^2).	82	2015	Information	Semiconductors etc.
92	Marine science	17 Practical use of systems for monitoring water pollution on a global scale.	82	2012	Environment	Global environment
93	Electronics	28 Practical use of automated production systems in which LSI chips are produced automatically by giving LSI design data.	82	2015	Information	Semiconductors etc.
94	Life science	07 Elucidation of the environmental factors and control mechanisms of the immune response which triggers allergies such as hay fever and atopy, facilitating the complete control over immediate type hyper-sensitivity.	82	2014	Life	
95	Information	68 Widespread use of systems to unitarily handle information management (orders, design, manufacturing, maintenance) among related companies.	82	2005	Information	Networks
96	Environment	04 Practical use of materials that replace fluorocarbons and halons, that do not damage the ozone layer and cause global warning problem.	82	2007	Environment	Global environment
97	Materials	20 Practical use of rechargeable polymer batteries having a volume-specific capacity of 400 Wh/liter. (Capacity of current Ni-Cd batteries: 180 Wh/liter)	82	2011		
98	Environment	27 Widespread use, including use at home, of compact waste-water treatment systems based on biotechnology for the highly efficient treatment of persistent substances and hazardous materials.	82	2010	Environment	
99	Life science	36 Widespread production of alcohol and other fuel oils utilizing microorganisms, seaweed, etc., accounting for 10% of total worldwide fuel oil production.	81	2015	New energy	
100	Health	20 Widespread use of scientific guidelines for adult-disease-preventing life-styles (nutrition, rest and exercise).	81	2006	Life	

1.2 Trends in forecasted realization time

To examine trends in the forecasted realization time of topics assessed to have a high degree of importance, we grouped the topics as follows. Figure 1.2-1 shows differences in realization times according to importance.

i) Top 100 topics in degree of importance (importance index ≥81.3)

ii) Medium degree of importance — 476 topics (60.0 ≤ importance index ≤ 81.2)

iii) Low degree of importance — 496 topics (importance index ≤ 59.9)

While some differences can be seen among each of the groups, the overall trend is quite similar.

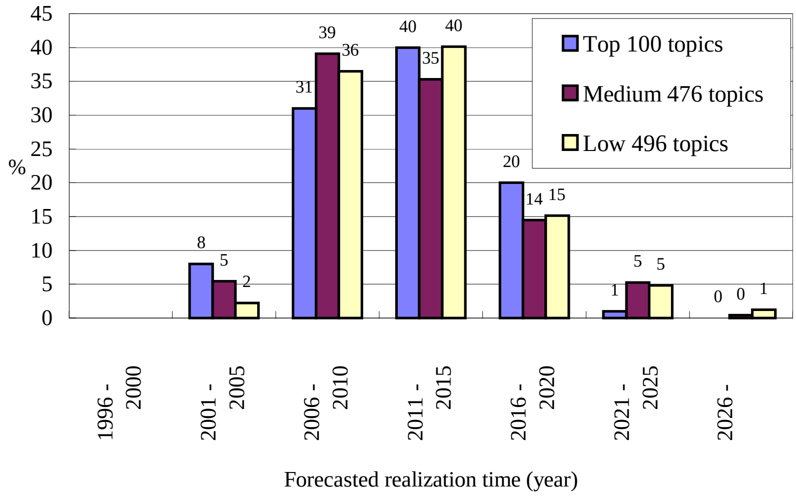

Figure 1.2-1 Forecasted realization time by degree of importance

1.3 Relationship with expected effect

Figure 1.3-1 shows the relationship between topics with a high degree of importance and expected effect. Respondent's expectation of topics in the top 100 are, compared to the other groups, considerably higher in the contribution to "resolution of global problems" and slightly higher in the contribution to "socioeconomic development," but somewhat lower in the contribution to "expansion of intellectual resources."

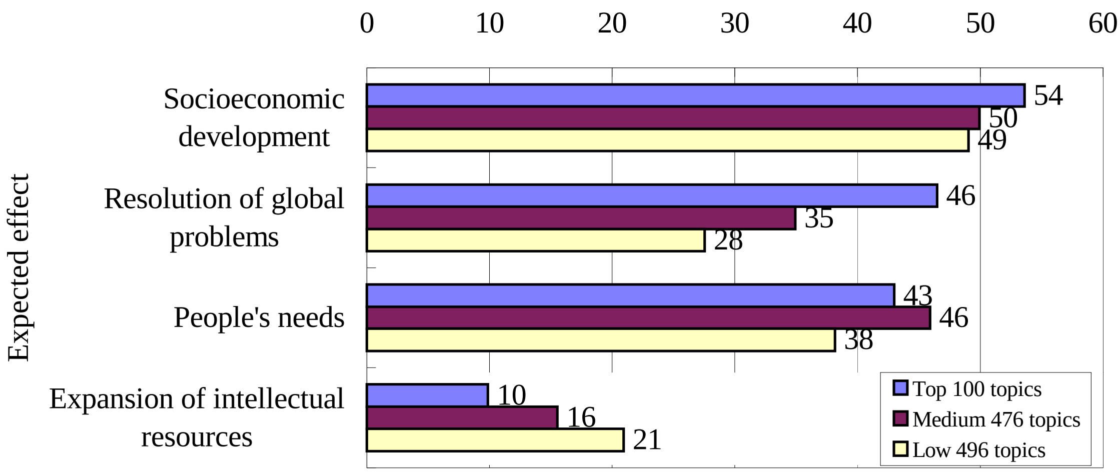

Figure 1.3-1 Expected effect by degree of importance

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2. Major technological trends in expected effect

This survey examines the kind of effect expected from each of the topics. Specifically, respondents were asked to choose from the following four items for each topic.

i) Contribution to socioeconomic development

ii) Resolution of various problems of a global scale

iii) Response to people's needs

iv) Expansion of human intellectual resources

2.1 Trends in each field

Figure 2.1-1 shows the average topic response rate for the above items by field. The average value for all topics is quite high in contribution to socioeconomic development and response to people's needs, and low in expansion of human intellectual resources.

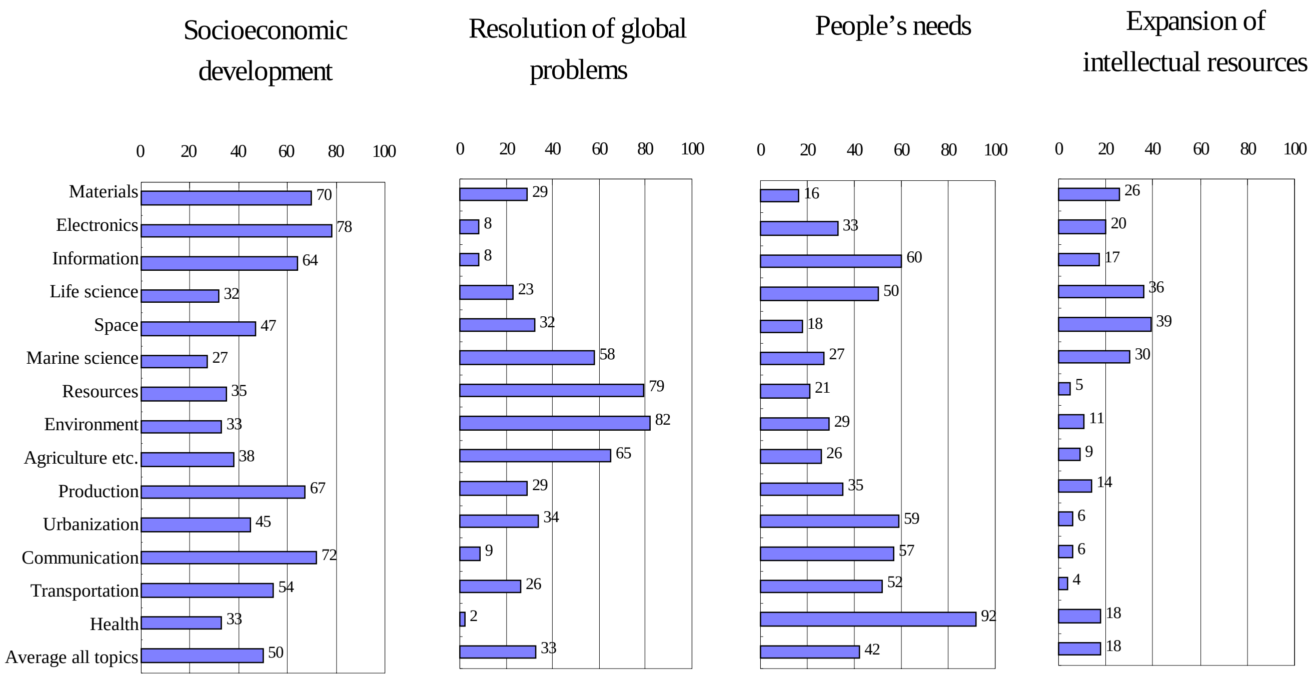


Figure 2.1-1 Trends in expected effect (by field)

Fields with a high number of topics considered to make a high contribution to socioeconomic development are "electronics" (77.6), "communication" (71.8), "materials" (69.6), "production" (67.0) and "information" (64.2); these fields also have a high number of topics thought to make only a minor contribution to resolution of global problems. Conversely, fields expected to make a high contribution to the resolution of global problems are "environment" (81.6), "resources" (78.7), "agriculture etc." (65.0) and "marine science" (57.6).

As for response to people's needs, "health" is extremely high at 92.0%, while those with a comparatively high expectation are "information" (59.7), "urbanization" (59.0), "communication" (57.2), "transportation" (52.0) and "life science" (50.4). As for expansion of intellectual resources, no field exceeded 50%, but those with comparatively high reading are "space" (39.0), "life science" (36.3) and "marine science" (29.8).

2.2 Trends in forecasted realization time

To examine trends in topics considered to have a particularly high effect on socioeconomic development etc., we looked at topics that at least 80% of respondents believe would have an effect on an item and that are considered to have a relatively high degree of importance (topics with a degree of importance index of at least 80 for “socioeconomic development,” “resolution of global problems” and “response to people’s needs,” and at least 50 for “expansion of intellectual resources”; hereinafter referred to as important topics with a high expected effect). Table 2.2-1 shows the realization trends for those topics chronologically.

Topics with a high expectation in “contribution to socioeconomic development”

Fields with a high number of topics thought to deliver a significant effect are “information,” “communication” and “electronics.” It is thought that from 2001 to 2010 advances made in network-related technology will have a significant impact. In the ten years from 2011, technology for mass production and processing of microscopic patterns and technologies revolving around devices such as high-speed processors and high-capacity memory chips will steadily move ahead, and the economic effects of these technologies is expected to be substantial.

Topics with a high expectation in “resolution of various problems of a global scale”

Until 2005 there is not expected to be any significant advancement, but from 2006 to 2015 recycling of plastics, motor vehicles and the like is expected to be firmly established. Meanwhile, motor vehicle pollution is expected to drop, with a reduction of nitrogen oxides in vehicle exhausts, lower exhaust emissions by large trucks, and the widespread use of electric cars. Advances are also expected in the development of environmental monitoring systems as a global approach to environmental issues, such as a real-time global monitoring network and a world-wide marine pollution monitoring system.

Topics with a high expectation in “response to people’s needs”

There is an especially large number of topics with a high expected effect in “life science,” followed by “urbanization.” Advances are expected in forecasting disasters and systems for transmitting disaster information by about 2010, and after 2010 developments are expected in the elucidation and treatment of cancer mechanisms. As for predicting earthquakes, 2016–2020 for magnitude 8 earthquakes and after 2020 for magnitude 7 earthquakes is the general line of thought.

Topics with a high expectation in “expansion of intellectual resources”

Fields with a large number of topics with a high expected effect are “life science” and “space”. Advances are expected in gene-level analysis of cells by about 2010, and 2011–2015 in the elucidation of the human memory structure and the mechanism by which neural networks are formed. Based on these advances, progress is expected in the elucidation of the mechanisms of human logical reasoning and creation from 2021.

Table 2.2-1 Realization trends by expected effect

Year	Socioeconomic development (35 topics)	Resolution of global problems (45 topics)	People's needs (32 topics)	Expansion of human intellectual resources (17 topics)
2001				
2002				
2003	(Communication) Development of a super high-speed computer communication protocol capable of achieving a throughput of hundreds of Mbps (Communication) Practical use of a highly secure next-generation internet that allows the transmission of real-time information (Information) Practical use of systems which facilitate multimedia communication from anywhere in the world			
2004	(Electronics) Practical use of ultraviolet, blue, and green, semiconductor lasers	(Agriculture etc.) Practical use in Japan of crop varieties improved by gene manipulation		
2005	(Information) Establishment of social rules regarding multimedia copyrights; (Information) Widespread use of systems to handle information management uniformly among related companies	(Agriculture etc.) Widespread use of biodegradable containers and wrapping materials that use bio-oriented materials		
2006	(Communication) Widespread use of electronic commerce carried out via a network; (Production) Radical changes to the production and machinery area through multimedia technology	(Environment) Introduction of environment tax aiming at global environmental conservation	(Transportation) Development of a system that safely stops trains in the early stages of an earthquake to avoid places that have a high risk of collapse (Health) Widespread use of scientific guidelines for adult-disease-preventing life-styles (nutrition, rest and exercise)	

Year	Socioeconomic development (35 topics)	Resolution of global problems (45 topics)	People's needs (32 topics)	Expansion of human intellectual resources (17 topics)
	(Information) Widespread use of software libraries which facilitate the re-utilization of software (Information) Widespread use of electronic money to settle monetary matters			
2007	(Information) Widespread use of highly reliable network systems capable of protecting privacy and secrecy	(Materials) Practical use of plastic recycling technology (Environment) Practical use of fluorocarbon and halon substitutes that do not damage the ozone layer and cause global warming (Transportation) Widespread use of motor vehicles with fuel efficiencies 30% greater than current vehicles (Environment) Widespread use of technologies capable of meeting the emission control standard for nitric oxide in virtually all types of automobiles (Space) Development of technology for measuring, in real time, the distribution and movement of air pollution via observation from space	(Information) Widespread use of security systems that provide emergency information at the time of a disaster (Marine science) Practical use of Tsunami forecasting systems using satellites (Communication) Widespread use of integrated information wiring and plug socket in homes and offices (Urbanization) Widespread use in Japan of monitoring and control systems for enhancing the safety of essential services in a disaster	
2008	(Information) Realization of an environment in which the utilization of high-capacity networks for around 2,000 yen/month is possible (Space) Realization of a high-accuracy satellite positioning system operated by an international organization	(Space) Widespread use of a global-scale real-time environmental surveillance network	(Urbanization) Widespread use in Japan of warning systems etc. based on localized weather forecasts	
2009	(Communication) Development of high performance batteries with an energy density of about 500 Wh/kg	(Agriculture etc.) Elucidation of the whole DNA sequences of crops (Urbanization) Practical use in Japan of a safe and rational technology for decommission of commercial nuclear power plants	(Urbanization) Development of disaster forecasting and information transmission systems to prevent panic during an earthquake	

Year	Socioeconomic development (35 topics)	Resolution of global problems (45 topics)	People's needs (32 topics)	Expansion of human intellectual resources (17 topics)
	(Communication) Widespread use of a security technology that monitors illicit activities involving information and communication ethics (Electronics) Production of household-use optical fiber signal transceiver units at a cost of around 5,000 yen (Production) Practical use of superprecision processing technologies that enable measurement to the angstrom order and time measurement to the femtosecond order	(Resources) Practical use of economical methods for separating and recycling valuable substances in urban garbage (Transportation) Realization of a 90% recyclability for motor vehicle parts and material		
2010		(Electronics) Development of solar cells capable of maintaining 15% efficiency for at least 10 years without light convergence (Transportation) Practical use of technologies to reduce the harmful components of truck exhausts to 1/10 of present levels	(Life science) Development of drugs capable of preventing the occurrence of certain types of cancer (Information) Practical use of robots which provide medical care support in homes, hospitals, etc. (Life science) Development of anti-cancer agents which target the manifestation functions of cancer genes (Marine science) Practical use of technology for predicting and forecasting landslides and rockslides caused by intense rainfall in certain locations in Japan	(Space) Return of samples from other planets
2011	(Electronics) Widespread use of a portable multimedia wireless terminal which can be used throughout the world	(Marine science) Practical use of technologies for predicting and forecasting changes in the ocean currents in the seas adjoining Japan (Resources) Practical use of technologies capable of separating useful metals from scrap cars etc. to a purity level of more than 99% (Materials) Practical use of large-area amorphous silicon solar cells with a conversion efficiency of more than 20%	(Materials) Widespread use of signal-responsive missile drugs capable of efficiently reaching tumor cells (Communication) Practical use of integrated building management systems linked to an earthquake detection system (Urbanization) Widespread use in Japan of a disaster prevention system that gives advance warning of earthquakes at a distance of at least 50km	(Marine science) Inauguration in Japan of international research centers for comparative planetology

Year	Socioeconomic development (35 topics)	Resolution of global problems (45 topics)	People's needs (32 topics)	Expansion of human intellectual resources (17 topics)
2012	(Information) Realization of software inspection and verification technology that enables quick development of error-free, large-scale software	(Marine science) Practical use of systems for monitoring water pollution on a global scale (Environment) General understanding of the impact of global warming on world agricultural production (Production) Widespread use of designing, producing, collecting and recycling systems which make it possible to recycle most used materials (Electronics) Practical use of solar cells which make the cost of power generation facilities less than 100 yen/watt	(Life science) Identification of the genes related to diabetes (Health) Elucidation of cancer metastasis mechanisms (Life science) Elucidation of the factors within daily life which influence the process of carcinogenesis (Communication) Development of an automatic Japanese-English-Japanese translation telephone system comparable to human simultaneous interpretation	
2013	(Electronics) Practical use of technology which allows mass processing of 10nm patterns; (Materials) Development of memory capacity of 1 terabit per chip	(Life science) Widespread use of bioplastic production so it accounts for 10% of total worldwide plastic production (Marine science) Development of a numerical model of the correlation between climatic changes and changes in marine living resources (Environment) Widespread use of nonpolluting automobiles (e.g., electric vehicles) so they account for at least 10% of all vehicles in the world	(Health) Elucidation of carcinogenic mutation mechanisms (Life science) Development of an entirely implantable artificial kidney (Health) Improvement in the average five-year survival rate for all types of cancer to more than 70% (Life science) Practical use of effective means to prevent metastasis of cancer	
2014	(Electronics) Practical use of optical multiplexed communication equipment capable of multiplexing 200 channels of signals with 100 Gbits/sec. and transmitting them over a single optical fiber (Space) The cost of rocket space transportation will be reduced to less than 1/10 current levels (Electronics) Practical use of VLSI with as much as 256 Gbits of memory per chip (Electronics) Development of processor LSIs with 10 GIPS performance and power consumption of 10 milliwatts or less	(Agriculture etc.) Development of an estimation technique for an optimum fisheries production level for each fishing area based on simulation techniques for biological propagation (Agriculture etc.) Widespread use of timber resources exploitation management techniques based on quantitative assessment methods for the environmental conservation functions of forests (Marine science) Establishment of scientific methods for long-range weather forecasting (1-6 months in advance)	(Life science) Identification of most genes related to cancer, and elucidation of the relationships between those genes and carcinogenesis (Life science) Realization of the complete control over spontaneous allergies through the elucidation of the immune control mechanisms	(Life science) Development of technology to analyze the genes manifested in a single cell in higher animals with an accuracy in the order of 1 mRNA molecule

Year	Socioeconomic development (35 topics)	Resolution of global problems (45 topics)	People's needs (32 topics)	Expansion of human intellectual resources (17 topics)
		(Resources) Development of technology that requires fossil fuel consumption less than half of the present level (Marine science) Elucidation of the impact on the ecosystem from ocean development through the establishment of a numerical model		
2015	(Electronics) Practical use of semiconductor LSIs that operate at a switching speed of 1 ps or less (Electronics) Practical use of systems in which LSI chips are produced automatically from LSI design data (Communication) Practical use of biochip devices that have a memory density 1,000 times that of current semiconductor devices	(Life science) Widespread production of fuel oils utilizing microorganisms, etc. so it accounts for 10% of total worldwide fuel oil production	(Life science) Widespread use of methods of multiplying stem cells in test tubes and using them for treatment purposes	(Life science) Complete elucidation of the molecular mechanism explaining the cell cycle in higher order mammals (Electronics) Development of X-ray microscopes capable of 10-100nm resolution (Life science) Elucidation of relationships between higher-order structures and functions of the nuclei in eukaryotic cells
2016	(Production) Practical use of room temperature superconductors in industrial products (Electronics) Practical use of optical memories with recording density of 10^{11} b/cm^2	(Materials) Practical use of multi-layer solar cells with a conversion efficiency of more than 50% (Agriculture etc.) Development of fishery production systems based on predictions of long term (10 to 20 years) changes major fishery resources (Production) Practical use of technologies that enable the direct storage of electricity (Materials) Practical use of carbon dioxide fixation technology necessary for protecting global environments	(Life science) Realization of cure for Alzheimer's disease (Environment) Elucidation of the long-term exposure effects of small quantities of harmful chemical substances on human beings	
2018	(Electronics) Practical use of TIPS level microprocessors	(Production) Widespread use of global environmental conservation measures throughout the world based on carbon dioxide recovery technologies (Agriculture etc.) Practical use of a system of removing almost the entire pollution load caused by environmental degradation on closed water bodies		(Life science) Elucidation of the molecular mechanisms for formation of neuronal networks at the molecular level (Life science) Elucidation of the whole molecular mechanisms for synaptic plasticity in the mammalian brain

Year	Socioeconomic development (35 topics)	Resolution of global problems (45 topics)	People’s needs (32 topics)	Expansion of human intellectual resources (17 topics)
		(Production) Widespread use of non-fossil energy in all areas of life including household, industry and transportation		
2019	(Production) Widespread use of highly functional materials and super materials that control structures at the atomic and molecular level	(Resources) Practical use of technology for the safe disposal of highly radioactive solid waste		(Marine science) Development of a positron microscope
2020	(Materials) Development of room temperature superconductors		(Life science) Widespread use of treatment methods for dysdifferentiating carcinogenic cells	
2021			(Life science) Clinical application of technology enabling organs to regenerate through the multiplication of their own cells	
2022		(Environment) Reduction of global carbon dioxide emissions to 20% below the 1990 level		(Life science) Complete elucidation of the molecular mechanisms of development and differentiation
2023			(Marine science) Development of technology capable of forecasting the occurrence of earthquakes of magnitude 7 or above several days in advance Expansion of intellectual resources	(Life science) Elucidation of brain mechanisms for logical reasoning; (Life science) Elucidation of the transcription cascade for all genes, from fertilized egg to individual, in a single higher animal species, e.g. mice, and the mechanism by which differentiation and functions are manifest (Marine science) Practical use of high-luminosity radiation with emission of 0.1 nano radians or less (Information) Elucidation of human creative mechanism to such an extent that it can be applied to computer science

Year	Socioeconomic development (35 topics)	Resolution of global problems (45 topics)	People's needs (32 topics)	Expansion of human intellectual resources (17 topics)
2024				
2025		(Resources) Practical use of fast breeder reactor systems including nuclear fuel cycle		(Life science) Elucidation of the molecular mechanism of life creation
2026 or later		(Resources) Development of fusion reactors		

2.3 Relationship with current leading countries etc.

The graphs at Figure 2.3-1 show current leading countries and regions in topics with a high expected effect highlighted in 2.2.

For topics with a high expected effect in "contribution to socioeconomic development," USA ranks highest, while Japan ranks above its average for "all topics." A similar pattern can be seen in "response to people's needs." In the "resolution of global problems" though, the percentage for the USA has dropped, while that for the EU is relatively higher. In the "expansion of intellectual resources," the USA percentage was particularly high, and the EU was also above its overall average, whereas Japan fell well below its overall average.

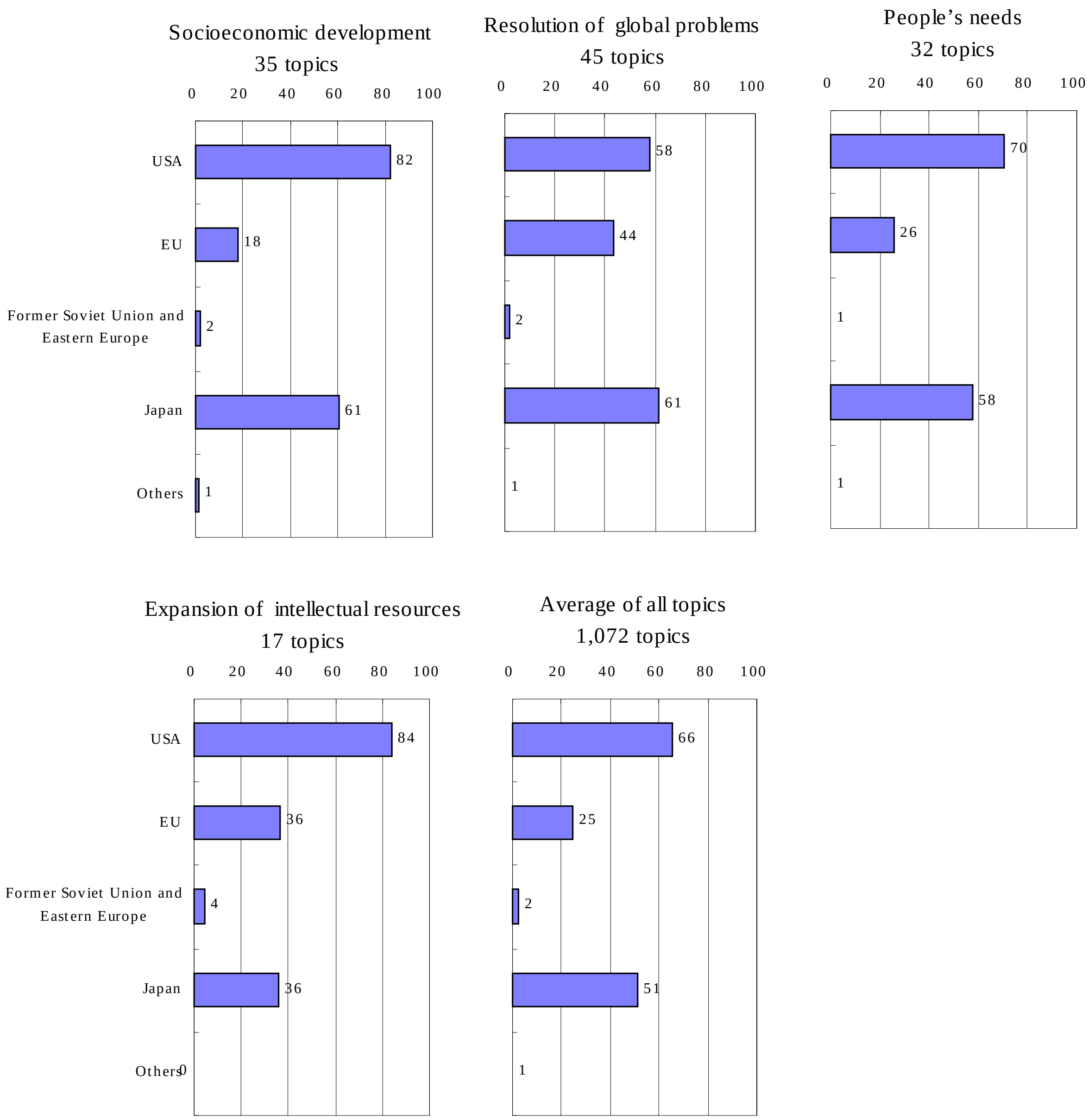


Figure 2.3-1 Expected effect and leading countries etc.

2.4 Relationship with measures the government should adopt

Figure 2.4-1 shows in graph form the effective measures respondents believe the government should adopt for topics with a high expected effect.

For topics with a high expected effect in “socioeconomic development,” “foster human resources,” “increase government research funding” and “promote exchanges among industrial, academic and government sectors and different fields” are ranked the highest, but all are below their respective averages for all topics. In contrast, a greater proportion of respondents want the government to “adjust regulations (relax/toughen)” than the average. Typical examples of this are topics related to multimedia and networks, such as “603066: Widespread use of electronic money to settle monetary matters” (adjust regulations (relax/toughen) — 84%), and “603064: Establishment of social rules regarding multimedia copyrights” (adjust regulations (relax/toughen) — 83%).

As for “resolution of global problems,” the percentage calling on the government to “promote exchanges among industrial, academic and government sectors and different fields,” “increase government research funding” and “adjust regulations (relax/toughen)” are higher than their respective averages for all topics, especially government funding, which is 11% higher than its overall average. Typical examples include topics related to the management and assessment of the environment and biological resources, such as “609084: Practical use of a system of removing almost the entire pollution load caused by environmental degradation on closed water bodies” (increase government research funding — 78%), and “609054: Development of an estimation technique for an optimum fisheries production level for each fishing area based on simulation techniques for biological propagation” (increase government research funding — 78%).

In the “response to people’s needs” item, “foster human resources” and “increase government research funding” are especially high. “Develop a research base” is also higher than its averages for all topics. Topics for which the voices calling for greater government spending are loudest are those connected with earthquakes, including “612063: Practical use of integrated building management systems linked to an earthquake detection system” (increase government research funding — 78%) and “611004: Widespread use in Japan of a disaster prevention system that gives advance warning of earthquakes at a distance of at least 50km” (increase government research funding — 74%).

Regarding the “expansion of intellectual resources,” percentages for “foster human resources” and “increase government research funding” are quite high, while “upgrade advanced facilities and equipment” is also above its all-topics average. “Foster human resources” is very high at 71%, and specific examples include topics connected with the elucidation of life phenomena, such as “604041: Elucidation of relationships between higher-order structures and functions of the nuclei in eukaryotic cells” (82%) and “604084: Complete elucidation of the molecular mechanisms of development and differentiation” (82%).

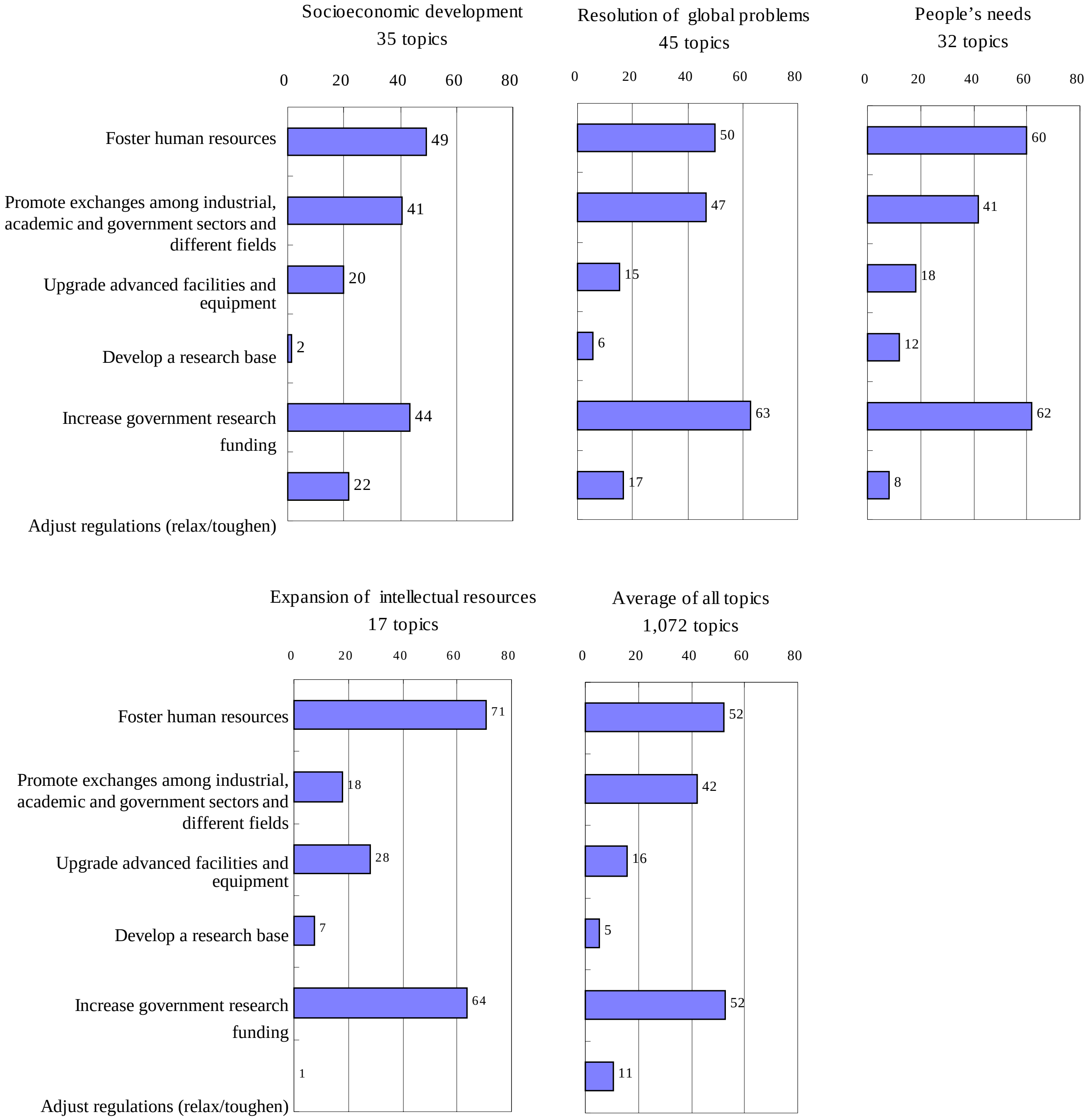


Figure 2.4-1 Expected effect and effective measures the government should adopt

2.5 Relationship with potential problems

Figure 2.5-1 shows in graph form concerns respondents have with the realization of topics with a high expected effect.

Respondents expressed a higher-than-average concern over the "adverse effect on safety" regarding topics with a high expected effect in "contribution to socioeconomic development," which include many network- and device-related topics, as can be seen by "603066: Widespread use of electronic money to settle monetary matters" (67%) and "612067: Widespread use of electronic commerce carried out via a network" (67%).

As for topics with a high expected effect in "resolution of global problems," respondents expressed considerable concern over the "adverse effect on the natural environment" regarding technologies connected with nuclear power, such as “611013: Practical use in Japan of a safe and rational technology for decommission of commercial nuclear power plants” (70%) and “607063: Practical use of technology for the safe disposal of highly radioactive solid waste” (54%), and technologies connected with improving crop quality through gene manipulation, such as “609002: Practical use in Japan of crop varieties improved by gene manipulation” (60%) and “604091: Development of technologies which dramatically improve photosynthetic ability in order to increase food production” (47%).

Regarding “response to people’s needs,” higher-than-average concern was expressed over “adverse effect on safety” and “adverse effect on morals, culture or society.” Topics that attracted a high response rate on “adverse effect on safety” include “611001: Widespread use in Japan of warning systems etc. based on localized weather forecasts” (52%) and “611003: Development of disaster forecasting and information transmission systems to prevent panic during an earthquake” (50%), while those attracting a high response rate on “adverse effect on morals, culture or society” include “614020: Widespread use of scientific guidelines for adult-disease-preventing life-styles (nutrition, rest and exercise)” (54%), “604001: Identification of multiple genes related to cancer, and elucidation of the relationships between those genes and carcinogenesis” (49%), and “614005: Elucidation of carcinogenic mutation mechanisms” (45%).

As for topics with a high expected effect in “expansion of intellectual resources,” the response rate for “adverse effect on morals, culture or society” was higher than its average for all topics; specific examples include topics connected with the elucidation of life phenomena, such as “604019: Elucidation of the molecular mechanism of life creation” (45%), and “604023: Elucidation of the transcription cascade for all genes, from fertilized egg to individual, in a single higher animal species, e.g. mice, and the mechanism by which differentiation and functions are manifest” (44%).

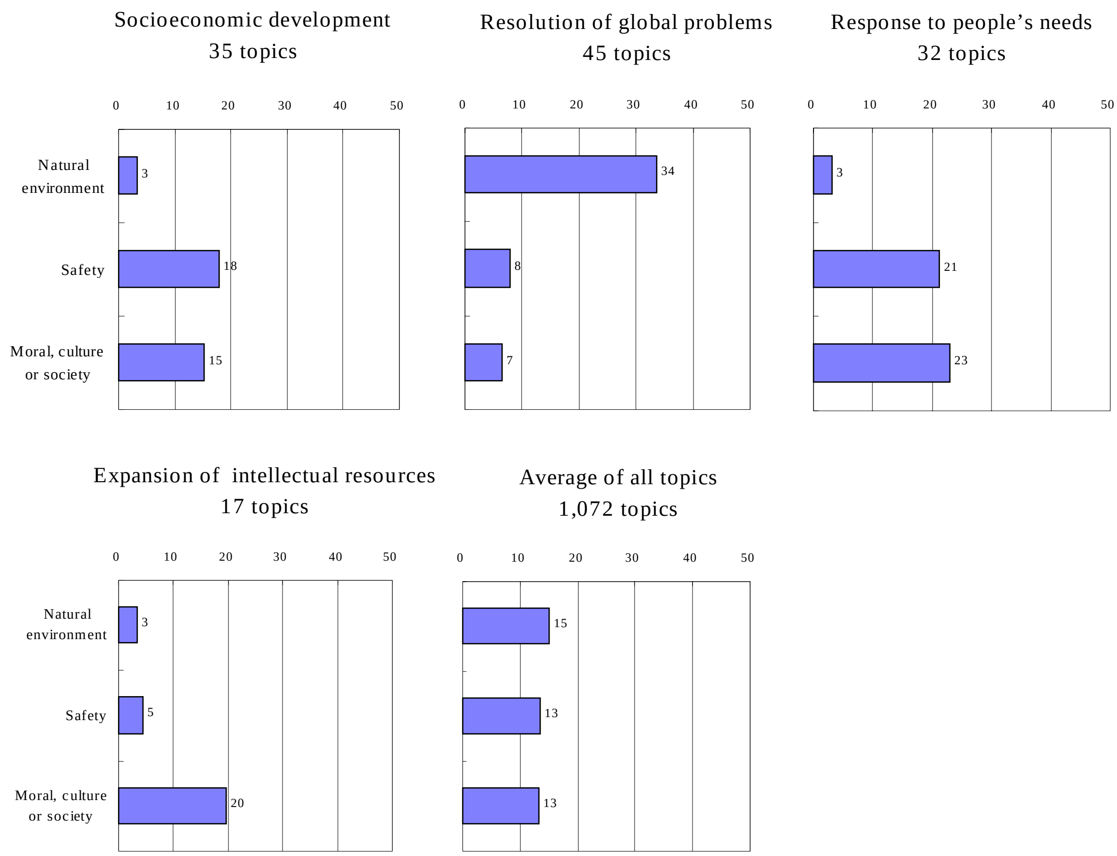
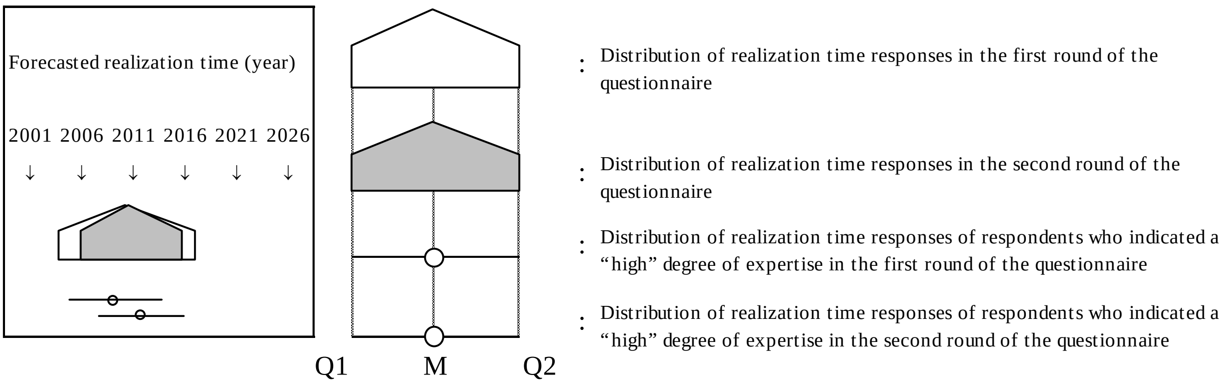


Figure 2.5-1 Expected effect and potential problems

3. Trends in forecasted realization time

3.1 Overall trends

Figure 3.1-1 shows the distribution of forecasted realization times of all 1,072 topics, and Table 3.1-1 shows the average forecasted realization time and the average range of forecasted times for each field. Here the “range of forecasted times” is the width between Q1 (forecasted realization year of the response at the 25th percentile of all responses) and Q2 (forecasted realization year of the response at the 75th percentile of all responses). A narrow width (responses from the half of all respondents who were positioned around the middle value) represents a strong consensus among respondents. The survey forecasts technologies up to the year 2025, so the questionnaires gave respondents realization time choices of five-year increments to 2025, after which the time was left open with “2026-”. Consequently, Table 3.1-1 omits any topics for which Q2 in the second round questionnaire (R2) is after 2026.



A mere 4.2% of topics (45 topics) are forecasted to be realized by 2005. And as shown in Figure 3.1-1, the “information” and “communication” fields have the largest proportions of these topics. In the five years between 2006 and 2010 and also between 2011 and 2015, respectively 37.1% (398 topics) and 38.0% (407 topics) of topics are expected to be realized, so over this ten-year period respondents forecast that 75.1% (805 topics) of all topics will be realized.

By fields, trends show us that “information” and “communication” contain many topics likely to be realized relatively early, whereas at the opposite end of the scale, “resources and energy” and “life science” have many topics that will be realized much later. Respondents forecast that 20.7% (222 topics) of topics will be realized after 2016, and the highest percentage of these are in the “life science” and “resources and energy” fields.

The range of forecasted times is narrow in the “communication,” transportation” and “information” fields where the forecasted realization time is relatively early, and broader in the “life science” and “resources and energy” fields where realization is expected to be later.

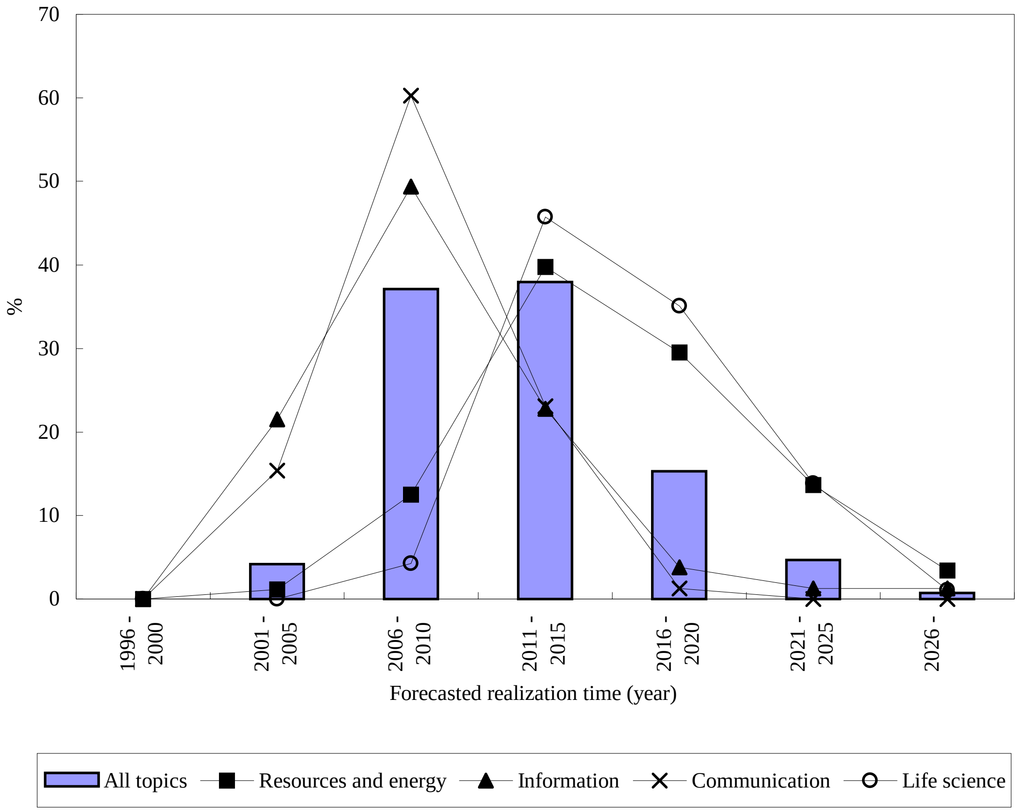


Figure 3.1-1 Trends in forecasted realization time

Table 3.1-1 Forecasted realization time and range of forecasted times

999 topics

Field	Forecasted realization time (year)	Range of forecasted times (years)
Materials	2012.3	8.5
Electronics	2013.7	8.7
Information	2009.1	7.4
Life science	2015.3	9.8
Space	2011.8	7.2
Marine science	2011.5	8.9
Resources	2014.6	9.0
Environment	2012.0	8.4
Agriculture etc.	2011.0	7.9
Production	2012.4	7.5
Urbanization	2010.7	7.6
Communication	2009.0	6.6
Transportation	2010.2	7.1
Health	2012.2	9.3
Average all topics	2011.9	8.2

3.2 Comparison of first and second round questionnaires

Here we shall look at the extent to which a consensus was reached among the respondents and how the forecasted realization times changed from the first round questionnaire (R1) to the second round questionnaire (R2). We use “the range of forecasted times” as an indicator of the degree of consensus.

3.2.1 Comparison of the convergence ratio

We calculated a convergence ratio for each topic using the following equation as an indicator to determine the extent to which a consensus had been formed through repetition of the questionnaire.

$$[\text{Conversion ratio }]= \frac{\text{R2 range of forecasted times}}{\text{R1 range of forecasted times}}$$

For example, in the case of “01001: Development of artificial muscle-like material that responds to stimuli reversibly,” the very first topic in the materials and processing field, the forecasted time range of 12.7 years in R1 was narrowed down to 4.7 years in R2, representing a convergence ratio of 4.7/12.7 = 0.37. This comparison excludes topics in which the 75th percentile of the R1 or R2 forecasted realization time is after 2026.

The average convergence ratio for the 967 topics covered is 0.75 — roughly the same ratio as that in the 5th Technology Forecast Survey. Table 3.2-1 shows that there is little difference among fields in the average convergence ratio.

Table 3.2-1 Convergence ratio by field

967 topics

Field	Average convergence ratio
Materials	0.76
Electronics	0.76
Information	0.78
Life science	0.71
Space	0.75
Marine science	0.79
Resources	0.76
Environment	0.77
Agriculture etc.	0.75
Production	0.74
Urbanization	0.70
Communication	0.76
Transportation	0.79
Health	0.75
Average all topics	0.75

Table 3.2-2 shows examples of topics with a small convergence ratio.

Table 3.2-2 Examples of topics with a small convergence ratio

Field	Topic	Convergence ratio	Forecasted realization time
Production	16 Widespread use of mega-space structures that make all-weather, 24-hour-a-day life-styles possible, including leisure activities.	0.44	2008
Space	50 Practical use in Japan of isotope batteries for probing deep space.	0.55	2011
Health	60 Practical use of batteries of artificial organs implanted in the living body.	0.55	2014
Resources	23 Advancement in artificial groundwater recharging technology and widespread practice of the conservation and the rationalized use of groundwater.	0.57	2014
Health	14 Practical use of prevention methods for stress-induced mental disorders.	0.58	2011

3.2.2 Changes in forecasted realization time

Table 3.2-3 shows the difference and absolute difference between R1 and R2 forecasted realization times for the 1,063 topics with a forecasted realization time of before 2025 in both R1 and R2. The forecasted realization times in R2 are, over all fields, later than in R1, with an average difference of all covered topics of 0.72 years, and an absolute difference of 0.80 years. The fact that the average difference at 0.72 is smaller than the absolute difference at 0.80 shows that while in many topics the forecasted realization time is later in R2 than in R1, there are also some topics whose forecasted realization time is earlier.

Table 3.2-3 Average difference and absolute difference in forecasted realization time

1,063 topics

Field	Average difference (years)	Average absolute difference (years)
Materials	0.79	0.84
Electronics	0.91	0.94
Information	0.40	0.57
Life science	0.72	0.85
Space	0.60	0.61
Marine science	0.99	1.00
Resources	0.68	0.75
Environment	0.47	0.51
Agriculture etc.	0.57	0.65
Production	0.79	0.87
Urbanization	0.76	0.83
Communication	0.46	0.55
Transportation	0.55	0.66
Health	1.16	1.22
Average all topics	0.72	0.80

3.3 Forecasted realization times by respondents with a high degree of expertise

To determine the response trends among respondents with a high degree of expertise, we compared differences in their responses with overall responses in the second round questionnaire. This is shown in Table 3.3-1. As can be seen in the table, in all fields realization time forecasts by respondents with a high degree of expertise are from 0.5 (information) to 2.4 years (life science) earlier than those by all respondents as a whole. The average difference across all fields is 1.5 years.

Table 3.3-1 Differences in forecasted realization times between respondents with a high degree of expertise and all respondents (years)

1027 topics

Field	High expertise (A)	Overall (B)	A-B
Materials	2010.3	2012.3	-2.0
Electronics	2012.0	2014.1	-2.1
Information	2008.7	2009.2	-0.5
Life science	2013.8	2016.2	-2.4
Space	2011.6	2013.3	-1.7
Marine science	2010.4	2012.1	-1.7
Resources	2014.3	2015.7	-1.4
Environment	2010.3	2012.0	-1.7
Agriculture etc.	2009.8	2011.3	-1.5
Production	2010.7	2012.0	-1.3
Urbanization	2009.9	2011.6	-1.7
Communication	2008.0	2009.0	-1.0
Transportation	2008.9	2010.4	-1.5
Health	2011.2	2012.4	-1.2
Average all topics	2010.8	2012.3	-1.5

3.4 Topics with a high "will not be realized" response rate

Table 3.4-1 shows topics with a high "will not be realized" response rate. The fact many experts judge that the topics "will not be realized" is a good indication of just how difficult realizing that technology will be, and with the exception of the paperless office topic in the production and machinery field, the forecasted realization times for all topics are 2020 or later.

Although as many as 40% of experts do not believe the paperless office will be realized, the overall forecasted realization time is a relatively early 2009. Considering a similar topic in the information field "603065: Widespread use of paperless processing for the majority of office work" (forecasted realization time of 2007) received a "will not be realized" response from only 11% of experts, the divergence in judgement probably arose on the basis of how strictly respondents applied the "100% paperless" qualification.

Table 3.4-1 Topics with a high "will not be realized" response rate

Field	Topic	Will not be realized (%)	Forecasted realization time
Life science	43 <u>Development</u> of technology capable of synthesizing living cells by using only artificially produced chemical compounds.	48	2027 or later
Urbanization	67 <u>Realization</u> of <u>deep</u> underground cities where people can <u>reside</u>.	47	2023
Resources	86 <u>Development</u> of antimatter production and storage technology and energy sources based on it.	47	2026 or later
Production	30 <u>Widespread use</u> of 100% paperless operation in offices.	40	2009
Electronics	07 <u>Widespread use</u> of wafers one meter in diameter.	39	2020

3.5. Chronological table of technology forecast

This table lists 104 of the entire 1072 survey topics, selected as being highly important, deserving special attention, etc., in chronological order.

Year	Field		Topic
2002	Transportation	10	Practical use of driving simulators that enable a learner driver to have a realistic experience of driving under extreme conditions and being involved in a traffic accident (realistically simulates impact or inertia).
2003	Communication	01	Practical use of a highly secure next-generation internet that allows the transmission of real-time information, leading to the implementation of internet-based telephone services and motion video broadcasts.
	Information	05	Practical use of systems which facilitate multimedia communication from anywhere in the world using pocket-size computers.
2004	Electronics	32	Practical use of ultraviolet, blue, and green, semiconductor lasers.
	Agriculture etc.	02	Practical use in Japan of crop varieties having the characteristics (higher yield and more disease- and cold-resistance) improved by gene manipulation.
2005	Information	64	Establishment of social rules regarding multimedia copyrights, and expanded production and distribution of multimedia information.
	Agriculture etc.	20	Widespread use of biodegradable containers and wrapping materials that use bio-oriented materials.
2006	Communication	67	Widespread use of electronic commerce carried out via a network based on an electronic funds transfer system and electronic money system.
	Transportation	07	Development of a system that detects the initial mild tremors of an earthquake at appropriate locations, and safely stops trains as necessary to avoid places that have a high risk of collapse (because of the earthquake).
	Environment	23	Introduction of environment tax aiming at global environmental conservation.
	Environment	31	Widespread use of power generation using refuse derived fuel (RDF).
	Health	20	Widespread use of scientific guidelines for adult-disease-preventing life-styles (nutrition, rest and exercise).
2007	Materials	34	Establishment and Practical use of plastic recycling technology.
	Information	22	Widespread use of highly reliable network systems capable of protecting the privacy and secrecy of individuals and groups from the intrusion of ill-intentioned hackers.
	Environment	04	Practical use of materials that replace fluorocarbons and halons, that do not damage the ozone layer and cause global warning problem.
	Transportation	14	Widespread use of traffic control systems on road, for optimal control of the flow of traffic in cities based on identification of vehicles on road, speed, and level of congestion.
	Space	05	Development of technology for measuring, in real time, the distribution and movement of air pollution via observation from space.
	Health	13	Development of an HIV vaccine.
2008	Communication	66	Widespread use of on-line seal-less document preparation services for various official documents such as contract documents which are provided via a network based on security technology capable of achieving both privacy protection and verification.
	Space	02	Widespread use of a global-scale environmental surveillance network in which environmental changes for the earth as a whole are monitored around the clock in real time, and this information is integrated, systematically analyzed, and distributed around the world.
	Marine science	69	Inauguration in Japan of global science and technology educational organizations in the broad sense, in order to foster international scientists and technologists contributing to conservation of the global environment, development and maintenance of global resources, etc.
	Agriculture etc.	09	Widespread use of the pest control method based mainly on the biological insecticides (natural microbial enemies, pheromones, etc.).
2009	Transportation	55	Practical use of floating off-shore airports.
	Health	36	Practical use of anti-AIDS therapy.
	Production	70	Widespread use of earthquake damage alleviation systems for industrial complexes, nuclear facilities, etc. based on the early operation of safety devices in response to initial mild tremors.
	Space	09	Realization of precision down to less than a centimeter in measurement of crustal movement using VLBI (very long baseline inter-ferometers), satellite lasers, inverse laser ranging, and synthetic aperture radar to improve accuracy in such as earthquake forecasting.
	Urbanization	13	Practical use in Japan of a safe and rational demolition technology for decommission of

Year	Field	Topic
		commercial nuclear power plants.
	Electronics	49 Production of household-use optical fiber signal tranceiver units at a cost of around 5,000 yen.
	Urbanization	29 Spread of community-based efforts to utilize unused energy sources and recycle household wastes etc. in Japan.
	Resources	19 Practical use of economical methods for separating and recycling valuable substances in urban garbage.
	Transportation	31 Achievement of a 90% recyclability for motor vehicle parts and material (scrapped vehicles).
2010	Space	16 Full-scale operation of a space station as a laboratory on the low earth orbit, and realization of next-generation facilities using the space environment for research, development, and trial production of semiconductors, pharmaceuticals, etc.
	Production	17 Impact of engineering techniques that control silicon microscopic structures (to choose desired atomic and molecular arrangements at will) felt in all aspects of the production and machinery area.
	Electronics	18 Development of solar cells capable of maintaining 15% efficiency for at least 10 years without light convergence.
	Marine science	13 Development of technologies based on large-scale numerical models for forecasting changes in the global oceans.
	Marine science	58 Practical use of technology for predicting and forecasting landslides and rockslides caused by intense rainfall in certain locations in Japan.
	Environment	27 Widespread use, including use at home, of compact waste-water treatment systems based on biotechnology for the highly efficient treatment of persistent substances and hazardous materials.
	Transportation	30 Practical use of heavy-duty freight truck exhaust clean-up technologies - such as diesel exhaust catalysts, particulate traps, lean-burn NO_x catalysts and high precision combustion technology - to reduce the harmful components of exhaust to 1/10 of present levels.
2011	Life science	04 Development of methods for surmising new functions of proteins from human genome information.
	Environment	29 Development of low-noise engines and tires, and sound-absorbing construction materials, leading to the reduction of automobile noise within the environmental standard for the area specified to be for resident.
	Environment	05 Elucidation of the accurate mechanism of carbon dioxide generation and absorption.
	Resources	17 Practical use of technologies capable of separating useful metals, such as iron, copper and aluminum, from metal-containing wastes, such as scrap cars, discarded electric appliances, to a purity level of more than 99%.
	Health	09 Elucidation of the arteriosclerosis contraction mechanisms.
	Urbanization	04 Development of a nationwide network for detecting earthquakes, and widespread use in Japan of a disaster prevention system that gives advance warning of earthquakes at a distance of at least 50km.
2012	Environment	34 Establishment of assessing socio-economic damage/loss because of the destruction of natural environment by soil contamination and land subsidence (e.g., loss of natural beaches, forests, or fields) and incorporation of its countermeasures in regulatory system.
	Production	50 Widespread use of designing, producing, collecting and recycling systems which make it possible to recycle most used materials through legally establishing manufacturers' responsibilities for collection and disposal of disused products.
	Health	06 Elucidation of cancer metastasis mechanisms.
	Communication	38 Development of an automatic Japanese-English, English-Japanese speech translation telephone system comparable to human simultaneous interpretation in service quality.
	Electronics	30 Practical use of solar cells which make the cost of power generation facilities less than 100 yen/watt.
2013	Health	05 Elucidation of carcinogenic mutation mechanisms.
	Life science	35 Widespread production of bioplastics using microorganisms and plants, accounting for 10% of the total volume of worldwide plastic production.
	Resources	81 Widespread use of electric vehicles with driving performance equal to that of gasoline motorcars.
	Electronics	05 Practical use of technology which allows mass processing of patterns with minimum line width as low as 10 nanometers.
	Marine science	14 Development of a numerical model of the correlation between climatic changes and changes in marine living resources.
	Health	44 Improvement in the average five-year survival rate for all types of cancer to more than 70% (currently about 40% for stomach cancer).

Year	Field		Topic
	Health	48	Practical use of effective methods against cancer metastasis.
	Life science	49	Practical use of effective means to prevent metastasis of cancer.
	Health	53	Development of effective methods of preventing Alzheimer's disease.
2014	Life science	01	Identification of multiple genes related to cancer, and elucidation of the relationships between those genes and carcinogenesis.
	Marine science	43	Establishment of scientific methods for long-range weather forecasting (1-6 months in advance).
	Resources	06	Development of a steelmaking technology that requires fossil fuel consumption less than half of the present level.
	Materials	49	Widespread use of industrial electric machines which employ superconductive materials having a critical temperature of liquid nitrogen (77 K) or more.
	Space	25	The cost of rocket thrusted space transportation will be reduced to less than 1/10 current levels.
	Electronics	06	Practical use of VLSI with as much as 256 Gbits of memory per chip.
2015	Information	49	Practical use of robots capable of recognizing, finding, and rescuing humans involved in a disaster.
	Life science	51	Practical use of artificial organs (pancreases, kidneys, livers, etc.) incorporating human cells and tissues.
	Electronics	09	Practical use of semiconductor LSIs that operate at a switching speed of 1 ps or less.
	Life science	36	Widespread production of alcohol and other fuel oils utilizing microorganisms, seaweed, etc., accounting for 10% of total worldwide fuel oil production.
	Communication	74	Practical use of biochip devices that have a memory density (10^{12} bit/ cm^2) 1,000 times that of current semiconductor devices (10^9 bits/ cm^2).
2016	Materials	84	Practical use of multi-layer solar cells with a conversion efficiency of more than 50%.
	Urbanization	20	Widespread use in Japan of active environmental clean-up facilities that absorb and fix air pollutants such as CO_2, NO_x and freons in urban areas, where the majority of emissions occur.
	Agriculture etc.	55	Development of production regulation systems as a step toward management of resources and fisheries once it becomes possible to predict the long term (10 to 20 years) changes major fishery resources.
	Production	44	Practical use of technologies that enable the direct storage of electricity (superconducting magnets, flywheels and capacitors).
	Materials	109	Widespread use of desert afforestation technology through the advancement of water retention technology and biotechnology.
	Production	08	Practical use of room temperature superconductors in industrial products.
2017	Life science	91	Development of technologies which dramatically improve photosynthetic ability in order to increase food production.
	Electronics	08	Practical use of non-volatile, erasable with more than 100 Gbits capacity random access semiconductor memories.
	Materials	107	Practical use of processes for water decomposition by the sunlight.
	Production	49	Widespread use of low entropy-generating eco-factories, which give due consideration to the impact on local ecosystems throughout product life cycles, from manufacture to disposal.
	Urbanization	05	Practical use in Japan of a mid-term (5 - 10 years in advance) prediction technique for large-scale (Magnitude 8 or stronger) earthquakes based on analyses of the distribution of strains in the earth's crust and past earthquake records.
2018	Production	51	Advancements in technological development such as carbon dioxide recovery and detoxification of harmful wastes, leading to the widespread use of global environmental conservation measures throughout the world.
	Agriculture etc.	84	Practical use of a system of removing almost the entire pollution load on lakes, bays and other closed water bodies that are suffering from water quality degradation by developing environmental restoration technology that utilizes ecosystems and biological functions.
	Production	42	Widespread use of non-fossil energy sources (wind, geothermal, solar (photovoltaic/solar thermal) and waste heat) in all areas of life including household, industry and transportation.
	Health	95	Elucidation of individual aging mechanisms.
2019	Resources	63	Practical use of technology for the safe disposal of highly radioactives solid waste.
2020	Life science	28	Control of signal transduction in the carcinogenesis of cells, and widespread use of treatment methods for dysdifferentiating carcinogenic cells.

Year	Field		Topic
	Space	36	<u>Capability for transmission of electrical power</u> to earth by <u>microwave</u> from solar power generation plants with huge solar cell panels, constructed in space.
	Materials	44	<u>Development</u> of superconductive materials with a transition temperature around <u>room temperature.</u>
	Marine science	56	<u>Development</u> of technology to alleviate dangerously heavy rainfall through the application of nephology.
2021	Resources	56	<u>Practical use</u> of hot dry rock power-generating technologies.
	Production	55	<u>Practical use</u> of technologies for mass-producing hydrogen by decomposing organic substances through application of solar energy and biological systems.
	Space	38	<u>Development</u> of <u>manned orbital</u> transfer vehicle for trips to and from geostationary orbits and the moon.
2022	Environment	09	<u>Reduction</u> of global carbon dioxide emissions to <u>20% below</u> the 1990 level.
	Electronics	66	<u>Development</u> of a strage system in which one atom or molecule corresponds to 1 bit.
2023	Life science	65	<u>Elucidation</u> of brain mechanisms for logical reasoning.
	Marine science	60	<u>Development</u> of technology capable of forecasting the occurrence of major earthquakes (magnitude <u>7 or above</u>) <u>several days in advance</u>.
	Information	35	<u>Elucidation</u> of human creative mechanism to such an extent that allows to apply to computer science.
2024	Electronics	21	<u>Development</u> of an "artificial intelligence chip" capable of understanding and sharing human emotions.
	Resources	75	<u>Practical use</u> of superconductive energy storage systems with a capacity (<u>1000 MWh</u>) as large as that of pumped hydro storage.
2025	Life science	58	<u>Development</u> of interfaces enabling direct linkage between the computer and the brain.
	Resources	77	<u>Practical use</u> of power networks utilizing superconducting cables.
	Resources	58	<u>Practical use</u> of fast breeder reactor systems <u>including nuclear fuel cycle</u>.
2026 or later	Information	38	Become possible for computers, using electromagnetic data, to read the <u>information recorded inside the human brain</u>.
	Resources	59	<u>Development</u> of fusion reactors.

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4. Leading countries etc.

4.1 Trends in each field

Here we have converted the average topic response rate in each field for each of the five country/region options (USA, EU, Former Soviet Union and Eastern Europe, Japan, Others, Do not know) into graph format.

The USA is regarded to be the leading country in 11 of the 14 fields, and especially so in the “space,” “life science,” “information,” “communication” and “health, medical care and welfare” fields. In the remaining three fields (“resources and energy,” “urbanization and construction” and “transportation”), Japan is placed above the USA. The EU is rated quite highly in “environment” and “transportation.” However, in this survey the respondents were able to give multiple responses for the “leading country etc.,” so the final figures show the rate at which each of the countries or regions attracted “votes,” and not a relative evaluation of their technological level. For example, even though there may be only a very slight difference between a country in the first group and a country in the second, the second group country may attract hardly any votes. There is also a difference in the volume of information each of the countries or regions publish, so it is anticipated that in cases where only limited information reaches Japan, those countries or regions will be at a disadvantage. Moreover, many of the topics themselves are considered necessary and are being tackled in Japan, and most of the technologies are at the applied stage (i.e. practical use or widespread use), so we should keep in mind that these factors will tend to push up Japan’s relative percentage.

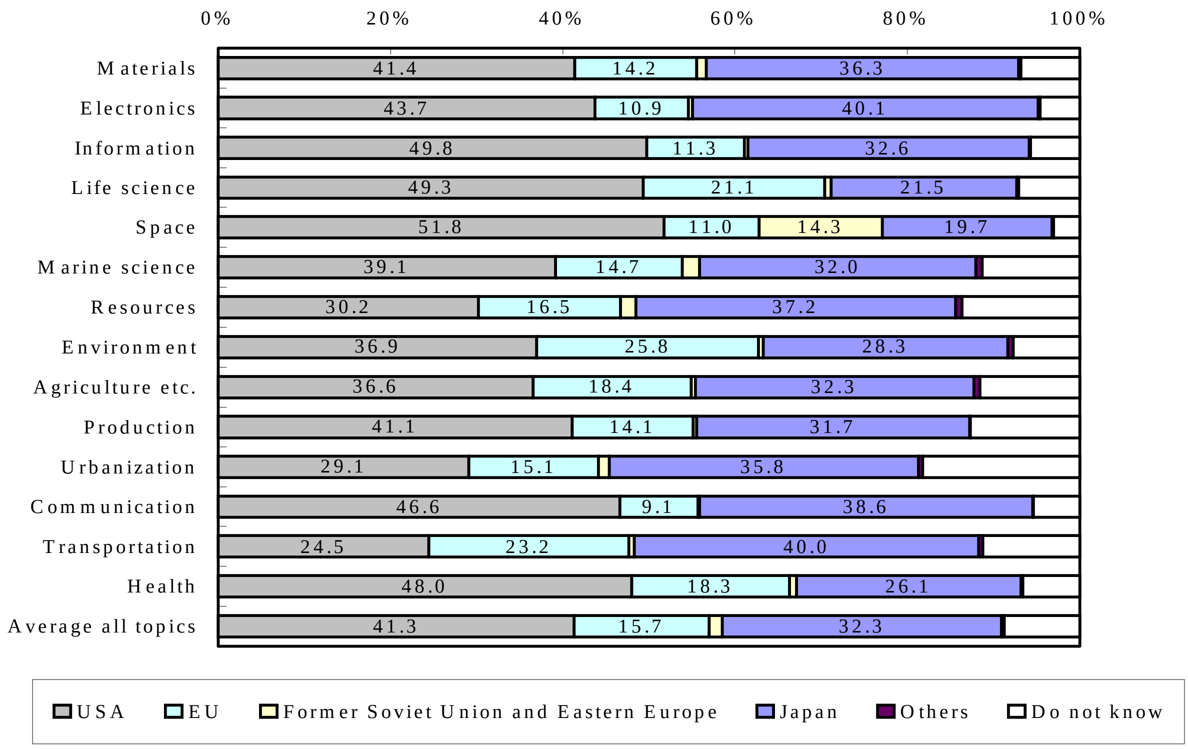

Figure 4.1-1 Leading countries etc. by field

4.2 Topics with a high "USA" response rate

Of the top 20 topics with a high "USA" response rate, the "space" field is most represented with eight, followed by "health, medical care and welfare" with four, and "urbanization and construction" with two space-related topics.

Table 4.2-1 Top 20 topics with a high "USA" response rate

Ranking	Field	Topic	USA	EU	Former Soviet Union and Eastern Europe	Japan
1	Life science	01 Identification of multiple genes related to cancer, and elucidation of the relationships between those genes and carcinogenesis.	**98**	42	0	39
2	Communication	01 Practical use of a highly secure next-generation internet that allows the transmission of real-time information, leading to the implementation of internet-based telephone services and motion video broadcasts.	**98**	6	0	19
3	Urbanization	72 Realization of facilities in the outer space where people in general can live in long period.(at least one year)	**98**	4	43	5
4	Space	15 Realization of a high-accuracy satellite positioning system operated by an international organization.	**97**	16	22	29
5	Urbanization	73 Realization of manned laboratories on Mars.	**97**	0	32	3
6	Space	48 Exploration of Saturn and other planets beyond it.	**97**	4	28	5
7	Health	75 Practical use of heterogeneous organ transplantation as means of treatment.	**97**	20	0	19
8	Space	16 Full-scale operation of a space station as a laboratory on the low earth orbit, and realization of next-generation facilities using the space environment for research, development, and trial production of semiconductors, pharmaceuticals, etc.	**97**	44	64	46
9	Health	05 Elucidation of carcinogenic mutation mechanisms.	**96**	46	1	59
10	Space	21 Development of a space plane capable of transporting between the earth and space stations in the similar manner as conventional airplanes.	**96**	19	26	29
11	Space	46 Realization of landing of manned spacecraft on Mars and the return to the Earth.	**96**	3	46	3
12	Space	02 Widespread use of a global-scale environmental surveillance network in which environmental changes for the earth as a whole are monitored around the clock in real time, and this information is integrated, systematically analyzed, and distributed around the world.	**96**	47	4	56
13	Information	52 Widespread use of in-home shopping via networks, by means of virtual shopping systems.	**96**	24	1	49
14	Space	38 Development of manned orbital transfer vehicle for trips to and from geostationary orbits and the moon.	**96**	7	46	8
15	Life science	27 Elucidation of the immune mechanisms which distinguish between "self" and "not self".	**96**	55	0	46
16	Health	73 Practical use of gene therapy for genetic disorders.	**96**	37	0	32
17	Space	04 Development of technology to construct of artificial satellites with large-scale antenna (several tens of meters in diameter) at permanent manned space stations in low earth orbit.	**96**	16	25	50
18	Information	21 Widespread use of computer networks in which a virtual space can be shared in real time by a large number of unspecified, geographically dispersed persons.	**96**	13	0	53
19	Information	03 Practical use of parallel computers with one million or more processors.	**96**	7	0	55
20	Health	09 Elucidation of the arteriosclerosis contraction mechanisms.	**96**	43	0	49

4.3 Topics with a high “EU” response rate

Not one topic recorded over 90% for the EU. Overall the top 20 topics lean toward an environmental theme; the “environment” field has four topics, “production and machinery” has three environment-related topics, and “materials and processing” and “transportation” have one environment-related topic each. “Resources and energy” also has three topics in the top 20, but all of these are connected with nuclear power.

Table 4.3-1 Top 20 topics with a high “EU” response rate

Ranking	Field	Topic	USA	EU	Former Soviet Union and Eastern Europe	Japan
1	Production	50 Widespread use of designing, producing, collecting and recycling systems which make it possible to recycle most used materials through legally establishing manufacturers' responsibilities for collection and disposal of disused products.	20	**84**	0	33
2	Environment	32 Wide acceptance of LCA-style product design concepts that encourage recycling and reuse.	39	**83**	1	42
3	Environment	13 Elucidation of the mechanism of the impact caused by acid rain to animals and plants.	45	**82**	4	42
4	Environment	23 Introduction of environment tax aiming at global environmental conservation.	22	**81**	0	22
5	Transportation	31 Achievement of a 90% recyclability for motor vehicle parts and material (scrapped vehicles).	18	**75**	0	48
6	Transportation	08 Utilization of new materials in rails and wheels and improvements in the technology of vehicle structures, leading to the continuous operation of Shinkansen bullet trains at a speed of 350 Km/h while satisfying environmental quality standards.	0	**75**	0	85
7	Materials	34 Establishment and practical use of plastic recycling technology.	50	**74**	0	63
8	Resources	63 Practical use of technology for the safe disposal of highly radioactives solid waste.	62	**71**	3	63
9	Resources	58 Practical use of fast breeder reactor systems including nuclear fuel cycle.	24	**71**	12	80
10	Environment	12 Elucidation of the worldwide long-distance migration mechanisms of acid-rain-causing substances, such as SO_x and NO_x, considering regional characteristics.	58	**70**	2	51
11	Production	51 Advancements in technological development such as carbon dioxide recovery and detoxification of harmful wastes, leading to the widespread use of global environmental conservation measures throughout the world.	47	**69**	0	47
12	Materials	33 Biodegradable plastics will account for 10% of all plastics.	66	**68**	1	67
13	Production	49 Widespread use of low entropy-generating eco-factories, which give due consideration to the impact on local ecosystems throughout product life cycles, from manufacture to disposal.	26	**68**	0	42
14	Agriculture etc.	33 Widespread use of fully automated feed formulation, feeding, milking and animal waste treatment systems.	58	**66**	0	41
15	Information	66 Widespread use of electronic money to settle monetary matters.	90	**65**	1	35
16	Agriculture etc.	31 Widespread use of advanced sustainable grazing techniques that improve pasture productivity and make labor-saving livestock management possible by taking advantage of the functions of organisms forming part of pasture ecosystems.	54	**64**	1	16
17	Resources	59 Development of fusion reactors.	79	**64**	17	75
18	Urbanization	29 Spread of community-based efforts to utilize unused energy sources and recycle household wastes etc. in Japan.	14	**63**	0	36
19	Agriculture etc.	35 Widespread use of animal waste utilization techniques via decomposition into constituents.	23	**62**	1	46
20	Urbanization	25 Widespread use in Japan of development techniques aimed at coexisting with nature (e.g. conservation of ecosystems and creation of wildlife habitats) through the elucidation of the mechanisms whereby development impacts on ecosystems.	25	**62**	0	28

4.4 Topics with a high "Former Soviet Union and Eastern Europe" response rate

Nineteen of the top 20 topics are connected with space (17 in the "space" field, and two of the remaining three are space-related).

Table 4.4-1 Top 20 topics with a high "Former Soviet Union and Eastern Europe" response rate

Ranking	Field	Topic	USA	EU	Former Soviet Union and Eastern Europe	Japan
1	Space	31 Development of high-pressure (1 atmosphere), flexible space suit for use outside of a spaceship.	95	5	**66**	3
2	Space	50 Practical use in Japan of isotope batteries for probing deep space.	90	3	**66**	3
3	Space	16 Full-scale operation of a space station as a laboratory on the low earth orbit, and realization of next-generation facilities using the space environment for research, development, and trial production of semiconductors, pharmaceuticals, etc.	97	44	**64**	46
4	Space	51 Practical use of space nuclear propulsion systems.	86	3	**63**	5
5	Marine science	49 Practical use of boring technology capable of reaching the depth of 15 Km.	77	34	**55**	21
6	Space	44 Long-term observation of the atmosphere of Venus by means of balloons.	91	5	**53**	22
7	Space	45 Analysis of the surface substances of Mars, its with weather observation and earthquake observation, etc., via an unmanned Mars exploration unit.	95	6	**51**	15
8	Space	23 Realization of bases for transporting to the moon and planets in middle or low-level orbiting transport	94	11	**50**	11
9	Space	27 Establishment of a remote medical diagnosis/treatment system for astronauts.	89	19	**49**	17
10	Space	42 Practical use of nuclear power generating system at lunar bases.	83	8	**48**	13
11	Space	26 Development of technologies for removing micro-organisms that lead to uncomfortable factors in space life such as mildew and offensive smells in space stations.	86	14	**46**	19
12	Space	46 Realization of landing of manned spacecraft on Mars and the return to the Earth.	96	3	**46**	3
13	Space	38 Development of manned orbital transfer vehicle for trips to and from geostationary orbits and the moon.	96	7	**46**	8
14	Space	30 Development of life support technology applied to a closed ecosystem, able to self-supply vegetable, grain, animal protein, and other food.	95	13	**44**	34
15	Space	43 Return of samples from other planets.	95	10	**43**	38
16	Urbanization	72 Realization of facilities in the outer space where people in general can live in long period.(at least one year)	98	4	**43**	5
17	Space	17 Realization of a micro gravity research facility capable of an environment of 10^{-6} G or less for several days.	91	39	**42**	46
18	Space	40 Creation of a permanent, manned station on the surface of the moon, executing geological surveys of the moon, scientific observations from the moon, and development of technology to utilize the moon's resources.	95	9	**41**	19
19	Health	96 Elucidation of the mechanism whereby living organisms undergo changes in the space environment.	86	14	**39**	8
20	Space	37 Development of high-performance orbital transfer vehicle to transfer large structures between lower and geostationary orbits.	92	18	**37**	26

4.5 Topics with a high "Japan" response rate

The "electronics" field accounts for the largest number of topics in the top 20 with nine, followed by "communication" with five.

Table 4.5-1 Top 20 topics with a high "Japan" response rate

Ranking	Field	Topic	USA	EU	Former Soviet Union and Eastern Europe	Japan
1	Communication	28 Practical use of 90 in. large wall-mountable high-definition flat color displays.	23	1	0	**96**
2	Communication	27 Development of a 4,000 x 4,000 pixel high-definition display, image sensor, and signal processing technique.	38	3	0	**96**
3	Electronics	06 Practical use of VLSI with as much as 256 Gbits of memory per chip.	61	2	0	**96**
4	Communication	51 Widespread use of character recognition technologies which enable a recognition rate with handwritten Chinese character of 99% or more.	12	2	0	**95**
5	Electronics	32 Practical use of ultraviolet, blue, and green, semiconductor lasers.	55	12	2	**95**
6	Transportation	04 Practical use of superconducting magnetically levitated railways with a maximum speed on the order of 500 Km per hour.	3	50	0	**94**
7	Information	07 Development of 5,000 dpi high-quality color printers.	52	2	0	**94**
8	Urbanization	16 Practical use in Japan of a technology to effectively control and absorb vibrations in massive structures caused by winds and earthquakes.	39	3	0	**94**
9	Electronics	36 Widespread use of opto-electronic integrated circuits (OEIC) in which multiple optical elements and their wave guide connections are integrated on a semiconductor substrate.	82	29	1	**93**
10	Electronics	05 Practical use of technology which allows mass processing of patterns with minimum line width as low as 10 nanometers.	75	10	0	**92**
11	Information	27 Widespread use of voice word processors in which Japanese text can be input by voice (continuous speaking by unspecified speakers).	47	9	0	**92**
12	Electronics	18 Development of solar cells capable of maintaining 15% efficiency for at least 10 years without light convergence.	68	16	0	**91**
13	Urbanization	14 Practical use in Japan of techniques to assess the soundness of foundations of existing structures and to seismically strengthen existing foundations.	32	4	0	**91**
14	Electronics	30 Practical use of solar cells which make the cost of power generation facilities less than 100 yen/watt.	65	11	1	**90**
15	Electronics	42 Practical use, in the field of optical communications and optical switching, of technology to convert the wavelength of a signal into another wavelength.	87	27	1	**90**
16	Environment	24 Widespread use of control technologies in virtually all types of automobiles, capable of meeting the emission control standard for nitric oxide at the order of 0.1 to 0.2 g/Km. (The current level for heavy diesel motorcars is on the order of 4 to 5 g/Km, and the standard control value for gasoline passenger cars in 1978 is 0.25 g/Km.)	46	40	0	**89**
17	Communication	73 Development of light-reflecting liquid crystal color displays (no backlighting) with the advantage of low power consumption.	27	1	0	**89**
18	Electronics	08 Practical use of non-volatile, erasable with more than 100 Gbits capacity random access semiconductor memories.	72	3	0	**89**
19	Communication	03 Practical use of modes of transmission ever extremely long distance without repeaters based on realization of optical fiber with ultra low rate of transmission loss (less than 0.01 dB/Km), enabling installation of Japan-Hawaii optical trunk ine without repeateers.	58	4	1	**88**
20	Electronics	49 Production of household-use optical fiber signal tranceiver units at a cost of around 5,000 yen.	72	17	0	**88**

4.6 Topics with a high "Other countries" response rate

In this survey, as well as the four specific countries or regions (USA, EU, Former Soviet Union and Eastern Europe, and Japan), respondents who believed a country or region other than those four is a world leader had "other countries" as an option, and were asked to indicate the specific country or region. Over all fields, there were few "other countries" responses, and Table 4.6-1 shows three topics with a reasonably high response rate. The "Did not indicate" in the table shows the cases where the "other countries" was selected, but a specific country or region was not written down.

Table 4.6-1 Topics with a high "Other countries" response rate

<table>
<tr><th>Field</th><th>Topic</th><th>USA</th><th>EU</th><th>Former Soviet Union and Eastern Europe</th><th>Japan</th><th colspan="4">Other countries</th><th>Do not know</th></tr>
<tr><td rowspan="2">Marine science</td><td rowspan="2">61 Elucidation of the existence of a correlation between animal behavior and earthquakes for use as earthquake prediction data</td><td rowspan="2">9</td><td rowspan="2">2</td><td rowspan="2">2</td><td rowspan="2">48</td><td>China</td><td colspan="2">Greece</td><td>Did not indicate</td><td rowspan="2">26</td></tr>
<tr><td>21</td><td colspan="2">1</td><td>1</td></tr>
<tr><td rowspan="2">Electronics</td><td rowspan="2">06 Practical use of VLSI with as much as 256 Gbits of memory per chip</td><td rowspan="2">61</td><td rowspan="2">2</td><td rowspan="2">0</td><td rowspan="2">96</td><td>ROK</td><td>Taiwan</td><td>NIES</td><td>Did not indicate</td><td rowspan="2">0</td></tr>
<tr><td>12</td><td>2</td><td>0</td><td>1</td></tr>
<tr><td rowspan="2">Resources</td><td rowspan="2">67 Widespread use of methanol fuel</td><td rowspan="2">54</td><td rowspan="2">26</td><td rowspan="2">0</td><td rowspan="2">41</td><td>Brazil</td><td colspan="2">South America</td><td>Did not indicate</td><td rowspan="2">19</td></tr>
<tr><td>7</td><td colspan="2">1</td><td>7</td></tr>
</table>

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5. Effective measures the government should adopt in Japan

We asked respondents to indicate whether they believe the government should adopt any measures to promote the technological topic, and if so, to choose up to three measures from among the following.

i) Foster researchers, engineers and research assistants

ii) Enhance systems to promote personnel exchanges among the industrial, academic and government sectors and cooperation among different fields of science and technology

iii) Upgrade advanced R&D facilities and equipment and make them available for more widespread use

iv) Develop a research base comprising data bases, standard reference material, genetic resources and the like

v) Increase the government's funding for research

vi) Adjust relevant regulations (relax/toughen/establish/abolish)

vii) Others

5.1 Overall trends

Figure 5.1-1 shows the average percentage value for all topics in each field. The average of all topics is quite high in "increase government research funding" (52.5) and "foster human resources" (52.1), followed by "promote personnel exchanges among the industrial, academic and government sectors and different fields" (42.4). This shows that over many topics, respondents want the government to provide greater R&D support in both personnel and funding aspects, and play a coordinating role in personnel exchanges and cooperation.

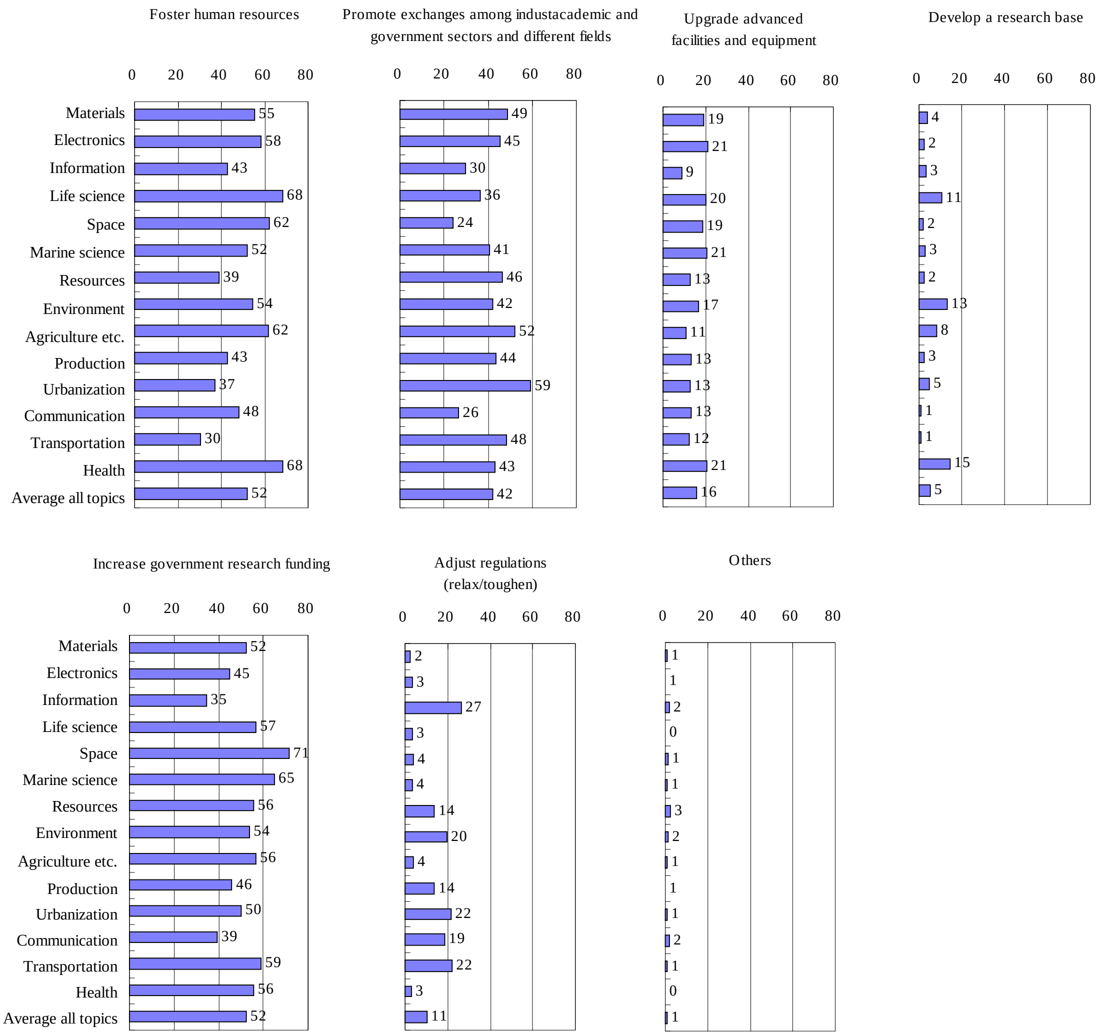

Figure 5.1-1 Measures the government should adopt by field

On the other hand, it is quite low in "develop a research base" (5.3) and "adjust regulations (relax/toughen)" (10.5), indicating there were relatively few topics for which respondents believed developing a research base and adjusting (relaxing or toughening) regulations would be effective.

The figures show that in some fields expectation of government participation is indeed strong, while in others it is less so. To quantify these expectations, we totaled the percentage values of i)–vii) for each topic, and plotted the field averages on a graph, shown at Figure 5.1-2. Since respondents could select up to three responses for each topic, the maximum value is 300. The aggregate value is smaller in "information" and "communication," fields with many topics with a relatively early forecasted realization time, and larger in the "health," "environment," "life science" and "agriculture etc." fields. As shown in Table 5.1-1, four of the top five topics are connected with gene technology.

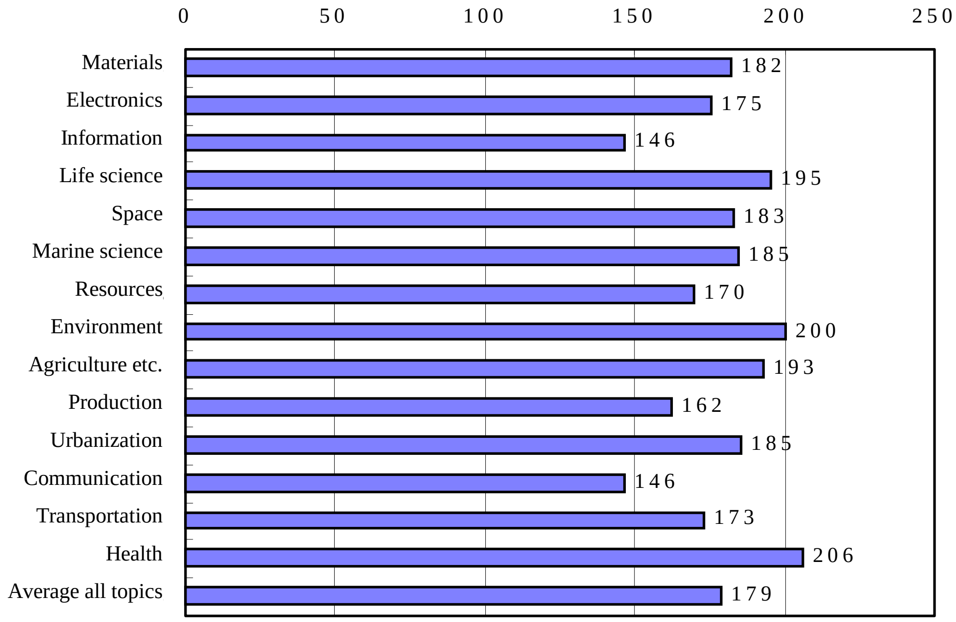

Figure 5.1-2 Response aggregates for measures the government should adopt

Table 5.1-1 Topics with a high response in "Measures the government should adopt"

Ranking	Field	Topic	Number of responded times	Forecasted realization time
1	Agriculture etc.	01 Elucidation of the whole DNA sequences of crops (e.g. Rice) to isolate useful genes.	2.44	2009
2	Health	51 Widespread use of gene therapy against malignant tumors.	2.39	2014
3	Agriculture etc.	02 Practical use of crop varieties having the characteristics (higher yield and more disease- and cold-resistance) improved by gene manipulation.	2.37	2004
4	Health	05 Elucidation of carcinogenic mutation mechanisms.	2.36	2013
5	Life science	01 Identification of multiple genes related to cancer, and elucidation of the relationships between those genes and carcinogenesis.	2.36	2014

5.2 Foster researchers, engineers and research assistants (Foster human resources)

With an average of all topics of 52.1, the "Foster human resources" measure is the second highest. Overall, the measure is comparatively high in the life-related fields of "health, medical care and welfare" (68.3), "life science" (68.2) and "agriculture, forestry and fisheries" (61.5), and in the eye-catching and extremely expensive science field of "space" (62.1); and low in "transportation" (30.4), "urbanization and construction" (36.9), "resources and energy" (38.9) and "production and machinery" (42.9). The highest ranking topic list is dominated by life-related topics: eight topics in the "life science" field, seven in "health, medical care and welfare" and five in "agriculture, forestry and fisheries".

Table 5.2-1 Top 20 topics in "Foster human resources"

Ranking	Field	Topic	Foster human resources	Forecasted realization time
1	Agriculture etc.	69 Elucidation of the mechanisms of totipotency of plant cells.	86	2021
2	Health	19 Widespread use of preventive measure for cerebral palsy.	86	2012
3	Agriculture etc.	24 Practical use of a livestock production technology that utilizes embryonic stem (ES) cells.	84	2011
4	Life science	83 Elucidation of the neural mechanisms of sleep and dreams.	84	2017
5	Marine science	51 Elucidation of the series of processes including the generation, rise, storage, and extrusion of magma.	82	2016
6	Life science	41 Elucidation of relationships between higher-order structures and functions of the nuclei in eukaryotic cells.	82	2015
7	Marine science	54 Practical use of analytical methods capable of tracing gradual changes (atomic fluctuations) involved in fossilization which cause material in organisms corpses to be replaced by silica.	82	2016
8	Life science	84 Complete elucidation of the molecular mechanisms of development and differentiation.	82	2022
9	Life science	82 Elucidation of the entire molecular mechanisms which generate the internal rhythms in organisms.	82	2015
10	Health	82 Development of methods for recombining disconnected central nerves.	82	2018
11	Agriculture etc.	82 Development of an ecosystem management system that enables rare species of organisms dependent on forests to propagate according to their ecological conditions.	81	2016
12	Life science	23 Elucidation of the transcription cascade for all genes, from fertilized egg to individual, in a single higher animal species, e.g. mice, and the mechanism by which differentiation and functions are manifest.	81	2023
13	Life science	68 Elucidation of the cause of manic-depressive psychosis at the molecular level.	81	2016
14	Agriculture etc.	03 Development of C_3 plants with modified photosynthesis systems through the techniques of biological/biochemical control or gene manipulation, etc.	81	2012
15	Agriculture etc.	43 Elucidation of the mechanism whereby organisms belonging to forest ecosystems turn into pests, and development of a prediction technique for the outbreak of major pests and an integrated pest control technique that takes advantage of the self-maintanance functions of forests.	81	2014
16	Health	51 Widespread use of gene therapy against malignant tumors.	81	2014
17	Health	40 Possible to cure autoimmune diseases.	80	2020
18	Health	60 Practical use of batteries of artificial organs implanted in the living body.	80	2014
19	Life science	86 Elucidation of the neurobiological basis for emotion.	80	2021
20	Life science	20 Complete elucidation of the molecular mechanism explaining the cell cycle in higher order mammals (humans, mice).	80	2015
20	Health	21 Elucidation of gout-causing genes.	80	2008
20	Marine science	70 Inauguration in Japan of international research centers for comparative planetology, including the science of the earth, based on the development of planetology through specimens obtained from meteorites and planets.	80	2011
20	Health	14 Practical use of prevention methods for stress-induced mental disorders.	80	2011
20	Marine science	64 Elucidation of the entire aspect of the movement and storage of carbon dioxide extending over the air, land, oceans, and sea bottoms.	80	2016

5.3 Enhance systems to promote personnel exchanges among the industrial, academic and government sectors and cooperation among different fields of science and technology (Promote exchanges among industrial, academic and government sectors and different fields)

The average of all topics for this measure is reasonably high at 42.4. It is highest in the “urbanization” (59.1) and “agriculture etc.” (51.9) fields, and lowest in the government-run field of “space” (24.3) and the multi-media-related fields of “communication” (26.3) and “information” (30.0). By topic, 12 of the top 20 topics are in “agriculture etc.,” and most of these are connected with food. There are also some robot-related topics among the top 20.

Table 5.3-1 Top 20 topics in “Promote exchanges among industrial, academic and government sectors and different fields”

Ranking	Field	Topic	Promote exchanges among industrial, academic and government sectors and different fields	Forecasted realization time
1	Agriculture etc.	75 Practical use of general-purpose taste measuring equipment provided with a taste sensor capable of sensing taste ingredients and a texture sensor capable of sensing physical properties.	80	2010
2	Agriculture etc.	20 Widespread use of biodegradable containers and wrapping materials that use bio-oriented materials.	80	2005
3	Agriculture etc.	14 Development of remote-controlled, multi-purpose agricultural robots with artificial intelligence, that can make even aged people self-reliant in cultivation and harvesting of crops.	80	2011
4	Agriculture etc.	18 Widespread use of a technology that keeps starch-based foods with high water content from deteriorating for a prolonged period, making it possible to eat such foods at any time without reheating, through combination with aseptic packaging.	79	2007
5	Agriculture etc.	77 Practical use of containers and packaging with in-built temperature control technology that obviates the need for refrigeration for processed foods aimed at the outdoor lifestyle.	78	2008
6	Agriculture etc.	12 Practical use of agricultural robots capable of harvesting and simultaneous sorting of fruits according to quality.	78	2007
7	Agriculture etc.	76 Development of household food testers capable of instantaneously determining freshness and microorganic contamination levels of foods.	78	2008
8	Agriculture etc.	68 Practical use of artificial sugar substitutes with the same cooking characteristics as sucrose which are ideal for diet food preparation.	78	2007
9	Agriculture etc.	32 Practical use of fully automated agricultural work execution techniques based on autonomous-travel tractors for the cultivation and harvesting of forage crops.	77	2009
10	Marine science	30 Widespread use of marine ranches with optimal environmental management through incorporation of biological system technology and a wide range of engineering technology.	77	2015
11	Transportation	38 Practical use of computer-integrated manufacturing systems (CIM) for shipbuilding, which incorporate design/production databases and intelligent CAD/CAM systems, leading to a reduction in shipbuilding labor costs to about half the present level.	76	2006
12	Agriculture etc.	33 Widespread use of fully automated feed formulation, feeding, milking and animal waste treatment systems.	76	2008
13	Urbanization	37 Practical use in Japan of distributed energy supply systems for houses utilizing fuel cells, cogeneration, etc..	75	2011
14	Urbanization	08 Introduction of robots to fire-fighting activities and their widespread use in search and rescue operations in fire events in Japan.	75	2010
15	Life science	62 Development of diagnostic and medical treatment micromachines capable of traveling on their own inside organisms (body cavity organs).	75	2015

Ranking	Field	Topic	Promote exchanges among industrial, academic and government sectors and different fields	Forecasted realization time
16	Urbanization	11 Widespread use in Japan of remote monitoring and control systems for enhancing the safety of essential services of utilities. (e.g. water, electricity and gas)	75	2007
17	Agriculture etc.	67 Practical use of functional foods which help prevent diseases according to individual body characteristics.	74	2011
18	Urbanization	38 Practical use in Japan of technology that facilitates the recycling of almost all construction by products such as concrete debris, asphalt waste and surplus soil.	73	2009
19	Agriculture etc.	41 Practical use of technologies for manufacturing paper and pulp by using the enzyme of wood decaying fungi.	73	2010
20	Life science	35 Widespread production of bioplastics using microorganisms and plants, accounting for 10% of the total volume of worldwide plastic production.	73	2013

5.4 Upgrade advanced R&D facilities and equipment and make them available for more widespread use (Upgrade advanced facilities and equipment)

The average of all topics for this measure is quite low at 15.9. It is relatively high in the basic technology fields of “electronics” (21.1), “marine science” (20.9), “health” (20.7) and “life science” (19.9). Lowest is the “information” field with 8.6.

Among the top 20 topics, only three are above 50%. By field, “electronics” has the highest share with nine topics, followed by “marine science” with four and “production” with three. Many of the topics are connected with electronics-related facilities and equipment, indicating that the respondents are looking to the government to upgrade and throw open electronics-related advanced R&D facilities and equipment across various fields.

Table 5.4-1 Top 20 topics in “Upgrade advanced facilities and equipment”

Ranking	Field	Topic	Upgrade advanced facilities and equipment	Forecasted realization time
1	Marine science	66 Practical use of high-luminosity radiation via electron or positron storage rings with emittance of 0.1 nano radians or less, for use in analysis of the atomic structure of materials deep inside the earth.	63	2023
2	Marine science	65 Development of a positron microscope.	59	2019
3	Electronics	05 Practical use of technology which allows mass processing of patterns with minimum line width as low as 10 nanometers.	58	2013
4	Electronics	06 Practical use of VLSI with as much as 256 Gbits of memory per chip.	48	2014
5	Electronics	01 Development of technology capable of manipulating single atoms and single molecules.	47	2007
6	Electronics	03 Practical use of LSIs using single-electron transistors.	44	2015
7	Marine science	67 Practical use of neutron spectrographs via megawatt-class spallation neutron sources, for use in analysis of the atomic structure of materials deep inside the earth.	43	2024
8	Production	18 Practical use of superprecision processing technologies (machining, analysis and testing) through the availability of length, displacement and surface roughness measurement to the angstrom order and time measurement to the femtosecond order, as a result of advancements in beam technology, involving ions, electrons and lasers, and equipment control technology.	42	2009
9	Electronics	02 Practical use of quantum-phase devices that control the phases of, for example, electron waves.	41	2012
10	Production	10 Establishment of atomic and molecular structure control techniques, leading to widespread use of high functionality materials and super materials, designed to operate under extreme conditions.	41	2019
11	Materials	23 Practical use of devices that enable X-ray structural analysis of supramolecular-biopolymer crystals in real time.	40	2011
12	Marine science	68 Practical use of 0.1-1.0 nm wavelength lasers, facilitating the observation of material structures via hard X-ray holography.	39	2014
13	Production	11 Realization of new material plants utilizing high-vacuum and weightless conditions in space.	39	2017
14	Electronics	07 Widespread use of wafers one meter in diameter.	38	2020
15	Materials	83 Practical use of technology for constructing material through the employment of ions and particle beams with controlled characteristics.	38	2011
16	Health	28 Practical use of diagnosing methods for determining the level and spread of arteriosclerosis focused by a non-invasive process.	38	2008
17	Electronics	43 Practical use of soft X-ray lasers oscillating at wavelengths in the order of 10/Å.	37	2016
18	Electronics	09 Practical use of semiconductor LSIs that operate at a switching speed of 1 ps or less.	37	2015
19	Life science	87 Elucidation of physiological effects of gravity-free state and development of measures for preventing deterioration in biological functions caused by the weightless state.	37	2016
20	Electronics	08 Practical use of non-volatile, erasable with more than 100 Gbits capacity random access semiconductor memories.	36	2017

5.5 Develop a research base comprising data bases, standard reference material, genetic resources and the like (Develop a research base)

The average of all topics here is lowest among the six measures at 5.3. It is highest in the life-related fields of "health" (14.8), "environment" (13.0), "life science" (10.6) and "agriculture etc." (8.4). Of the top 20 topics, nine are in "health" and eight are in "life science." Many are gene-related, with 16 containing the term "genome" in the topic text.

Table 5.5-1 Top 20 topics in "Develop a research base"

Ranking	Field	Topic	Develop a research base	Forecasted realization time
1	Life science	03 Utilization of information about the gene structure of each individual patient in diagnosis and treatment.	77	2015
2	Life science	21 Application of human genome analysis methods to other animals and plants, and practical use of technology to analyse whole genome sequence in livestock breeding, and fisheries, agriculture and forestry.	73	2017
3	Agriculture etc.	01 Elucidation of the whole DNA sequences of crops (e.g. Rice) to isolate useful genes.	67	2009
4	Life science	04 Development of methods for surmising new functions of proteins from human genome information.	66	2011
5	Life science	01 Identification of multiple genes related to cancer, and elucidation of the relationships between those genes and carcinogenesis.	62	2014
6	Health	23 Widespread use of a cancer risk assessment technique based on genetic analysis.	56	2010
7	Life science	22 Establishment of technology enabling to decipher human DNA modification (methylization) information for all genomes.	55	2014
8	Health	18 Practical use of the prevention against congenital anomaly originating in the embryonic or fetal period.	50	2013
9	Health	73 Practical use of gene therapy for genetic disorders.	48	2012
10	Agriculture etc.	02 Practical use in Japan of crop varieties having the characteristics (higher yield and more disease- and cold-resistance) improved by gene manipulation.	47	2004
11	Health	42 Practical use of gene therapy for diabetes.	46	2014
12	Health	56 Widespread use of gene therapy for muscular dystrophy.	45	2016
13	Life science	94 Advancement of the analysis of the human genome diversity regarding individual races, and the elucidation of the origin and phylogeny of human being.	45	2018
14	Health	21 Elucidation of gout-causing genes.	45	2008
15	Health	51 Widespread use of gene therapy against malignant tumors.	43	2014
16	Life science	25 Establishment of technologies enabling prediction of the functions of proteins from their higher-order structures.	43	2014
17	Health	05 Elucidation of carcinogenic mutation mechanisms.	42	2013
18	Urbanization	06 Practical use in Japan of online data base on natural disasters in Japan necessary for risk management.	40	2009
19	Life science	23 Elucidation of the transcription cascade for all genes, from fertilized egg to individual, in a single higher animal species, e.g. mice, and the mechanism by which differentiation and functions are manifest.	40	2023
20	Health	43 Widespread use of gene therapy for familial hypercholesterolemia.	39	2014

5.6 Increase the government's funding for research (Increase government research funding)

With an average of all topics of 52.5, "Increase government research funding" is the highest of all measures. It is especially high in the eye-catching and extremely expensive science field of "space" (71.4), and in "marine science and earth science" (65.1). Conversely, it is lowest in the media-related fields of "information" (34.8) and "communication" (39.1). Of the top 20 topics, ten are in "space," indicating that respondents expect the government to inject the massive amounts of funds needed for success in this field.

Table 5.6-1 Top 20 topics in "Increase government research funding"

Ranking	Field	Topic	Increase government research funding	Forecasted realization time
1	Transportation	37 Development of autonomous, unmanned, underwater investigation vessels employing artificial intelligence which are capable of investigating sea-bottom resources and undertaking other activities without receiving any energy supply or external communication.	85	2009
2	Space	20 Development of two-stage-to-orbit, completely re-usable, space transport system.	85	2011
3	Space	21 Development of a space plane capable of transporting between the earth and space stations in the similar manner as conventional airplanes.	84	2016
4	Space	39 Set of optical or radio telescopes on the surface of the moon.	83	2017
5	Space	37 Development of high-performance orbital transfer vehicle to transfer large structures between lower and geostationary orbits.	83	2015
6	Space	04 Development of technology to construct of artificial satellites with large-scale antenna (several tens of meters in diameter) at permanent manned space stations in low earth orbit.	82	2008
7	Space	40 Creation of a permanent, manned station on the surface of the moon, executing geological surveys of the moon, scientific observations from the moon, and development of technology to utilize the moon's resources.	82	2025
8	Agriculture etc.	44 Practical use of the forecasting of landslide and avalanche as the result of development in remote sensing techniques using suitable sensors and computer systems.	82	2011
9	Marine science	50 Development of technologies for digging into the crust at the ocean floor to gather mantle materials.	82	2016
10	Space	43 Return of samples from other planets.	80	2010
11	Space	11 Practical use of global-scale marine and land mapping using satellite-mounted multi-frequency/multi-polarization synthetic aperture radar.	80	2008
12	Transportation	57 Practical use of robots to guide blind people in particular districts such as stations and shopping centers.	80	2006
13	Space	45 Analysis of the surface substances of Mars, its with weather observation and earthquake observation, etc., via an unmanned Mars exploration unit.	80	2008
14	Space	38 Development of manned orbital transfer vehicle for trips to and from geostationary orbits and the moon.	79	2021
15	Marine science	52 Positioning in several locations, under an international agreement, of neutrino detectors for the purpose of surveying the earth's internal structure.	79	2012
16	Marine science	67 Practical use of neutron spectrographs via megawatt-class spallation neutron sources, for use in analysis of the atomic structure of materials deep inside the earth.	79	2024
17	Materials	109 Widespread use of desert afforestation technology through the advancement of water retention technology and biotechnology.	78	2016
18	Agriculture etc.	80 Practical use of technologies for efficient management and use of tropical forest and the organisms living there through elucidation of the mechanisms of structure and functions of forest ecosystems in tropical regions.	78	2016
19	Communication	63 Practical use of integrated building management systems and home security systems which are linked to an earthquake detection system and take the necessary safety measures to protect human lives in the event of a non-direct-hit earthquake, taking advantage of the time lag to the arrival of seismic waves.	78	2011
20	Transportation	55 Practical use of floating off-shore airports.	78	2009

5.7 Adjust relevant regulations (relax/toughen/establish/abolish)

The average of all topics for this measure is a low 10.5. It is relatively high in “information” (26.7), “transportation” (22.0), and “urbanization” (21.6), and low in “materials” (2.2), “health” (3.1) and “electronics” (3.3). Of the top 20 topics, 17 are media-related fields: 12 in “information” and five in “communication”. And most of these are connected to the use of networks. Many respondents expressed their hope that the government would review relevant regulations as our society enters an era of advanced information technology, as typified by the remarkable growth of the internet over recent years.

Table 5.7-1 Top 20 topics in “Adjust regulations”

Ranking	Field	Topic	Adjust regulations (relax/toughen)	Forecasted realization time
1	Information	66 Widespread use of electronic money to settle monetary matters.	84	2006
2	Information	61 Realization of in-home electronic voting (elections).	84	2009
3	Information	58 Realization of applications, registrations, and other official public procedures and services over networks.	83	2004
4	Information	57 Full computerization of the foreign exchange, stock and other financial markets, and widespread use of fully automated rapid trading systems that do not require dealers or traders.	83	2005
5	Information	64 Establishment of social rules regarding multimedia copyrights, and expanded production and distribution of multimedia information.	83	2005
6	Information	62 The holding of electronic parliamentary sessions (electronic prefectural council meetings) in conjunction with television broadcasts of parliament, and the passage of bills (acts) through electronic voting by the citizenry.	79	2013
7	Information	67 Become possible to verify the counterparty to a contract concluded over a network with the use of database systems.	77	2004
8	Communication	67 Widespread use of electronic commerce carried out via a network based on an electronic funds transfer system and electronic money system.	77	2006
9	Environment	23 Introduction of environment tax aiming at global environmental conservation.	77	2006
10	Information	73 Establishment of electronic primary and middle schools, making it possible for students who cannot travel to and from schools to take courses and obtain graduation diplomas.	75	2008
11	Urbanization	59 Widespread use in Japan of "three-dimensional" cities where the space above railway lines etc. is utilized through the establishment of artificial ground foundations and the like.	75	2013
12	Communication	01 Practical use of a highly secure next-generation internet that allows the transmission of real-time information, leading to the implementation of internet-based telephone services and motion video broadcasts.	75	2003
13	Communication	66 Widespread use of on-line seal-less document preparation services for various official documents such as contract documents which are provided via a network based on security technology capable of achieving both privacy protection and verification.	74	2008
14	Information	18 Realization of an environment in which the unlimited utilization of high-capacity networks (150 Mbps) for around 2,000 yen/month is possible.	73	2008
15	Information	19 Completion of networks enabling interconnection from anywhere in Japan through pocketbook-size telephones.	72	2005
16	Information	52 Widespread use of in-home shopping via networks, by means of virtual shopping systems.	72	2005
17	Communication	70 Realization of high-security communication, and widespread use of electronic secret ballots.	71	2012
18	Production	33 Strengthening of the relationship between consumption and production and advancements in networking between stores and factories, leading to widespread mergers between manufacturers and retailers/wholesalers and between manufacturers and distributors.	71	2007
19	Information	59 Formation and widespread use of a dynamic information market (including auctions) based on information provided by individuals.	70	2005
20	Communication	09 Widespread use of integrated information wiring and plug socket that incorporate services such as the telephone, Internet, VOD and high-definition TV in homes and offices.	70	2007

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6. Potential problems in Japan

In this section, we asked respondents to indicate whether they believe there are any potential problems that should be considered beforehand in relation to the realization of each of the topics, and if so, to choose up to two items from among the following.

i) Adverse effect on the natural environment

ii) Adverse effect on safety

iii) Adverse effect on morals, culture or society

iv) Other adverse effects

6.1 Overall trends

Figure 6.1-1 shows the average percentage value for all topics in each field. The average of all topics is quite low in "adverse effect on the natural environment," "adverse effect on safety" and "adverse effect on morals, culture or society," indicating that overall the respondents have no major concerns that topic realization could produce an adverse effect.

Fields where concern about an "adverse effect on the natural environment" is relatively high are those closely linked to the natural environment, such as "environment" (47.4), "resources" (38.1) and "agriculture etc." (27.5). In contrast, concern was lowest in "information" (1.0), "health" (1.1) and "electronics" (1.6).

As for "adverse effect on safety," concern is highest in the urban-base fields of "transportation" (30.4), "urbanization" (24.7) and "information" (22.9), and lowest in the basic technology fields of "materials" (4.6) and "electronics" (5.5).

As for "adverse effect on morals, culture or society," concern is by far the highest in the "health" field (37.7), followed by "information" (27.5) and "life science" (21.9), and lowest in "transportation" (2.0), "resources" (2.7) and "marine science" (2.9).

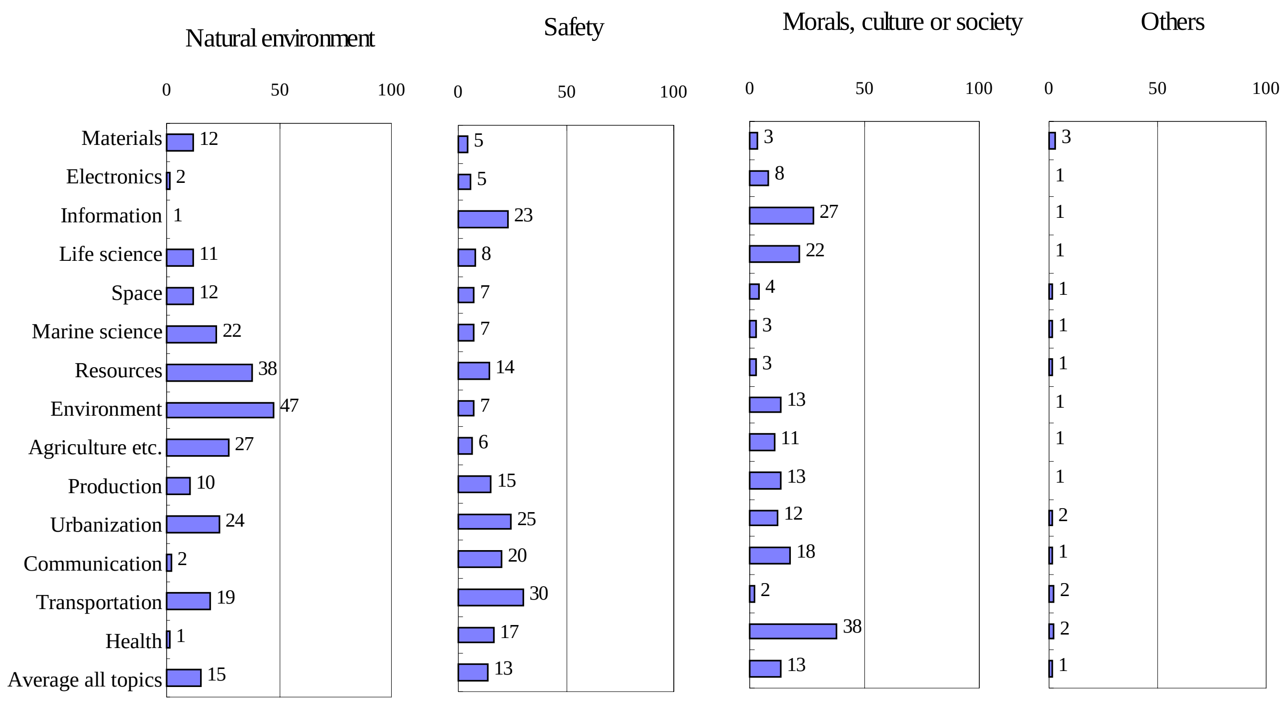

Figure 6.1-1 Potential problems in Japan

6.2 Adverse effect on the natural environment

Among the top 20 topics, six are in the “resources” field, and four are in “urbanization.” Most of the topics are connected to the deep underground, deep sea, artificial islands and gene manipulation.

Table 6.2-1 Top 20 topics in “Adverse effect on the natural environment”

Ranking	Field	Topic	Natural environment	Forecasted realization time
1	Resources	01 Practical use of solution mining, a technology to recover minerals from deep underground deposits by rendering ores such as chalcopyrite and sulfides of lead and zinc into solutions and pumping them up.	84	2020
2	Environment	10 Development of storage methods of carbon dioxide at deep sea levels of more than 3,000 m below surface.	75	2014
3	Resources	20 Practical use of inducing artificial rainmarking in event of drought.	74	2014
4	Life science	40 Widespread use of worldwide environmental remediation using genetically-engineered microorganisms released into the environment.	72	2016
5	Agriculture etc.	45 Realization of the creation of varieties of fisheries-resource aquatic organisms with traits advantageous for cultivation, such as high resistance to changes in water temperature and diseases, through cell fusion, gene manipulation, etc.	72	2010
6	Urbanization	32 Widespread use in Japan of "snow dam" technology to store snow and use it as cold heat source.	71	2014
7	Resources	41 Practical use of large-scale underground coal gasification.	71	2021
8	Urbanization	61 Development in Japan of design and construction technology for floating airports along coastal areas.	70	2005
9	Urbanization	13 Practical use in Japan of a safe and rational demolition technology for decommission of commercial nuclear power plants.	70	2009
10	Urbanization	69 Practical use of technology system needed to systematically build cities in remote areas such as deserts and polar regions.	70	2022
11	Resources	56 Practical use of hot dry rock power-generating technologies.	69	2021
12	Transportation	48 Development of a passenger transport that cruises at Mach 3 - 4 (1.5 - 2 times as fast as the Concorde) with a maximum of 300 passengers on board (3 times as many as the Concorde), and is capable of crossing the Pacific Ocean in 3 - 4 hours.	69	2016
13	Agriculture etc.	09 Widespread use of the pest control method based mainly on the biological insecticides (natural microbial enemies, pheromones, etc.).	68	2008
14	Agriculture etc.	48 Practical use of technologies for using a large volume of deep sea water for new fishing grounds in the open sea.	66	2013
15	Environment	21 Development of plants that are resistant to dry and saline conditions via biotechnology with the aim of greening deserts.	66	2013
16	Resources	23 Advancement in artificial groundwater recharging technology and widespread practice of the conservation and the rationalized use of groundwater.	66	2014
17	Resources	40 Practical use of methane hydrate mining.	65	2019
18	Marine science	18 Practical use of man-made off-shore islands processing of living disposal. (total dissassembly and decomposition of waste materials in order to dump harmful matter and recycle useful matter)	65	2012
19	Marine science	28 Practical use of marine cities (bases for transportation, communication, research, production and recreational activities) mainly of the legged or floating structures.	65	2013
20	Environment	11 Practical use of carbon dioxide fixing technologies using marine organisms such as microscopic algae.	65	2015

6.3 Adverse effect on safety (disaster prevention, health, security, privacy etc.)

Of the top 20 topics, eight are in “communication” and seven are in “information,” for a total of 15 in fields dealing with networks and other sophisticated information technologies that have been advancing rapidly over the past few years, indicating there is a fair amount of concern about the growing levels of computer crime in these areas and the improper use of personal information.

Table 6.3-1 Top 20 topics in “Adverse effect on safety”

Ranking	Field	Topic	Safety	Forecasted realization time
1	Information	66 Widespread use of electronic money to settle monetary matters.	67	2006
2	Communication	67 Widespread use of electronic commerce carried out via a network based on an electronic funds transfer system and electronic money system.	67	2006
3	Communication	66 Widespread use of on-line seal-less document preparation services for various official documents such as contract documents which are provided via a network based on security technology capable of achieving both privacy protection and verification.	66	2008
4	Information	67 Become possible to verify the counterparty to a contract concluded over a network with the use of database systems.	66	2004
5	Information	57 Full computerization of the foreign exchange, stock and other financial markets, and widespread use of fully automated rapid trading systems that do not require dealers or traders.	64	2005
6	Communication	69 Widespread use of security systems capable of identifying individuals based on the recognition of distinguished features of a person such as finger prints, hand writing, voice and face.	64	2009
7	Communication	01 Practical use of a highly secure next-generation internet that allows the transmission of real-time information, leading to the implementation of internet-based telephone services and motion video broadcasts.	63	2003
8	Information	58 Realization of applications, registrations, and other official public procedures and services over networks.	62	2004
9	Urbanization	70 Practical use in Japan of a technology to construct super high-rise buildings (around 1,000 m tall) with living spaces.	62	2020
10	Information	56 Widespread use of automobiles which drive automatically.	62	2017
11	Transportation	60 Practical use of vertical transportation systems for super high-rise buildings capable of providing a transporting capacity per occupant volume which is at least five times that of current elevators. (e.g., systems equipped multiple car-gondolas, turn-back function, and passing function)	61	2011
12	Communication	68 Widespread use of a security technology that automatically monitors illicit activities involving network ethics, such as copyright infringement concerning multimedia software use over a network and the violation of privacy.	59	2009
13	Communication	19 Practical use of a personal mobile communication system that enables communication with anyone anywhere in the world through advances in distributed databases and personal ID technology.	59	2008
14	Communication	02 Widespread use of indoor broadband optical wireless communication via indirect or scattered light that enables PCs and graphics terminals to make wireless connection to a network.	59	2005
15	Transportation	53 Achievement of radical automation of air traffic control through advances in computer technology, leading to a labor saving of about 50% compared to the present level.	58	2009
16	Information	59 Formation and widespread use of a dynamic information market (including auctions) based on information provided by individuals.	58	2005
17	Communication	70 Realization of high-security communication, and widespread use of electronic secret ballots.	57	2012
18	Life science	03 Utilization of information about the gene structure of each individual patient in diagnosis and treatment.	57	2015
19	Information	08 Widespread use of multipurpose ID card system with wireless communication capability.	55	2005
20	Resources	58 Practical use of fast breeder reactor systems including nuclear fuel cycle.	55	2025

6.4 Adverse effect on morals, culture or society

Of the top 20 topics, "health, medical care and welfare" has the highest share with eight, and most are connected with genes and other aspects of personal information, organ transplant, brain, and networks.

Table 6.4-1 Top 20 topics in "Adverse effect on morals, culture or society"

Ranking	Field	Topic	Morals, culture or society	Forecasted realization time
1	Life science	03 Utilization of information about the gene structure of each individual patient in diagnosis and treatment.	75	2015
2	Communication	01 Practical use of a highly secure next-generation internet that allows the transmission of real-time information, leading to the implementation of internet-based telephone services and motion video broadcasts.	73	2003
3	Health	02 Practical use of a method to quantitatively assess the level of aging (biological age) in relation to chronological age.	68	2008
4	Health	76 Widespread use of a worldwide organ supply system.	68	2010
5	Information	38 Become possible for computers, using electromagnetic data, to read the information recorded inside the human brain.	67	2026
6	Materials	02 Practical use of hybrid artificial organs in which cells are immobilized on materials such as high polymer plastics.	67	2014
7	Health	18 Practical use of the prevention against congenital anomaly originating in the embryonic or fetal period.	66	2013
8	Urbanization	40 Widespread use in Japan of devices in ordinary households that enable people to enjoy imaginary experiences of trips, sporting events, etc. utilizing virtual reality technology.	65	2010
9	Information	62 The holding of electronic parliamentary sessions (electronic prefectural council meetings) in conjunction with television broadcasts of parliament, and the passage of bills (acts) through electronic voting by the citizenry.	64	2013
10	Communication	37 Realization of electronic courts based on a teleconferencing system and electronic filing system.	64	2013
11	Life science	15 Development of technology to regenerate organs or individuals from separated animal cells.	63	2023
12	Health	01 Realization of the quantification of stress levels.	63	2007
13	Life science	50 Widespread use of technologies for long-term (semi-permanent) culturing and preservation of organs.	62	2017
14	Agriculture etc.	64 Widespread use of cross-species organ transplantation based on transgenic animals created through the introduction of genes that alleviate or prevent organ rejection as part of organ transplant treatment.	62	2015
15	Health	75 Practical use of heterogeneous organ transplantation as means of treatment.	61	2016
16	Health	14 Practical use of prevention methods for stress-induced mental disorders.	60	2011
17	Health	19 Widespread use of preventive measure for cerebral palsy.	59	2012
18	Health	27 Practical use of classification and stage determination of schizophrenia based on diagnostic imaging.	58	2013
19	Information	60 Formation of virtual communities, and realization of cultural interchange over wide areas.	58	2005
20	Environment	23 Introduction of environment tax aiming at global environmental conservation.	57	2006

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7. Intersecting technological fields

7.1 Setting the intersecting axes

We set the following axes that intersected all fields in view of current social, economic and technological conditions, selected and arranged topics related to these axes from each field, then analyzed each of their characteristics etc.

Aging countermeasures	:	(no age barriers, quality of life, support for independence)
Safety	:	(tackles natural disasters, tackles computer crime, etc.)
Environmental preservation and recycling	:	(new energy development, energy saving measures, recycling technology, etc.)
Common base technologies	:	(design technology, processing technology, handling, measuring and observation technology, etc.)

Table 7.1-1 shows the number of topics for each field intersecting axis.

Table 7.1-1 Number of topics in the four field intersecting axes

Field	Aging countermeasures	Safety	Environmental preservation and recycling	Common base technologies
Materials	2	3	11	41
Electronics	6	1	4	18
Information	12	10	4	6
Life science	13	0	10	22
Space	0	1	4	1
Marine science	2	12	20	1
Resources	0	5	48	2
Environment	0	0	39	0
Agriculture etc.	7	4	18	3
Production	10	5	15	16
Urbanization	7	24	20	1
Communication	7	12	2	9
Transportation	7	15	16	1
Health	30	1	0	4
Total	103	93	211	125

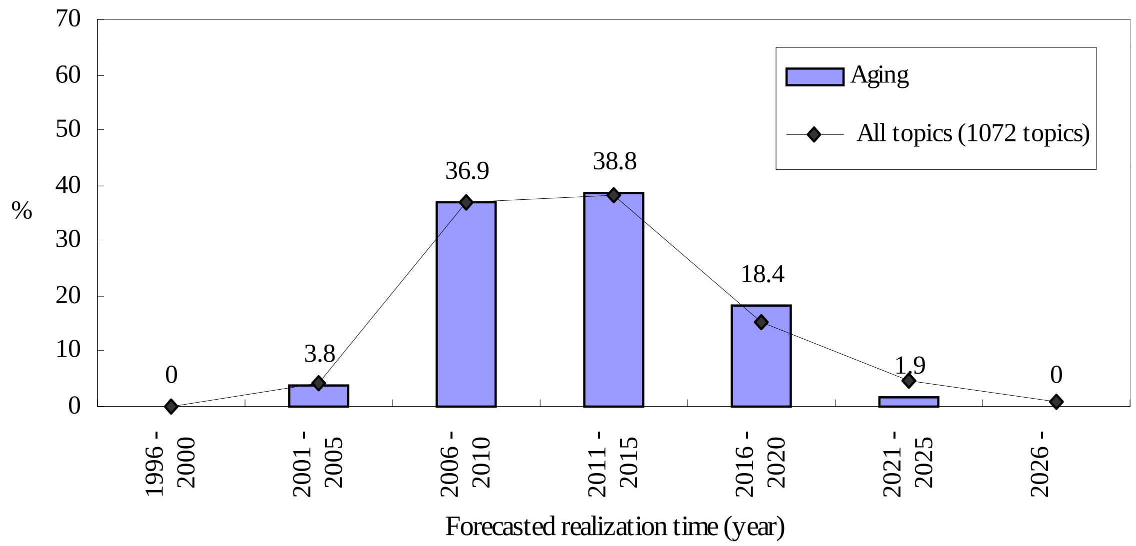
7.2 Aging countermeasures

We analyzed the 103 aging-related topics after classifying them into the following five domains.

i)	Medical care technology	:	13 topics (micro medical devices, dementia and aging, diagnostic and treatment technology for adult diseases)
ii)	Technology to aid or substitute physical functions	:	26 topics (artificial organs, supporting devices, etc.)
iii)	Health management technology	:	8 topics (disease prevention methods, health examinations)
iv)	Daily life support systems technology	:	26 topics (use of virtual reality technology, nursing care and housekeeping robots, etc.)
v)	Social systems technology	:	30 topics (use of internet, medical information systems, systems that support visually impaired people, etc.)

7.2.1 Forecasted realization time

Figure 7.2-1 shows the distribution of forecasted realization times for the 103 topics dealing with aging countermeasures. The average realization time of these topics is 2012.3 — roughly the same as the average over all 1,072 topics of 2012.6. The distribution of percentages is also virtually the same.



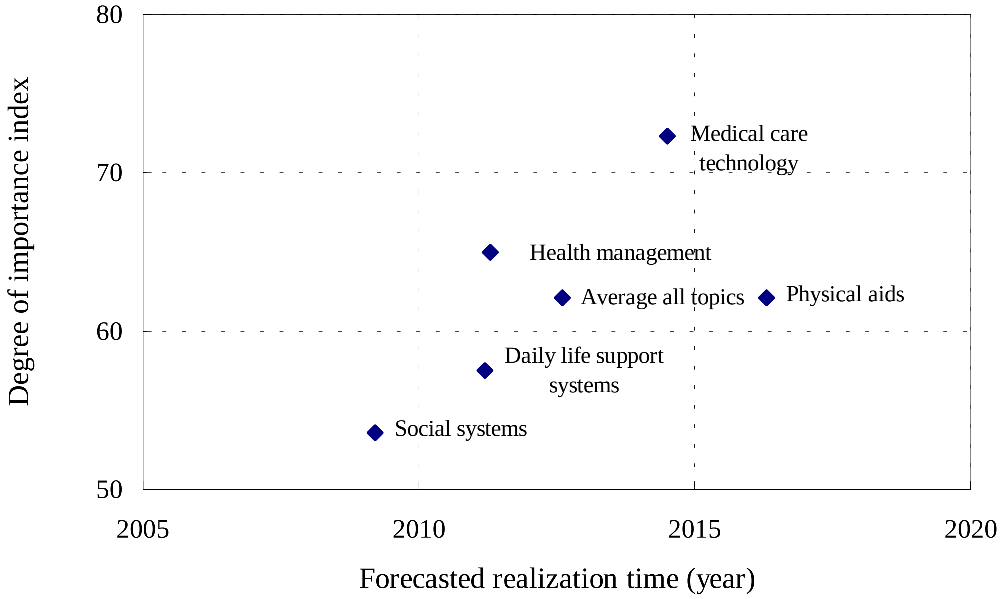
(Figures in the graph shows percentages for aging countermeasures)

Figure 7.2-1 Distribution of forecasted realization times (aging countermeasures)

Figure 7.2-2 shows the relationship between forecasted realization time and degree of importance index for each of the five domains. As for the medical care technology topics, the forecasted realization time is later and the degree of importance index is higher than the average of all topics, indicating that while elucidation of the causes of disease and R&D for methods of diagnosing and treating disease is important in Japan, their realization is likely to take considerable time.

On the other hand, social systems technology is earliest in the forecasted realization time and lowest in degree of importance among the five domains. This is thought to be largely because although the rapid advancement of the internet etc. over recent years means that realization will not take as long as the other domains, there are various methods of achieving the objectives and non-technical issues that have to be addressed. However, among these topics, systems that aid the employment of elderly people, such as the widespread use of production systems that support elderly people suffering from functional degeneration, are considered to have a comparatively high degree of importance.

The overall degree of importance is quite low for daily life support systems technology, although it is reasonably high, as are expectations, for the practical use of robots which provide medical care support in homes, hospitals, etc.



(Total topics: 1,072)

Figure 7.2-2 Cross-comparison between forecasted realization time and degree of importance (aging countermeasures)

7.2.2 Technological development outlook

Tables 7.2-1 – 7.2-3 show the forecasted realization times of topics connected with aging countermeasures with a comparatively high degree of importance. In medical care technology, treatment of dementia and elucidation of the aging mechanism will steadily be realized in the 2010s, while basic research into adult diseases will be realized between the late 2000s and early 2010s. However, new developments in the treatment of myocardial infarction is thought to be at least 20 years away.

As for technology to aid or substitute physical functions, steady developments in artificial organ technology are expected in the 2010s, and the 2020s will see the clinical application of technology enabling organs to regenerate through the multiplication of their own cells.

As for health management technology, methods of preventing of adult diseases and presbyopia, and basic research into health management will be realized between the late 2000s and late 2010s. Moreover, home health examination and diagnosis systems will be realized between the late 2000s and early 2010s, greatly improving the convenience for elderly people and others with limited mobility.

Regarding daily life support systems technology, the widespread use of virtual reality technology that enables in-home shopping and provides vicarious experiences of vacations etc. for elderly people and others with limited mobility will be realized from the late 2000s to the early 2010s. Furthermore, robots that care for elderly or disabled people and perform household chores will be steadily realized in the 2010s.

As for social systems technology, the first decade of the new century is forecasted to be a period in which systems that facilitate social communication by elderly or disabled people at home through the internet etc. will be realized and medical care information systems will be developed. It is also forecasted that systems that help elderly or disabled people to engage in work will be realized between the late 2000s and early 2010s.

Table 7.2-1 Forecasted realization times of topics connected with aging countermeasures (1)

Realization time (Year)	Medical care technology			Aid or substitute physical functions
	Micro medical devices	Dementia and aging	Adult-diseases-related	Artificial organs, supporting devices, etc
2000				
2005				
	(Health) Development of a capsule-type total gastro-intestinal tract monitoring system			
2010				(Health) Practical use of implanted bladder control devices
			(Health) Elucidation of the arteriosclerosis contraction mechanisms	
		(Health) Elucidation of the emergence mechanism of Alzheimer's disease	(Life science) Identification of the genes related to diabetes, hypertension, and arteriosclerosis	(Health) Widespread use of artificial hemoglobin as a red blood cell substitute
	(Electronics) Development of non-invasive, CT-type devices capable of recognizing, in real time, excited cerebro-neural states with a resolution on the order of 1 mm	(Health) Development of effective methods of treating Alzheimer's disease		(Life science) Development of an entirely implantable artificial kidney
	(Electronics) Practical use of micro medical devices for performing blood diagnosis and thrombus treatment			(Health) Development of fully implanted artificial hearts
2015				(Health) Practical use of fully implanted artificial pancreas
	(Life science) Development of diagnostic and medical treatment micromachines capable of traveling on their own inside organisms			(Life science) Practical use of artificial organs incorporating human cells and tissues
		(Life science) Realization of cure for Alzheimer's disease		(Health) Development of artificial liver (external devices supporting liver functions) usable on a long-term, continuous basis
				(Life science) Widespread use of technologies for long-term (semi-permanent) culturing and preservation of organs
		(Health) Elucidation of individual aging mechanisms		
			(Health) Application of a technique to induce the differentiation of fibroblasts into cardiac muscle to the treatment of myocardial infarction	(Life science) Development of an artificial cornea, allowing the visually impaired to regain their sight
				(Health) Practical use of fully implanted artificial lungs
2020				
				(Life science) Clinical application of technology enabling organs to regenerate through the multiplication of their own cells
2025				

Table 7.2-2 Forecasted realization times of topics connected with aging countermeasures (2)

Realization time (Year)	Health management technology	Daily life support systems technology	
	Disease prevention methods, health examinations	Use of virtual reality technology	Nursing care and housekeeping robots, etc.
2000			
2005		(Information) Widespread use of in-home shopping by means of virtual shopping systems	
	(Health) Widespread use of scientific guidelines for adult-disease-preventing life-styles (nutrition, rest and exercise)		
	(Health) Widespread use of prevention and treatment methods to ensure the retention of 20 or more teeth at 80 years of age (Health) Practical use of systems for an appropriate diagnosis at home in event of accident or diseases	(Life science) Widespread use of vicarious experience devices which allow bed-ridden patients to take vacations, etc.	
2010		(Information) Realization of the operation of information equipment through conversation between virtual operators and humans (Production) Widespread use of virtual reality life-style service communication systems for people with limited mobility	(Information) Practical use of robots which provide medical care support in homes, hospitals, etc.
	(Production) Widespread use of operatorless systems enabling at-home health examination and diagnosis (Health) Widespread use of presbyopia prevention methods		(Health) Widespread use of robots that care for people with severe physical and mental disabilities
			(Urbanization) Widespread use in Japan of houses equipped with robots and other devices that assist senior citizens and disabled people (Production) Development of housekeeping robots that carry out household chores by learning their owners' habits
2015	(Life science) Elucidation of the mutual regulatory mechanisms of the immune system, nervous system, and endocrine system		
			(Electronics) Widespread use (one in every household) of housekeeping robots that carry out cleaning, laundry, etc.
2020			
2025			

Table 7.2-3 Forecasted realization times of topics connected with aging countermeasures (3)

Realization time (Year)	Social systems technology		
	Use of internet	Medical information systems	Workplace support systems
2000			
2005	(Information) Realization of applications, registrations, and other official public procedures and services over networks (Information) Formation of virtual communities, and realization of cultural interchange over wide areas		
		(Health) Practical use of an ID card system that covers an individual's health conditions and medical data (Communication) Widespread use of systems for transmitting images etc. between ambulance and hospital for emergency medical care (Transportation) Practical use of systems for guiding visually impaired people at stations etc.	
2005			(Agriculture etc.) Practical use of labor-saving grazing techniques using computers etc. (Transportation) Widespread use of systems that facilitate the automation and mechanization of the inspection/construction of railway vehicles, railroad tracks, etc. (Production) Widespread use of telecommuting via multimedia information exchange tools based on the internet
2010	(Information) Realization of in-home electronic voting in elections	(Urbanization) Widespread use in Japan of systems for guiding visually impaired people on footpaths using magnetic sensors etc.	(Production) Practical use of keyboardless input devices in computerized office/distribution systems (Urbanization) Widespread use at Japanese urban public facilities of information systems which can be used by senior citizens and disabled people;
	(Communication) Widespread use of electronic secret ballots through the realization of high-security communication		
2015			(Production) Widespread use of production systems that provide comprehensive support for senior citizens and people with disabilities (Agriculture etc.) Widespread use of super labor-saving fishing boats designed to automate searching for shoals of fish, dragging and lifting nets, etc. (Transportation) Widespread use of guidance and control systems that enable the automatic operation of motor vehicles on expressways etc.;
			(Information) Widespread use of automobiles which drive automatically
2020			
2025			

7.2.3 Current leading countries etc.

Figure 7.2-3 is a breakdown of Japanese expert's selections of the leading countries in the various fields. As can be seen in the figure, overall the USA is ranked highest, followed by Japan and the EU. The USA is ranked especially high in topics connected with medical care with a considerable gap between it and Japan and the EU in topics concerning arteriosclerosis and other adult diseases and Alzheimer's disease.

Japan is placed relatively high in technology connected with systems that help people in their daily lives. For example, experts in the communication or information field have a high regard for Japan in the conversion of text into voice and vice versa. Japanese experts also give Japan a fairly high mark in household robots and medical or nursing care robots.

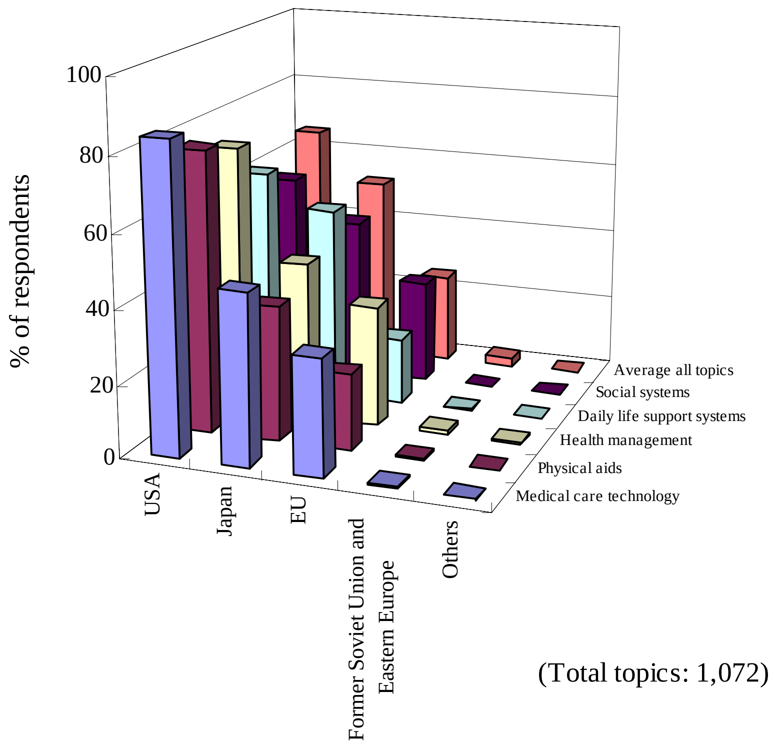


Figure 7.2-3 Leading countries etc. (aging countermeasures)

7.2.4 Effective measures the government should adopt

Figure 7.2-4 shows overall trends for government measures, with the highest being "foster human resources," followed by "increase government research funding" and "promote exchanges among industrial, academic and government sectors and different fields." Highest expectations of the government in "foster human resources" are in medical care technology and technology to aid or substitute physical functions, and especially Alzheimer's disease and arteriosclerosis topics and topics connected with artificial organs and supporting devices, such as implanted bladder control devices. Although "adjust regulations (relax/toughen)" is, overall, quite low, it is relatively high in social systems technology, and in particular, respondents want the government to review regulations on electronic voting and official public procedures and services over networks.

As for "increase government research funding," most focus is on topics connected with support in the daily and social lives of elderly people and others with limited mobility, such as systems for guiding visually impaired people, intelligent wheelchairs, and health or nursing care robots. As for "promote exchanges among industrial, academic and government sectors and different fields," topics connected with farming support for elderly people, such as multi-purpose agricultural robots, feed formulation systems and other fully automated systems are considered to be effective.

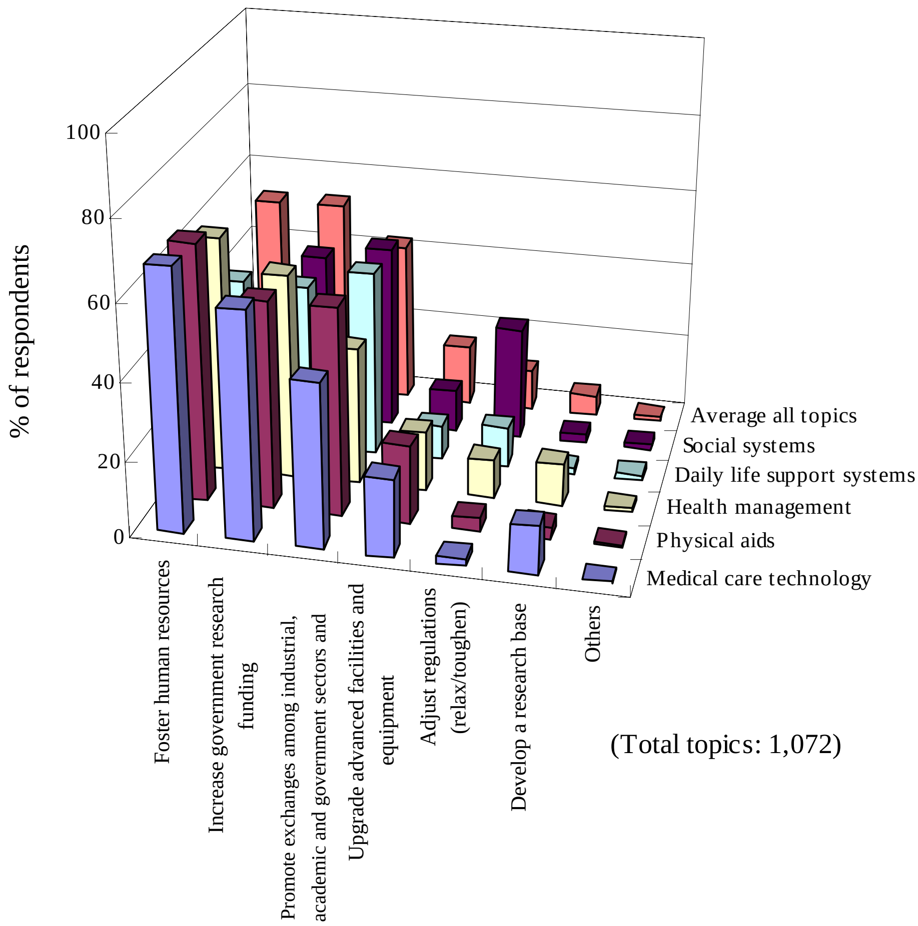


Figure 7.2-4 Measures the government should adopt (aging countermeasures)

(Reference) The following table shows a breakdown by field of the 103 aging-related topics

Table 7.2-4 Number of topics by field (aging countermeasures)

Field	Aging countermeasures					
	i) Medical care technology	ii) Physical aids	iii) Health management	iv) Daily life support systems	v) Social systems	Total
Materials	0	2	0	0	0	2
Electronics	4	1	0	1	0	6
Information	0	0	0	8	4	12
Life science	3	7	2	1	0	13
Space	0	0	0	0	0	0
Marine science	0	0	0	0	2	2
Resources	0	0	0	0	0	0
Environment	0	0	0	0	0	0
Agriculture etc.	0	0	0	4	3	7
Production	0	0	0	2	5	7
Urbanization	0	0	1	4	5	10
Communication	0	0	0	4	3	7
Transportation	0	0	0	1	6	7
Health	6	16	5	1	2	30
Total	13	26	8	26	30	103

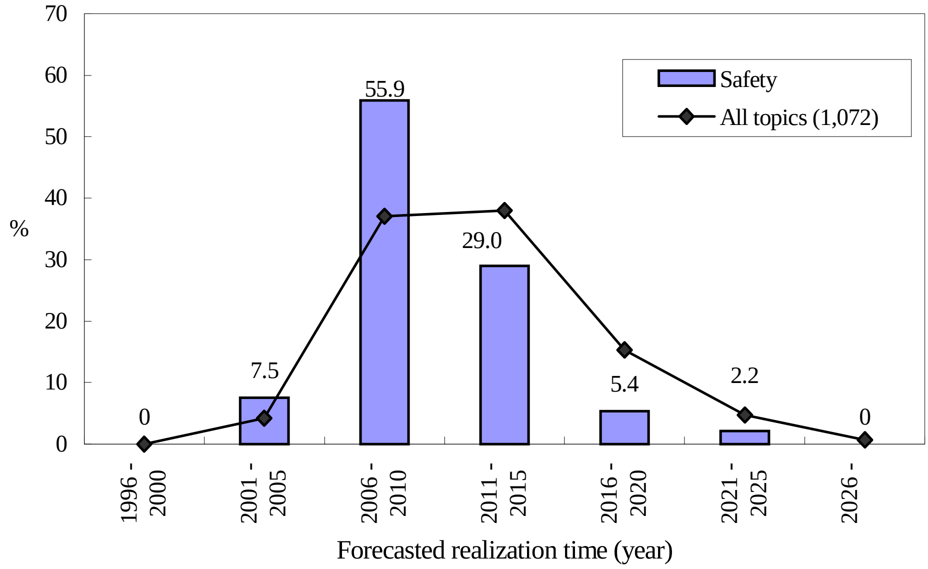
7.3 Safety

We analyzed 93 safety-related topics classified into the following five domains.

i)	Natural disaster research	:	20 topics (research into earthquake prediction, research into volcanic eruptions, etc.)
ii)	Natural disaster countermeasures	:	30 topics (improving the earthquake resistance of buildings and material, disaster prevention systems, search and rescue robots, etc.)
iii)	Information and communication security	:	16 topics (network technology, etc.)
iv)	Labor and transportation safety	:	21 topics (traffic accident prevention measures, workplace automation, etc.)
v)	General life safety	:	6 topics (safety at medical facilities, food safety, etc.)

7.3.1 Forecasted realization time

Figure 7.3-1 shows the distribution of forecasted realization times for the 93 topics dealing with safety. The average realization time of these topics is 2010.4, or about two years earlier than the average over all 1,072 topics of 2012.6. More than half of the topics are expected to be realized in the five years between 2006 and 2010.



(Figures in the graph shows percentages for safety)

Figure 7.3-1 Distribution of forecasted realization times (safety)

Figure 7.3-2 shows the relationship between forecasted realization time and degree of importance index for each of the five domains. As for natural disaster research, the forecasted realization time is relatively late, and about three years later than that for natural disaster countermeasures. The degree of importance is relatively high, indicating that while research into earthquake prediction is considered very important to Japan, its realization is going to be quite difficult indeed.

On the other hand, realization times for safety in our general life and information and communication security are about four years earlier than the average for all topics. We can probably put this down to the reasonably promising outlook in these domains due to the advancement of information networks technology, and especially the internet, over recent years.

Looking at degree of importance by topic, we can see that over half of the top 20 topics are earthquake-related, while many of the others are connected with countermeasures aimed at ensuring the security of information networks.

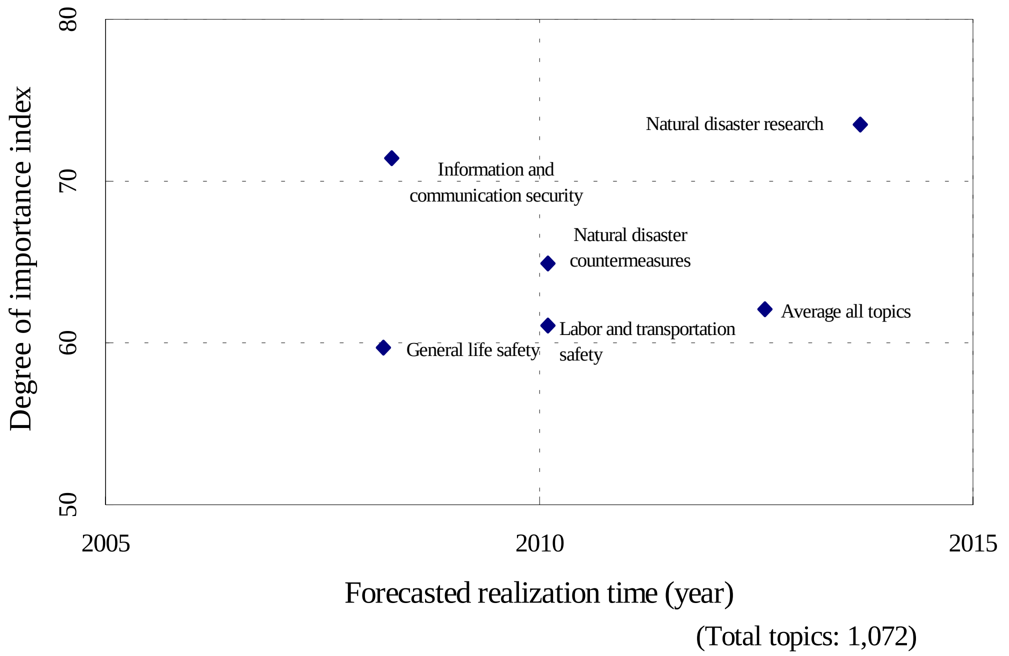


Figure 7.3-2 Cross-comparison between forecasted realization time and degree of importance (safety)

7.3.2 Technological development outlook

Table 7.3-1 and 7.3-2 show the forecasted realization times of topics connected with safety with a comparatively high degree of importance. In natural disaster research, progress is expected in the development of nationwide information transmission systems facilitating tsunami forecasting using satellites, greater accuracy in earthquake observation technology, and earthquake prediction between the late 2000s and early 2010s. On the other hand, technology for forecasting earthquakes of magnitude 7 or larger in the medium to short-term is unlikely to be realized until the late 2010s to early 2020s, while progress is expected to be seen in research into volcanic eruption during the 2010s.

As for natural disaster countermeasures, improving the earthquake resistance of building structures is expected to be realized in the 2000s, while advances are expected in technology for measuring the life of building material late in the first decade of the new century. On the other hand, realization of material that is able to repair itself is not expected until much later in the 2010s and 2020s. Various disaster prevention systems will be realized between the late 2000s and early 2010s, while the period from the late 2000s to the 2010s will see the realization of robots that can rescue victims of disasters.

Regarding information and communication security, topics dealing with the internet and other advanced information networks, for example, the development of technology for drawing up contracts over a network or producing vaccines automatically, are expected to be realized in the 2000s, whereas, electronic voting is not expected to appear until the 2010s, largely because this will require a far-reaching review of social systems.

In labor and transportation safety, the prevention of traffic accidents is likely to be enhanced with the steady realization of driving simulators in the early 2000s and automobiles that drive automatically in the late 2010s. And between the late 2000s and early 2010s we will see the automation of the workplace so that workers are not placed at risk doing dangerous work.

As for safety in our general lives, in the 2000s large numbers of people will carry around ID cards that contain personal medical information. Furthermore, technology to improve food safety will be realized from the late 2000s to the early 2010s.

Table 7.3-1 Forecasted realization times of topics connected with safety (1)

Realization time (Year)	Natural disaster research		Natural disaster countermeasures	
	Earthquake prediction research	Research into volcanic eruptions, etc.	Buildings and material	Disaster prevention systems, search and rescue robots
2000				
			(Urbanization) Practical use in Japan of techniques to rationally enhance earthquake resistance (Urbanization) Practical use in Japan of a technology to control and absorb vibrations in massive structures	
2005				
	(Marine science) Practical use of tsunami forecasting systems through satellites			(Information) Widespread use of security systems that provide emergency information at the time of a disaster (Urbanization) Widespread use in Japan of monitoring and control systems for enhancing the safety of essential services in a disaster (Urbanization) Widespread use in Japan of warning systems etc. based on localized weather forecasts
	(Space) Realization of precision down to less than a centimeter in measurement of crust movement using VLBI, satellites, etc.	(Marine science) Widespread use in Japan of observation systems for predicting downbursts at airports immediately before their occurrence		(Urbanization) Development of disaster forecasting and information transmission systems to prevent panic during an earthquake
			(Transportation) Practical use of a technology to automatically monitor bridges for fatigue	(Production) Widespread use of earthquake damage alleviation systems for industrial complexes etc. based on the early operation of safety devices in response to initial mild tremors
2010		(Marine science) Practical use of technology for predicting and forecasting landslides and rockslides caused by intense rainfall in certain locations in Japan	(Materials) Development of technologies for estimating remaining life of metallic materials structures and components depending on service conditions by non-destructive means	(Urbanization) Widespread use in Japan of robots in search and rescue operations at fires
	(Marine science) Nationwide installation of bore-hole-type observation equipment for use in earthquake forecasting			(Communication) Practical use of integrated building management systems linked to an earthquake detection system
2015		(Marine science) Realization of technology for forecasting the outbreak and scale of pyroclastic flows accompanying volcanic eruption (Marine science) Realization of time-series observation of the condition	(Urbanization) Development of intelligent construction materials with self-diagnostic functions etc.	(Information) Practical use of robots capable of recognizing, finding, and rescuing humans involved in a disaster

Realization time (Year)	Natural disaster research		Natural disaster countermeasures	
	Earthquake prediction research	Research into volcanic eruptions, etc.	Buildings and material	Disaster prevention systems, search and rescue robots
		of magma inside volcanoes		
		(Marine science) Elucidation of the series of processes involved in the generation, rise, etc. of magma		
	(Urbanization) Practical use in Japan of mid-term prediction techniques for large-scale (magnitude 8 or above) earthquakes			
2020		(Marine science) Development of technology to alleviate dangerously heavy rainfall through the application of nephology		
			(Transportation) Widespread use of road structures using smart materials with self-repairing functions etc.	
	(Marine science) Development of technology capable of forecasting the occurrence of major earthquakes (magnitude 7 or above) several days in advance			
2025				

Table 7.3-2 Forecasted realization times of topics connected with safety (2)

Realization time (Year)	Information and communication security	Labor and transportation safety	General life safety
	Network technology etc.	Transport countermeasures, workplace automation, etc.	Safety at medical facilities, food safety, etc.
2000			
		(Transportation) Practical use of driving simulators that give a realistic experience of driving under extreme conditions and being involved in a traffic accident	
	(Communication) Practical use of a highly secure next-generation internet that allows the transmission of real-time information (Information) Verification of a counterpart to a contract concluded over a network with the use of database systems		
2005	(Information) Practical use of face, voice, and other personal recognition technology in the area of security management	(Transportation) Practical use of systems that can detect obstacles on railway tracks and brake the train automatically	
		(Transportation) Practical use of systems for guiding visually impaired people at stations etc.	(Health) Practical use of an ID card system that covers an individual’s health conditions and medical data (Communication) Widespread use of systems for transmitting images etc. between ambulance and hospital for emergency medical care
	(Information) Widespread use of highly reliable network systems capable of protecting privacy and secrecy		(Agriculture etc.) Widespread use of a technology for full food sterilization at 3,000 atmospheres in a continuous process
	(Communication) Practical use of a technology that ensures a crash-proof communication network	(Transportation) Widespread use of systems that facilitate the automation and mechanization of the inspection/construction of railway vehicles, railroad tracks, etc.	(Agriculture etc.) Development of household food testing devices capable of instantaneously determining food freshness and micro-organic contamination levels
	(Communication) Widespread use of security technology that monitors illicit activities involving information and communication ethics (Information) Development of technology capable of automatically detecting harmful viruses and automatically producing vaccines	(Urbanization) Widespread use in Japan of systems for guiding visually impaired people on footpaths using magnetic sensors	(Information) Practical use of automatic security surveillance systems using robots
	(Information) Realization of in-home electronic voting in elections	(Transportation) Practical use of a fully automatic aircraft takeoff, landing and taxiing system	
2010		(Production) Widespread use of safety measures at industrial complexes etc. that are in line with their size and functionality based on potential danger assessment	
		(Production) Widespread use of robots for work in hazardous or extreme conditions to ensure worker safety	(Agriculture etc.) Widespread use of allergy-free livestock product manufacturing techniques
	(Communication) Widespread use of electronic secret ballots through the realization of high-security communication		
2015		(Transportation) Widespread use of guidance and control systems that enable the automatic operation of motor vehicles on expressways etc.; (Information) Widespread use of automobiles which drive automatically	
2020 2025			

7.3.3 Current leading countries etc.

Figure 7.3-3 is a breakdown of Japanese expert's selections of the leading countries in the various fields, and as shown in the figure, in both natural disaster domains and labor and transportation safety, the experts place Japan at the top, followed by USA and EU, while in information and communication security and general life safety, USA is ranked first followed by Japan and EU.

As for individual topics, many experts rank Japan top in earthquake prediction research and strengthening the earthquake resistance of buildings and structures, while many put the USA on top in the internet-related topics, especially the practical use of the next-generation internet and measures to combat hackers and viruses. Among the topics in which the EU is ranked high are those connected with systems for guiding visually impaired people at stations and other public facilities.

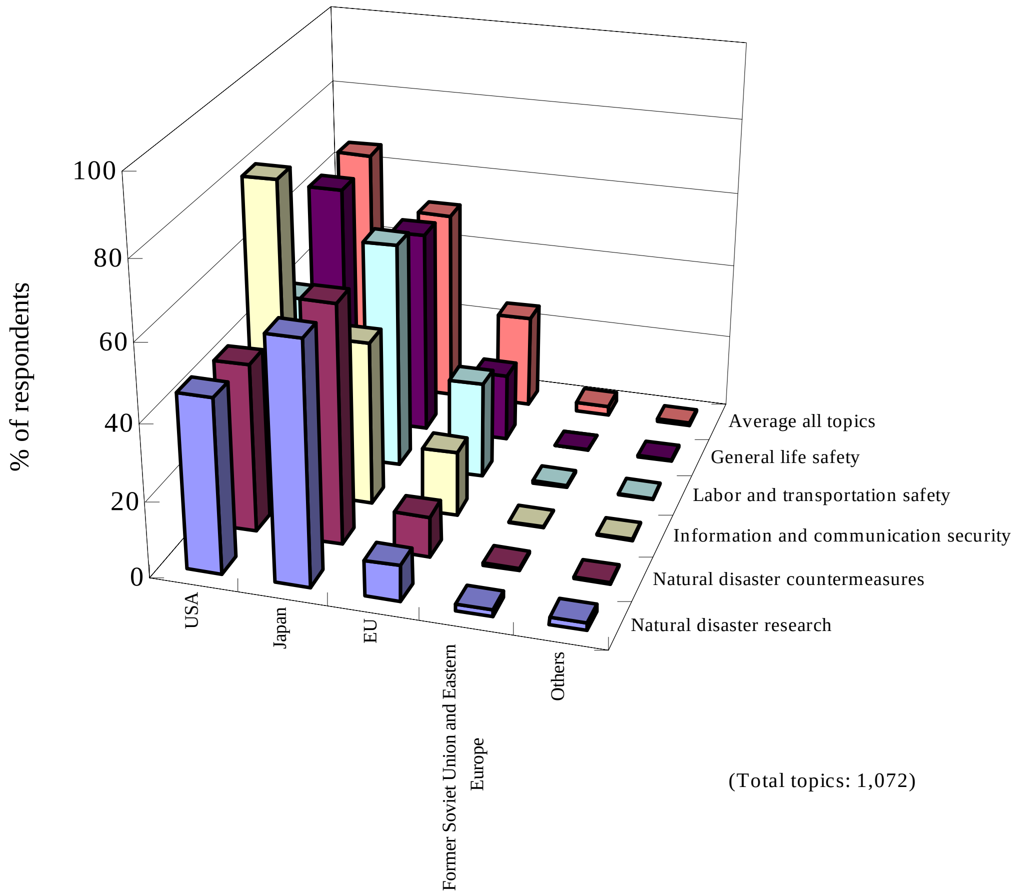


Figure 7.3-3 Leading countries etc. (safety)

7.3.4 Effective measures the government should adopt

Figure 7.3-4 shows overall trends for government measures, with the highest being "increase government research funding," followed by "promote exchanges among industrial, academic and government sectors and different fields" and "foster human resources."

Respondents expect more funding from the government in topics connected with earthquake prediction research and earthquake disaster countermeasures, while more effort by the government at promoting exchanges is wanted in topics dealing with food safety and fire-fighting robots and intelligent robots for construction sites. A relatively high percentage of respondents believe more government effort is required for fostering human resources in research on earthquake prediction and volcanic eruption and magma observation.

In information and communication security, "adjust regulations (relax/toughen)" is ranked relatively high, indicating that respondents expect the government to give greater regulatory consideration to improving the security of information networks.

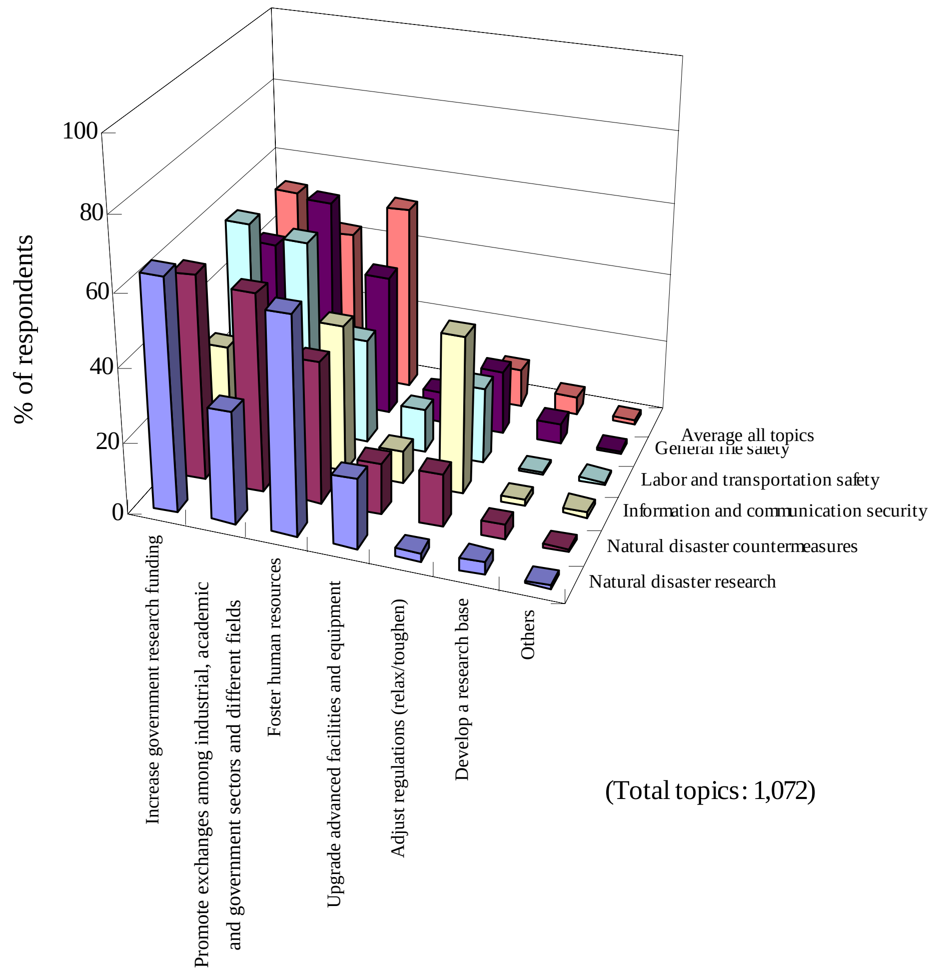


Figure 7.3-4 Measures the government should adopt (safety)

(Reference) The following table shows a breakdown by field of safety-related topics

Table 7.3-3 Number of topics by field (safety)

Field	Safety					
	i) Natural disaster research	ii) Natural disaster countermeasures	iii) Information and communication security	iv) Labor and transportation safety	v) General life safety	Total
Materials	0	3	0	0	0	3
Electronics	0	0	1	0	0	1
Information	1	2	5	1	1	10
Life science	0	0	0	0	0	0
Space	1	0	0	0	0	1
Marine science	12	0	0	0	0	12
Resources	1	3	0	1	0	5
Environment	0	0	0	0	0	0
Agriculture etc.	1	0	0	0	3	4
Production	0	1	0	4	0	5
Urbanization	3	16	1	4	0	24
Communication	0	2	9	0	1	12
Transportation	1	3	0	11	0	15
Health	0	0	0	0	1	1
Total	20	30	16	21	6	93

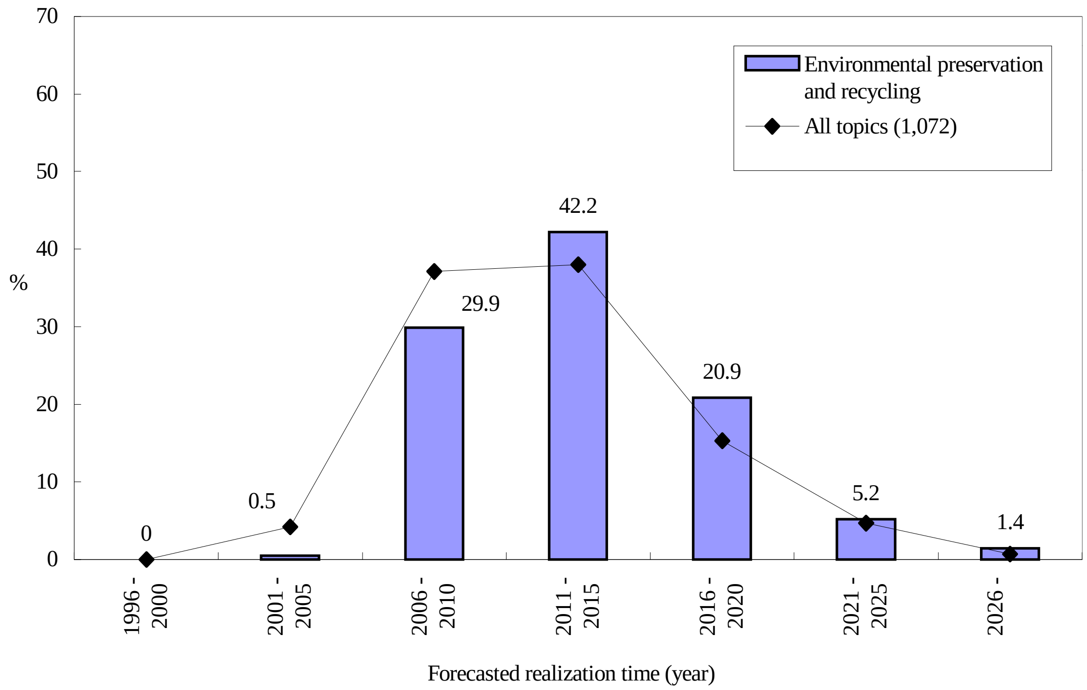
7.4 Environmental preservation etc.

We analyzed 211 topics dealing with environmental preservation and recycling, classified into the following three domains.

i)	Global environment	:	57 topics (protection of the ozone layer, controlling CO_2 emissions, agriculture, forestry and fisheries countermeasures, etc.)
ii)	Regional environment	:	81 topics (recycling technology, vehicle-related environmental countermeasures, biodegradable plastics, etc.)
iii)	New energy and energy saving	:	73 topics (solar cells, alternative energy, energy saving measures, etc.)

7.4.1 Forecasted realization time

Figure 7.4-1 shows the distribution of forecasted realization times for the 211 topics dealing with environmental preservation and recycling. The average realization time of these topics is 2013.6, or one year later than the average over all 1,072 topics of 2012.6.



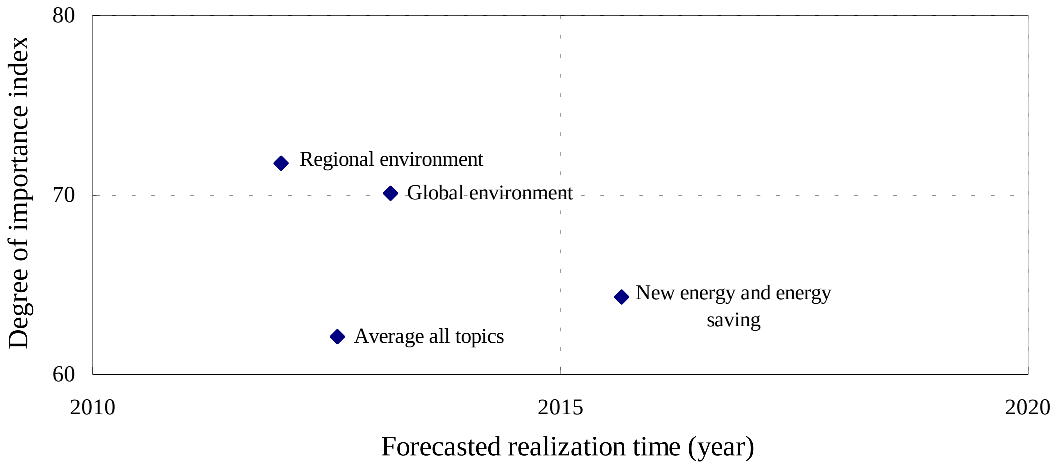
(Figures in the graph shows percentages for environmental preservation and recycling

Figure 7.4-1 Distribution of forecasted realization times (environmental preservation and recycling)

Figure 7.4-2 shows the relationship between forecasted realization time and degree of importance index for each of the three domains. The overall degree of importance is higher than the average of all 1,072 topics, reflecting the considerable importance with which environmental preservation and recycling is generally regarded.

Regional environment has the highest importance index of the three domains, and on average, its realization will be earlier than the other two domains. Conversely, new energy and energy saving is considered to be not as important, and requires much more time for realization.

By topic, those connected with the widespread use of non-fossil energy and practical use of solar cells are ranked highly important, and while plastic recycling and acceptance of LCA-style product design concepts are expected to be realized relatively early, topics connected with the widespread use of non-fossil energy for various purposes, use of superconductors in energy, and also nuclear power are not expected to be realized until much later.



(Total topics: 1,072)

Figure 7.4-2 Cross-comparison between forecasted realization time and degree of importance (environmental preservation and recycling)

7.4.2 Technological development outlook

Tables 7.4-1–7.4-3 show the forecasted realization times of environmental preservation and recycling topics with a comparatively high degree of importance. In the global environment, progress is expected in R&D into ozone layer protection, such as the practical use of fluorocarbon substitutes, between 2006 and 2010. As for control of CO_2 emissions, 2000–2010 is expected to see the introduction of an environment tax, the 2010s will see progress in the development of plants with a high CO_2 fixing capability, while the early half of the 2020s should witness a reduction of global CO_2 emissions to 20% below the 1990 level according to the experts. Desert afforestation technology is expected to be well on the road to realization in the 2010s, while in the agriculture, forestry and fisheries area, industries that are closely linked to the environment, elucidation of the acid rain mechanism, development of numerical models for analyzing climatic change, and advanced forest management technology are also expected to be realized successively in the 2010s.

In the regional environment, progress is expected in recycling technology from the late 2000s to late 2010s. Advances will be made in the recycling of plastics, and auto parts and materials between 2006 and 2010, and the widespread use of recycling systems for almost all materials used will take place in the early 2010s. Regarding vehicle-related environmental countermeasures, reductions in heavy-duty freight truck exhaust gases will be achieved in the period 2006–2010, and in the early 2010s we will see the first practical electric cars on our streets. A few years later in the late 2010s, we will begin to see the widespread use of hydrogen cars. As for plastics, in the late 2000s, biodegradable plastics are expected to account for 10% of all plastics used.

In new energy and energy saving, the scope of solar cell use will extend to portable computers and road and tunnel lighting in the late 2000s, and in the first half of the 2010s we will be using solar cells that provide power at less than 100 yen/watt. Therefore these and other technologies that will facilitate our shift in energy dependence from fossil fuels to alternative sources of energy will steadily be realized from the late 2000s to the early 2020s. Meanwhile, the tangible application of superconductors in the energy area is expected after the 2010s. As for energy saving technology, significant improvements in automobile fuel efficiency, energy-efficient houses and the like are expected to be realized from the late 2000s to the early 2010s.

Table 7.4-1 Forecasted realization times of topics connected with environmental preservation and recycling (1)

Realization time (Year)	Global environment			
	Ozone layer protection	CO_2 reduction	Desert afforestation	Agriculture, forestry and fisheries countermeasures
2000				
2005				
		(Environment) Introduction of an environment tax aiming at global environmental conservation		
	(Environment) Practical use of fluorocarbon and halon substitutes that do not damage the ozone layer and cause global warming			
	(Environment) Quantitative elucidation of effect of fluorocarbon and the like on change in the ozone layer			
	(Marine science) Elucidation of the mechanisms of ozone layer formation, variation and extinction			(Environment) Elucidation of the mechanism of the impact caused by acid rain to animals and plants
2010	(Environment) Elucidation of the impact on humans, plants and animals of increased UV radiation due to depletion of the ozone layer			(Environment) Elucidation of the worldwide long-distance migration mechanisms of acid-rain-causing substances
		(Environment) Elucidation of the precise mechanism of carbon dioxide generation and absorption		
		(Life science) Production of genetically engineered plants with high CO_2 fixing ability		(Environment) General understanding of the impact of global warming on world agricultural production
			(Environment) Elucidation of the effect of desertification on climate and weather	(Marine science) Development of a numerical model of the correlation between climatic changes and changes in marine living resources
			(Environment) Development of plants that are resistant to arid and saline conditions through biotechnology with the aim of desert afforestation	
				(Marine science) Elucidation of the impact on the ecosystem from ocean development through the establishment of a numerical model
2015		(Environment) Practical use of carbon dioxide fixing technologies using marine organisms such as microscopic algae	(Agriculture etc.) Development of new plants and cultivation systems which enable those plants to grow in regions with very limited rainfall	

Realization time (Year)	Global environment			
	Ozone layer protection	CO_2 reduction	Desert afforestation	Agriculture, forestry and fisheries countermeasures
		(Marine science) Elucidation of the entire aspect of the movement and storage of carbon dioxide	(Materials) Widespread use of desert afforestation technology through the advancement of water retention technology and biotechnology	Agriculture etc.) Development of a forest management method that realizes the advanced use of forests, while maintaining sustainable forest operation, on a global scale
		(Materials) Practical use of carbon dioxide fixation technology necessary for protecting the global environment		(Agriculture etc.) Development of fishery production systems based on predictions of long term (10 to 20 years) changes major fishery resources;
		(Life science) Practical use of technology for the biological fixation of highly concentrated carbon dioxide at thermal power plants		
		(Production) Widespread use of global environmental conservation measures throughout the world based on carbon dioxide recovery technology		(Agriculture etc.) Practical use of a management technique for fishery resources that migrate over great distances
2020		(Environment) Reduction of global carbon dioxide emissions to 20% below the 1990 level		
2025				

Table 7.4-2 Forecasted realization times of topics connected with environmental preservation and recycling (2)

Realization time (Year)	Regional environment			
	Recycling technology etc.	Vehicle-related environmental countermeasures	Biodegradable plastics	Environmental preservation in bays etc.
2000				
2005			(Agriculture etc.) Widespread use of biodegradable containers and wrapping materials that use bio-oriented materials	
	(Materials) Practical use of plastic recycling technology	(Environment) Widespread use of NOx emission control technologies in virtually all types of automobiles		
	(Environment) Wide acceptance of LCA-style product design concepts that facilitate recycling and reuse			
	(Resources) Practical use of economical methods for separating and recycling valuable substances in urban garbage		(Environment) Widespread use of biodegradable plastics that can be fully decomposed by anaerobic microorganisms	(Marine science) Development of a model for predicting the occurrence of Red Tides
	(Transportation) Realization of a 90% recyclability for motor vehicle parts and material		(Materials) Biodegradable plastics will account for 10% of all plastics	
2010		(Transportation) Practical use of technologies to reduce the harmful components of truck exhausts to 1/10 of present levels		(Environment) Widespread use of formulation methods for water environment plans based on a quantitative understanding of natural purification functions
				(Environment) Realization of technology to predict and forecast the impact of water pollution on ecosystems in closed water bodies
	(Resources) Practical use of technologies capable of separating useful metals from scrap cars etc. to a purity level of more than 99%	(Transportation) Widespread use of electric vehicles that can run for more than 200 Km after rapid battery recharging		
	(Production) Widespread use of designing, producing, collecting and recycling systems which make it possible to recycle most used materials			
		(Resources) Widespread use of electric vehicles with driving performance equal to that of gasoline motorcars	(Life science) Widespread use of bioplastic production so it accounts for 10% of total worldwide plastic production	(Marine science) Widespread use of technologies for the comprehensive use and conservation of entire bays that are subject to intensive use
		(Environment) Widespread use of nonpolluting automobiles (e.g., electric vehicles) so they account for at least 10% of all		

Realization time (Year)	Regional environment			
	Recycling technology etc.	Vehicle-related environmental countermeasures	Biodegradable plastics	Environmental preservation in bays etc.
		vehicles in the world		
		(Transportation) Widespread use of electric vehicles carrying fuel cells which have high energy conversion efficiencies.		
2015	(Agriculture etc.) Halving new tree requirements by extending the service life of wood resources and improving their recycling rate			
	(Production) Widespread use of low entropy-generating eco-factories, which give due consideration to the impact on ecosystem	(Materials) Production of automobiles powered by hydrogen fuel stored in hydrogen-occlusive alloys exceeds 10% of the total automobile production		(Resources) Improvement in the water quality of closed water areas such as Tokyo Bay so that people can safely swim there
				(Agriculture etc.) Practical use of a system of removing almost the entire pollution load caused by environmental degradation on closed water bodies
2020				
		(Resources) Widespread use of hydrogen cars		
2025				

Table 7.4-3 Forecasted realization times of topics connected with environmental preservation and recycling (3)

Realization time (Year)	New energy and energy saving			
	Ozone layer protection	Alternative energy	Superconductor use and nuclear energy	Energy saving technology
2000				
2005	(Information) Practical use of portable computers powered primarily by solar cells	(Environment) Widespread use of power generation using refuse derived fuel (RDF)		
				(Transportation) Widespread use of motor vehicles with fuel efficiencies 30% greater than current vehicles
	(Urbanization) Widespread use in Japan of photovoltaic power generation systems designed for road and tunnel lighting	(Marine science) Practical use of breakwaters capable of utilizing wave energy to generate electricity		(Urbanization) Practical use in Japan of a highly efficient heating and cooling system through a combination of solar energy and super heat pumps
2010	(Electronics) Development of solar cells capable of maintaining 15% efficiency for at least 10 years without light convergence			(Agriculture etc.) Practical use of technologies for manufacturing paper and pulp by using the enzyme of wood decaying fungi
	(Materials) Practical use of large-area amorphous silicon solar cells with a conversion efficiency of more than 20%			
	(Electronics) Practical use of solar cells which make the cost of power generation facilities less than 100 yen/watt			(Information) Widespread use of low-energy personal computers capable of running for one year on a single button-type battery
				(Resources) Widespread use of energy-efficient houses that consume less than half the power for air conditioning that present houses consume
		(Resources) Development of technology that requires fossil fuel consumption less than half of the present level		
2015		(Life science) Widespread use of fuel oil production technology using microorganisms etc. so it accounts for 10% of total worldwide fuel oil production		(Resources) Practical use of aluminum reduction methods that do not use electrolysis
	(Materials) Practical use of multi-layer solar cells with a conversion efficiency of more than 50%		(Production) Practical use of room temperature superconductors in industrial products	
	(Resources) Practical use of 100 MW photovoltaic power generation system in desert areas		(Production) Practical use of technologies that enable the direct storage of electricity	
		(Materials) Practical use of processes for water decomposition by the sunlight		

Realization time (Year)	New energy and energy saving			
	Ozone layer protection	Alternative energy	Superconductor use and nuclear energy	Energy saving technology
2020		(Production) Widespread use of non-fossil energy in all areas of life including household, industry and transportation (Production) Practical use of technologies for mass-producing hydrogen from organic substances through application of solar energy and biological systems		
2025			(Resources) Widespread use in industry of generators and other power equipment that use high-temperature superconductivity (Resources) Development of high-safety small to medium-scale nuclear reactors designed for cogeneration of heat and power (Resources) Practical use of fast breeder reactor systems including nuclear fuel cycle	

7.4.3 Current leading countries etc.

Figure 7.4-3 is a breakdown of Japanese expert's selections of the leading countries in the various fields, and as shown in the figure, in the global environment, USA is placed highest followed by Japan and the EU, while in the regional environment and new energy and energy saving, Japan is placed highest, followed by USA and EU.

The USA is ranked quite high in topics connected with environmental monitoring at the global level, while in the regional environment and new energy and energy saving, many experts consider Japan to be a world leader in topics connected with vehicle-related environmental controls and solar cells.

Overall, the USA average for environmental preservation and recycling topics is about 15 points below its all-topics average (1,072 topics), Japan's average is about the same as its all-topics average, while the EU is about 10 points above.

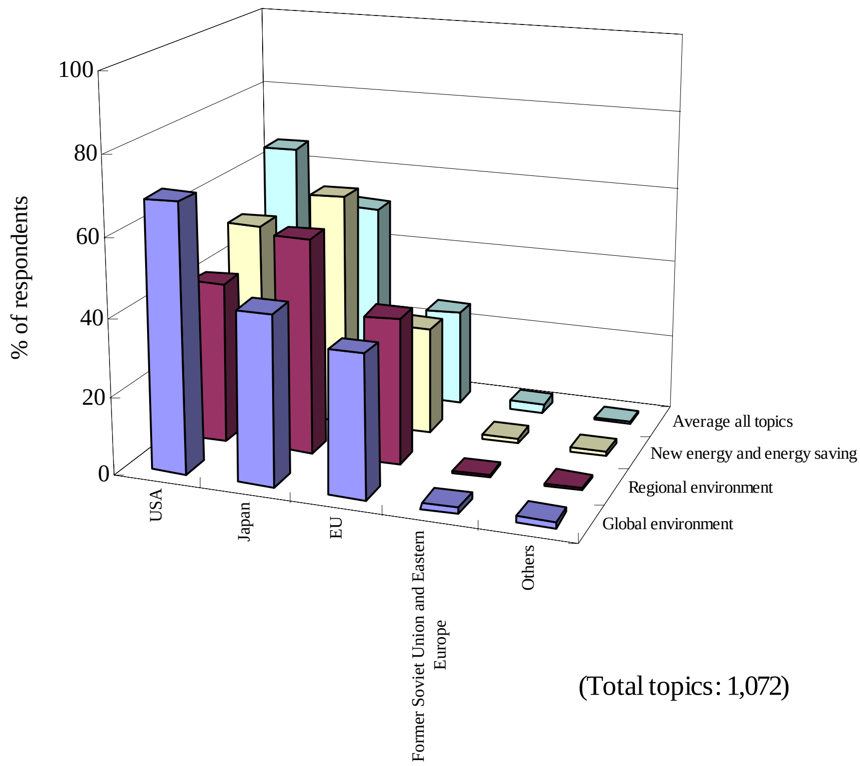


Figure 7.4-3 Leading countries etc. (environmental preservation and recycling)

7.4.4 Effective measures the government should adopt

Figure 7.4-4 shows overall trends for government measures, and like the average for all topics, "increase government research funding" is at the top, followed by "foster human resources" and "promote exchanges among industrial, academic and government sectors and different fields" with roughly the same percentages.

"Adjust regulations (relax/toughen)" is relatively high in regional environment topics such as those connected with preserving resources through controls on vehicle exhaust gas emissions and noise and the paperless office, and also the realization of a recycling society.

Many of the topics with a pressing need for the government to foster human resources are connected with forests, including technologies for the management of forest ecosystems and the organisms living there, the relationship between the destruction of tropical forests and the weather and climate, and the development of forest management techniques.

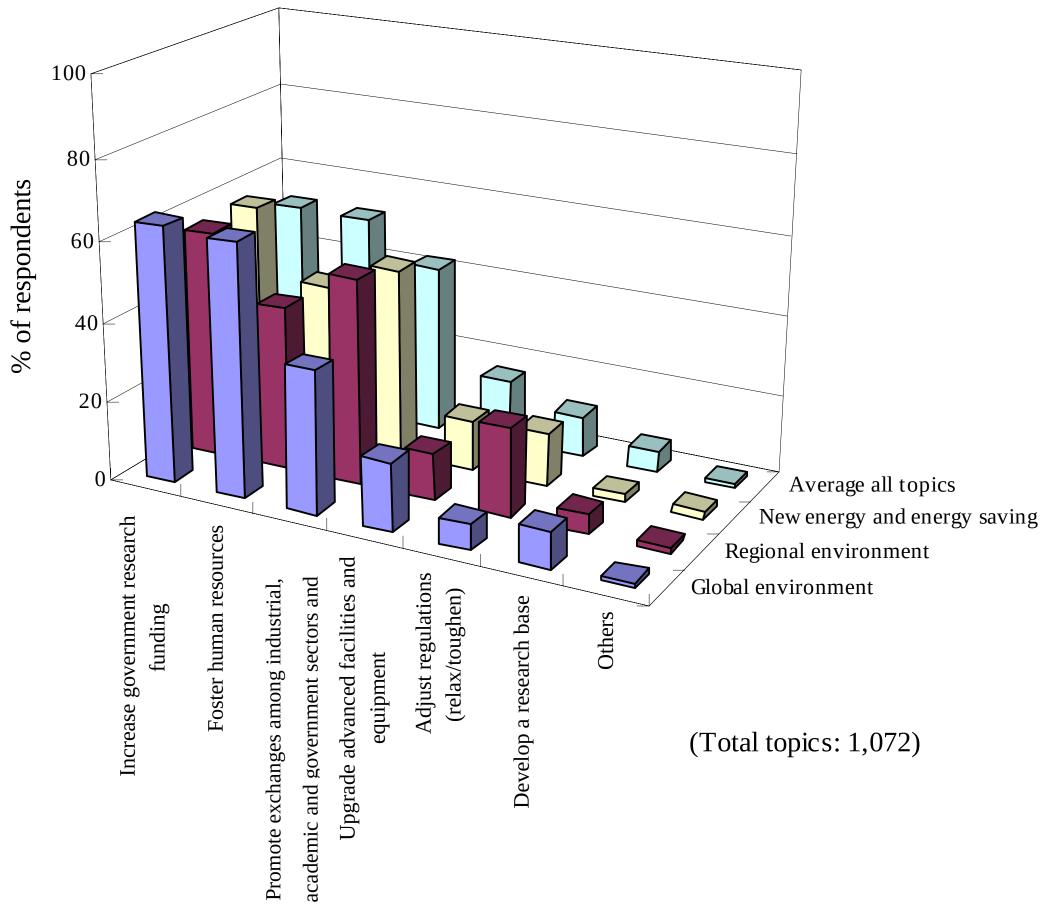


Figure 7.4-4 Measures the government should adopt (environmental preservation and recycling)

(Reference) The following table shows a breakdown by field of topics related to environmental preservation and recycling

Table 7.4-4 Number of topics by field (environmental preservation and recycling)

Field	Environmental preservation and recycling			
	i) Global environment	ii) Regional environment	iii) New energy and energy saving	Total
Materials	2	4	5	11
Electronics	0	0	4	4
Information	1	1	2	4
Life science	6	1	3	10
Space	4	0	0	4
Marine science	11	7	2	20
Resources	0	11	37	48
Environment	23	15	1	39
Agriculture etc.	6	11	1	18
Production	2	5	8	15
Urbanization	1	13	6	20
Communication	1	1	0	2
Transportation	0	12	4	16
Health	0	0	0	0
Total	57	81	73	211

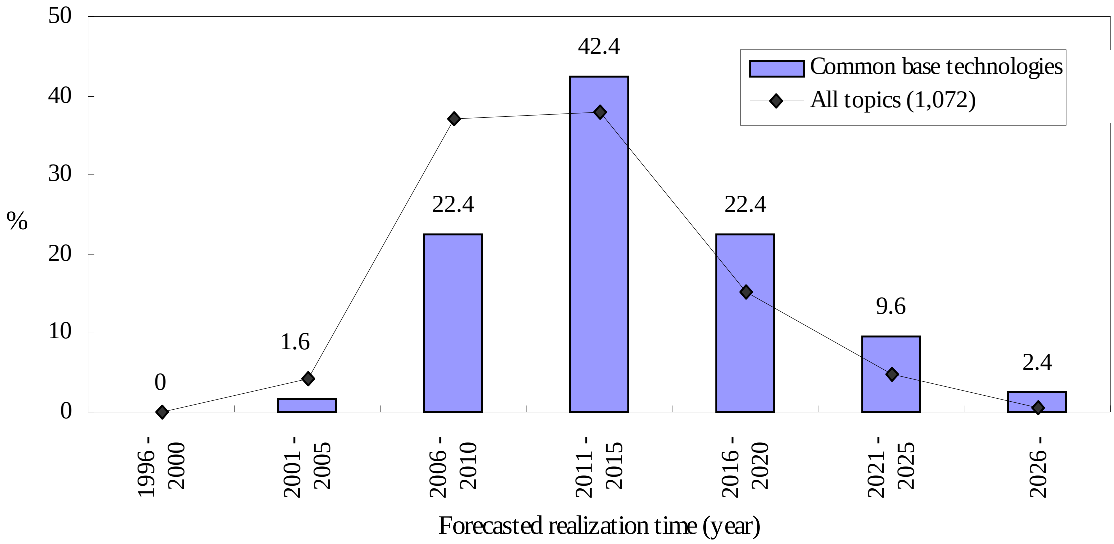
7.5 Common base technologies

We analyzed 125 topics dealing with common basic technologies, classified into the following five domains.

i)	Materials base	:	30 topics (superconductors, microscopic structures, simulation technology, new processes, etc.)
ii)	Medical care and biotechnology base	:	28 topics (medical engineering, gene-related, cancer-related, brain functions and nerve systems, etc.)
iii)	Energy base	:	11 topics (secondary batteries, superconductor use in energy, use of biological functions, etc.)
iv)	Measuring and processing base	:	26 topics (high-precision measuring, superprecision processing, etc.)
v)	Computer/electronics base	:	30 topics (Network communication, system software, etc.)

7.5.1 Forecasted realization time

Figure 7.5-1 shows the distribution of forecasted realization times for the 125 topics dealing with common base technologies. The average realization time of these topics is 2014.7, or about two years later than the average over all 1,072 topics of 2012.6, indicating a belief among respondents that technologies which can form a base for various scientific and technological developments will, for the most part, take quite some time to be realized.



(Figures in the graph shows percentages for common base technologies)

Figure 7.5-1 Distribution of forecasted realization times (common base technologies)

Figure 7.5-2 shows the relationship between forecasted realization time and degree of importance index for each of the five domains. The overall forecasted realization time is later than average, and although the degree of importance of the energy base is high, its forecasted realization time is also later than the average, in this case by at least four years.

In both the medical care and biological base and the computer/electronics base, many topics have a high degree of importance and also will require considerable time before they can be realized.

Topics with a high degree of importance are those connected with superprecision processing technology, the development of superconducting material and its use in energy, cancers, genes, and enhancing computer performance.

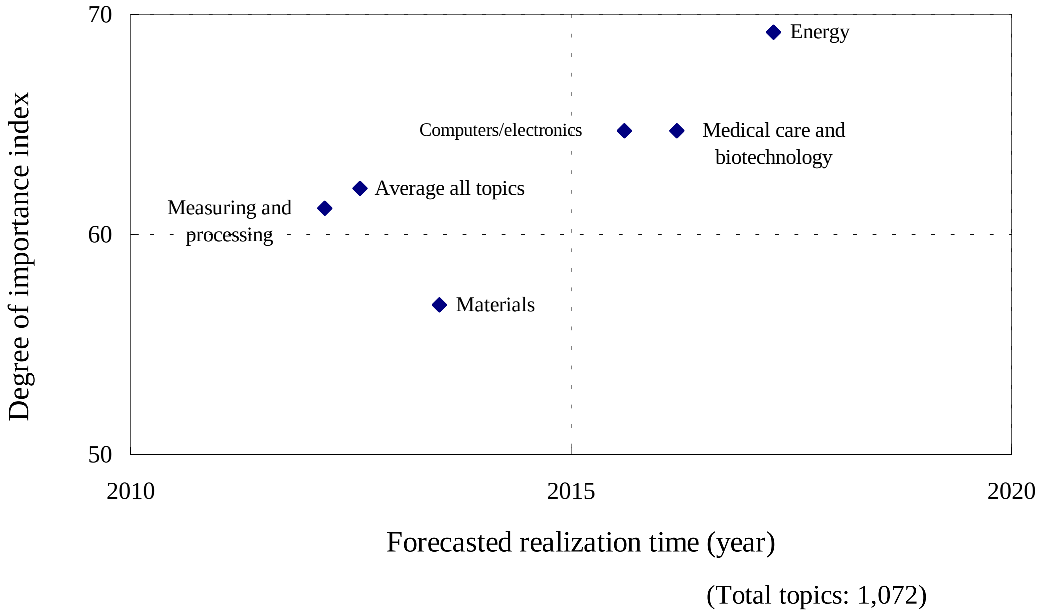


Figure 7.5-2 Cross-comparison between forecasted realization time and degree of importance (common base technologies)

7.5.2 Technological development outlook

Tables 7.5-1 – 7.5-4 show the forecasted realization times of common base technology topics with a comparatively high degree of importance. In the materials base, development of intelligent material with self-diagnostic functions and high-temperature organic superconductors is expected in the latter half of the 2010s, while steady progress in the practical use of materials with specific microscopic structures is expected in the 2010s. The development etc. of new polymer reaction processes is expected to be realized in the early 2010s.

As for the medical care and biotechnology base, advancements in medical engineering will be seen from the late 2000s, and in the 2020s we will probably see the realization of interface technology that improves the performance of artificial limbs dramatically. In the genetics area, elucidation of the whole DNA sequences of crops is expected in the late 2000s, while elucidation of the mechanism by which differentiation and functions are manifest in higher order animals will not take place until the early 2020s. Elucidation of the carcinogenesis mechanism is expected in the early 2010s, while research into brain functions and the nervous system is expected to bear fruit in the late 2010s and early 2020s.

In energy, advancements in secondary battery technology are expected around 2010, while the use of superconductors in the energy area is unlikely to be realized until the late 2010s at the earliest. In measuring and processing, X-ray microscopes with high resolution and positron microscopes will appear in the 2010s, and in processing technology, we can expect changes in the design of artificial objects through microtechniques also in the 2010s.

As for the computer and electronics base, topics concerned with network communication will be realized in the 2000s, and in electronics (hardware), progress is expected to be seen in the development of various new devices between the late 2000s and early 2010s. Around 2020 we will probably see the development of switching devices that are operated by the movement of a single atom. Biocomputers are viewed as a relatively long-term prospect, and their realization is not expected until the mid 2010s at the earliest.

Table 7.5-1 Forecasted realization times of topics connected with common base technologies (1)

Realization time (Year)	Materials base			
	Superconductors etc.	Microscopic structures	Simulation technology	New process technologies
2000				
2005				
	(Materials) Development of heat-resistant polymer capable of continuous use at temperatures of up to 450°C			
2010	(Materials) Development of a ceramic-metal bonding technology that can withstand heat fatigue from repeated temperature changes of over 500°C;		(Materials) Development of first-principle computer simulation technology of 10,000 atom scale	(Materials) Elucidation of the crystallization growth mechanism using femtosecond technology
				(Materials) Development of a heteroepitaxial technology for growing semiconductor material on silicon substrate
				(Materials) Development of precision supplementary polymerization processes for polymer controlled at the molecular level
	(Materials) Development of alloys which can tolerate loads of 15Kgf/mm^2 at ambient temperatures of 1,050°C for more than 1,000 hours	(Materials) Practical use of organic and inorganic composite materials with constituent parts in the order of tens to hundreds of Å.		(Materials) Development of technology that can freely control molecular weight and its distribution in condensation polymer
		(Materials) Development of inorganic materials which exhibit self-organization phenomenon with specific nano-scale structure/characteristics	(Materials) Practical use of computer-aided material design methods for solid catalysts	
	(Transportation) Development of composite materials that adapt to external stimuli by changing rigidity in response to load	(Materials) Practical use of organic hybrid composite materials of a controlled structure at the monomolecular level		
2015	(Urbanization) Development of intelligent construction materials with self-diagnostic functions etc.			
	(Materials) Widespread use of intelligent materials with self-diagnostic and self-repair functions			
	(Materials) Development of organic superconductor with a transition temperature higher than 77 K			
		(Production) Widespread use of highly functional materials and super materials that control structures at the atomic and molecular level		
2020	(Materials) Development of room temperature superconductors			
2025				

Table 7.5-2 Forecasted realization times of topics connected with common base technologies (2)

Realization time (Year)	Medical care and biotechnology base			
	Medical engineering	Gene-related	Cancer-related	Brain functions and nerve systems
2000				
2005	(Electronics) Practical use of biosensors utilizing antibodies			
		(Agriculture etc.) Elucidation of the whole DNA sequences of crops		
2010	(Electronics) Practical use of ultra-small medical biosensors that utilize biochemical reactions		(Agriculture etc.) Development of biomicromachining technology which uses a cancer drug delivery system that is biodegradable after drug discharge	
		(Life science) Practical use of technology to alter the functions of biological molecules and cells by means of molecular evolutional engineering techniques (Life science) Development of technology that artificially alters organelle genes and causes the altered organelle genes to function within cells	(Health) Elucidation of cancer metastasis mechanisms	
	(Materials) Practical use of artificial materials that promote development of biological tissues and organogenesis		(Health) Elucidation of carcinogenic mutation mechanisms	
			(Life science) Identification of most genes related to cancer, and elucidation of the relationships between those genes and carcinogenesis	
2015				(Materials) Elucidation of the information transmission structure of sensory nerves
	(Electronics) Development of medical micromachine devices powered by the ATP etc. contained in blood	(Life science) Practical use of technology to analyse whole genome sequence in livestock breeding, and fisheries, agriculture and forestry		
	(Electronics) Practical use of biosensors capable of identifying single molecules			(Life science) Elucidation of the molecular mechanisms for formation of neuronal networks at the molecular level (Health) Elucidation of molecular mechanism of memory
2020	(Life science) Establishment of interface technology between neural information and artificial organism structures			
		(Life science) Elucidation of the transcription cascade for all genes, from fertilized egg to individual, in a single higher animal species, e.g. mice, and the mechanism by which differentiation and functions are manifest		(Life science) Elucidation of brain mechanisms for logical reasoning
2025				

Table 7.5-3 Forecasted realization times of topics connected with common base technologies (3)

Realization time (Year)	Energy base		Measuring and processing base	
	Secondary batteries and superconductors	Use of biological functions	High-precision measuring	Superprecision processing
2000				
2005				
				(Electronics) Development of technology capable of manipulating single atoms and single molecules
			(Materials) Development of technology to analyze the chemical species of solid surface atoms	
	(Communication) Development of high performance batteries with an energy density of about 500 Wh/Kg		(Space) Realization of a micro gravity research facility capable of an environment of 10^{-6}G or less for several days	(Production) Practical use of superprecision processing technologies that enable measurement to the angstrom order and time measurement to the femtosecond order
2010				(Production) Initial impact of engineering techniques that control silicon microscopic structures in the production and machinery area
	(Materials) Practical use of plastic secondary batteries with a capacity of 400Wh/liter		(Materials) Development of technology for inducing and measuring ultra-high vacuums in the order of 10^{-14} torr	(Production) Realization of radical changes in the theories of designing artificial objects based on microtechniques
			(Materials) Practical use of equipment capable of ultra-micro-analysis up to the ppt level	
				(Electronics) Practical use of technology which allows mass processing of 10nm patterns
		(Life science) Development of artificial membranes with functions similar to biological membranes	(Materials) Establishment of technology to measure minute levels of force (10^{-19} newtons or less)	
2015			(Electronics) Development of X-ray microscopes capable of 10-100nm resolution	
	(Production) Practical use of technologies that enable the direct storage of electricity	(Life science) Development of engineering technologies that apply biological energy conversion mechanisms		(Production) Discovery of new laws etc. based on the functions of living organisms, leading to a radical change in the theories of designing artificial objects
	(Production) Practical use of room temperature superconductors in industrial products			
		(Life science) Development of light energy elements patterned after photosynthetic response		
			(Marine science) Development of a positron microscope	
2020				
		(Life science) Development of technology for synthesizing artificial cells that replace such functions as cell membrane transport and substance conversion		
	(Resources) Practical use of superconductive energy storage systems with a capacity as large as that at pumped hydroelectric power plants			
2025				

Table 7.5-4 Forecasted realization times of topics connected with common base technologies (4)

Realization time (Year)	Computer/electronics base			
	Network communication	Electronics	System software	Biocomputers etc.
2000				
	(Communication) Development of a super high-speed computer communication protocol with a throughput of hundreds of Mbps			
2005		(Communications) Development of a 4,000 x 4,000 pixel high-definition display, image sensor, etc.		
	(Production) Realization of radical changes to the production and machinery area through multimedia technology			
	(Communication) Development of an encoding technique that can compress image information to about 1/250 of the original size	(Electronics) Development of digital optical logic circuits which carry out binary operations		
	(Communication) Practical use of narrow-band high-quality image encoding technology with a bit rate of around 10 Kbps			
2010		(Material) Development of elements which utilize colossal magnetic resistance effect		
			(Information) Development of software capable of using sensory and learning functions to rewrite itself into an even more advanced program	
			(Information) Realization of software inspection and verification technology that enables quick development of error-free, large-scale software	
	(Communication) Development of an optical fiber communication method using the quantum state of photons	(Materials) Development of PHB memory devices		
2015				(Communication) Practical use of biochip devices that have a memory density 1,000 times that of current semiconductor devices
			(Electronics) Practical use of multi-processor systems with advanced self-restoration capabilities	(Information) Practical use of biocomputers based on a new algorithm
		(Electronics) Development of high-speed, highly-integrated devices that switch by the movement of a single atom		(Life science) Development of neural-computers with new logic structures modeled on brain functions

Realization time (Year)	Computer/electronics base			
	Network communication	Electronics	System software	Biocomputers etc.
2020				(Electronics) Development of artificially functioning bio-nerve circuits with about 10,000 cells
		(Electronics) Development of a storage system in which one atom or molecule corresponds to 1 bit		
				(Information) Elucidation of human creative mechanism to such an extent that it can be applied to computer science
				(Electronics) Development of an “artificial intelligence chip” capable of understanding and sharing human emotions
2025				(Life science) Development of interfaces that enable a direct linkage between computer and brain

7.5.3 Current leading countries etc.

Figure 7.5-3 is a breakdown of the leading countries in the various fields, and as can be seen in the figure, overall the USA is ranked highest, followed by Japan and the EU. The USA is placed above its all-topics average in all five domains, and is ranked especially high in the medical care and biotechnology base, which includes cancer- and gene-related technologies, and in the computer/electronics base, which includes computer software and computer communication.

Japan is generally at about the same level as its all-topics average, and is ranked relatively high in the materials base and the measuring and processing base. As for the EU, its score for the medical care and biotechnology base is higher than its all-topics average.

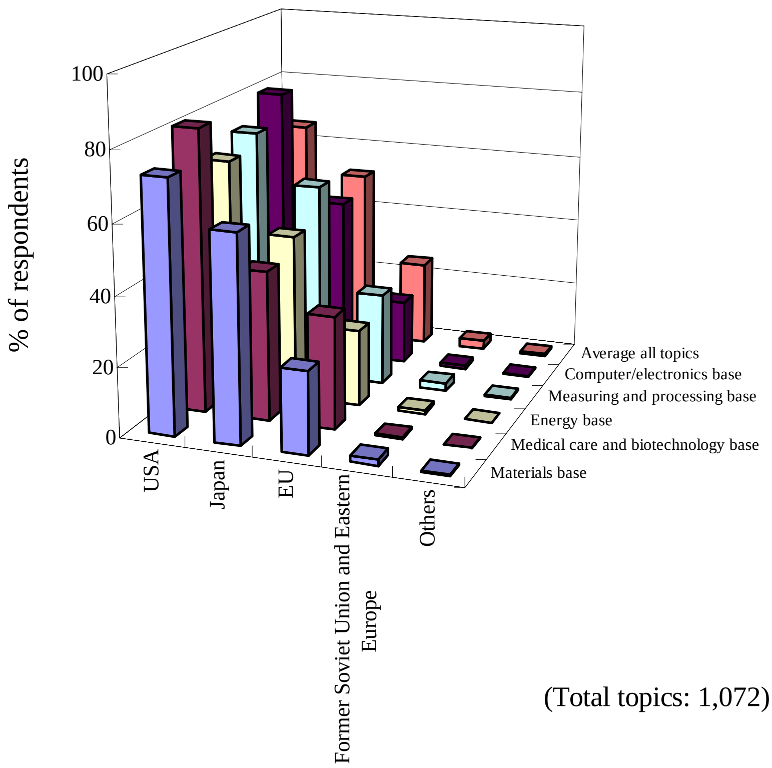


Figure 7.5-3 Leading countries etc. (common base technology)

7.5.4 Effective measures the government should adopt

Figure 7.5-4 shows overall trends. “Foster human resources” ranks highest, followed by “increase government research funding” and “promote exchanges among industrial, academic and government sectors and different fields.” The percentage for “foster human resources” is higher than the average percentage for all 1,072 topics.

“Foster human resources” is particularly high in the medical care and biotechnology domain, and topics in which this was highlighted by large numbers of respondents include those connected with genes, such as the elucidation of the mechanism by which differentiation and functions are manifest in mice etc., those connected with the nervous system, including the elucidation of the information transmission structure of sensory nerves, and those connected with cancer, such as the elucidation of carcinogenic mutation mechanisms.

In the energy base, a high percentage of respondents want the government to increase its research funding, and also foster human resources to a much greater degree. The use of superconductors in the storage of energy is one example of the topics in which most respondents believe the government should inject more research money.

And in medical care and biotechnology, “develop a research base” is ranked relatively high.

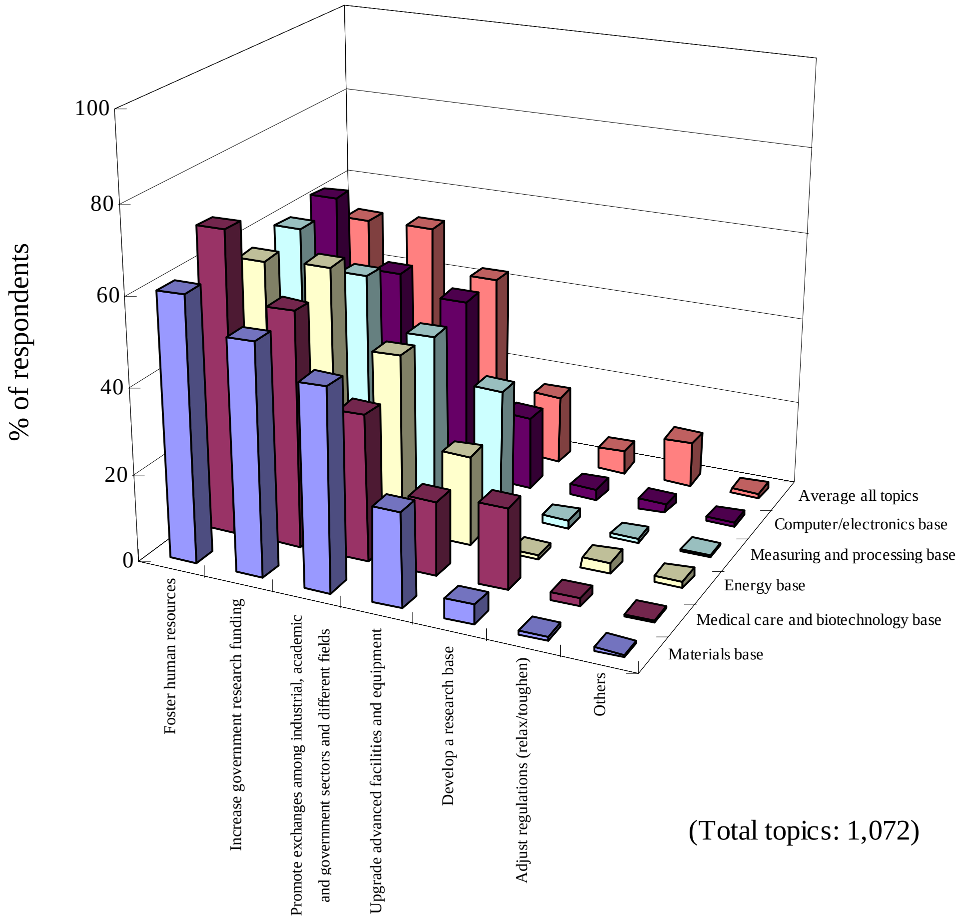


Figure 7.5-4 Measures the government should adopt (common base technology)

(Reference) The following table shows a breakdown by field of topics related to common base technology

Table 7.5-5 Number of topics by field (common base technology)

Field	Common base technology					
	i) Materials	ii) Medical care and biotechnology	iii) Energy	iv) Measuring and processing	v) Computers/electronic	Total
Materials	26	4	1	8	2	41
Electronics	0	5	0	6	7	18
Information	0	0	0	1	5	6
Life science	0	12	4	0	6	22
Space	0	0	0	1	0	1
Marine science	0	0	0	1	0	1
Resources	0	0	2	0	0	2
Environment	0	0	0	0	0	0
Agriculture etc.	0	3	0	0	0	3
Production	2	1	2	9	2	16
Urbanization	1	0	0	0	0	1
Communication	0	0	2	0	7	9
Transportation	1	0	0	0	0	1
Health	0	3	0	0	1	4
Total	30	28	11	26	30	125

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8. Identical and similar topics among fields

We compared and examined forecasts by the experts in different fields based on the results of identical and similar topics set over several fields. Of the 1,072 topics of this survey, two groups (five topics) were identical, and 69 groups (162 topics) were similar. In most cases, the forecasted realization times are practically the same. Table 8.1-1 gives four groups as examples of similar results for similar topics, while Tables 8.2-1–3 and 8.3-1–2 shows examples of different results for similar topics.

8.1 Examples of topics with similar results

(1) Cancer (identical topics)

This is an identical topic common to both “life science” and “health.” In the degree of importance, the topic in the “health” field is, at 91, slightly higher than the identical topic in the “life science” field with 76. In the other questionnaire items the trends are quite similar.

(2) ID card (similar topics)

In both the “information” and “communication” fields, the realization time for these topics is forecasted to be 2004–2005, and the degree of importance is also virtually the same. The same is also true for the other questionnaire items.

(3) Electric car (similar topics)

Six similar topics in three fields deal with electric cars. Experts in all three fields indicate realization times for these topics of between 2011 and 2014. In degree of importance, the highest rating was given by experts in the “environment” field, while the lowest was given by experts in “resources.” As for measures the government should adopt in Japan, environmental experts believe “adjust regulations (relax/toughen)” is the most important, but experts in the other fields rate “increase government research funding” the highest, and attach less importance to any adjustment of regulations.

(4) Portable automatic interpreting devices (similar topics)

Four topics in four fields are similar regarding portable automatic interpreting devices. In all four fields the forecasted realization time is roughly the same at between 2010 and 2013. However, considering the topic in the “health” field deals with the widespread use of such devices whereas topics in the other fields talk about their practical use, the forecasted realization times indicated by the health experts are perhaps somewhat optimistic. Among the experts in the four fields, this topic area was given the lowest degree of importance rating by those in the “health” field.

Table 8.1-1 Examples of topics with similar results (identical and similar topics among fields)

Key word	Field	Topic	Degree of importance index	Expected effect (%)				Forecasted realization time	Leading countries (%)			Measures the government should adopt (%)						Potential problems (%)		
				Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources		USA	EU	Japan	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Natural environment	Safety	Morals, culture or society
Cancer	Life science	49 Practical use of effective means to prevent metastasis of cancer.	76	32	1	93	18	2013	84	34	54	76	46	24	19	59	0	1	13	26
	Health	48 Practical use of effective methods against cancer metastasis.	91	22	0	97	11	2013	91	48	49	70	51	19	9	67	2	1	10	19
ID card	Information	08 Widespread use of multipurpose ID card system with wireless communication capability.	66	84	6	83	4	2005	84	30	78	35	26	3	1	18	62	2	55	29
	Communication	16 Widespread use of battery-free wireless cards in automatic train ticket inspection and physical distribution systems.	70	81	4	75	1	2004	70	31	76	31	39	8	0	22	45	2	52	16
Electric vehicles	Resources	81 Widespread use of electric vehicles with driving performance equal to that of gasoline motorcars.	79	57	89	32	2	2013	74	40	83	28	57	11	0	58	37	23	12	4
	Environment	38 Widespread use (e.g., more than 10% in the world) of automobiles as urban transportation system (e.g., electric vehicles) which do not cause air or noise pollution.	86	68	80	51	1	2013	72	45	67	24	55	12	1	45	63	40	13	16
	Transportation	26 Widespread use of electric vehicles that carry a battery capable of powering a vehicle for 200 km after about 15 minutes of rapid charging and are capable of driving patterns necessary to follow actual urban traffic flows.	77	40	96	17	3	2011	78	48	70	33	62	13	0	73	24	35	17	2
	Transportation	27 Widespread use of electric vehicles carrying fuel cells which have high energy conversion efficiencies.	71	32	93	16	3	2014	76	33	58	40	55	13	2	76	16	38	14	1
	Resources	82 Practical use of electric vehicles powered by solar cells and secondary batteries.	65	49	88	22	2	2013	73	35	82	33	53	10	0	57	30	24	12	2
	Resources	83 Practical use of electric vehicles powered by fuel cells and secondary batteries.	66	51	91	20	0	2013	73	36	71	37	53	8	0	59	30	23	18	2

Key word	Field	Topic	Degree of importance index	Expected effect (%)				Forecasted realization time	Leading countries (%)			Measures the government should adopt (%)						Potential problems (%)		
				Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources		USA	EU	Japan	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Natural environment	Safety	Morals, culture or society
Interpreting machines	Information	28 Practical use of portable translation devices (translates simple, common phrases in both directions) using voice input.	63	57	4	86	14	2012	64	18	82	65	41	7	6	39	1	0	3	18
	Electronics	23 Practical use of portable automatic translation systems with a single-chip LSI.	77	84	4	79	5	2013	68	15	82	55	61	16	2	46	1	1	5	15
	Production	27 Practical use of pocket-size voice actuated interpreting machines that enable people to communicate even if they do not speak each other's language.	64	63	5	81	9	2012	48	9	72	57	46	8	2	43	5	0	5	27
	Communication	38 Development of an automatic Japanese-English, English-Japanese speech translation telephone system comparable to human simultaneous interpretation in service quality.	81	73	8	86	10	2012	39	13	84	63	34	10	3	57	2	0	6	34
	Health	89 Widespread use of portable conversational speech interpretation systems.	58	66	2	78	17	2010	64	14	72	50	67	24	0	43	2	0	14	36

8.2 Examples of topics with a recognized difference in forecasted realization time

(1) Power generation using high-temperature rock base (similar topics)

Experts in “marine science” are more optimistic about this technology than are the experts in “resources.” The difference in forecasted realization time is ten years, but if we consider that the topic in “marine science” talks about the widespread use of the technology whereas the topic in “resources” deals with its practical use, the real difference between the two would be considerably more. The degree of importance is assessed to be lower in the “resources” field, where energy experts outnumber resources experts, than in the “marine science” field.

Table 8.2-1 Topics with different results (high-temperature rock base power generation)

Field	Topic	Importance index	Forecasted realization time
Marine science	55 Widespread use of systems for forcing water into high-temperature subterranean locations in order to extract thermal energy in the form of steam.	65	2011
Resources	56 Practical use of hot dry rock power-generating technologies.	50	2021

(2) Artificial muscles (similar topics)

The terms used in the topics are slightly different in artificial muscle material and artificial muscle devices, and forecasts by experts in the “materials” field are earlier than those by experts in “life science” and “health.” The topic in the “production” field deals with robots, not humans, and experts here forecast that actuators resembling human muscles will be developed in 2013. The degree of importance is generally the same across all four fields.

Table 8.2-2 Topics with different results (artificial muscles)

Field	Topic	Importance index	Forecasted realization time
Materials	01 Development of artificial muscle-like material that responds to stimuli reversibly.	51	2012
Life science	55 Development of artificial muscle elements.	57	2019
Health	58 Practical use of artificial muscles for limbs.	47	2020
Production	56 Development of flexible actuators resembling human muscles, which can be applied to small, lightweight robots.	53	2013

(3) Energy conversion (similar topics)

Most experts here are in the biotechnology area, and experts in “life science,” who provide the necessary technology forecast a realization time five years earlier than experts in “production,” who set up and use this technology. The degree of importance is virtually the same.

Table 8.2-3 Topics with different results (energy conversion)

Field	Topic	Importance index	Forecasted realization time
Life science	31 Development of technologies, such as biomotors, using the biological energy conversion mechanisms.	59	2016
Production	58 Development of high energy converting efficiency machines which apply the biological energy converting mechanism.	60	2021

8.3 Examples of topics with a recognized difference in degree of importance

(1) Hydrogen production (similar topics)

This technology is afforded the lowest degree of importance in “resources,” where energy experts form the majority, and is as much as 26 points lower than the corresponding figure in “materials.” The forecasted realization time is quite similar across the three fields at between 2017 and 2021.

Table 8.3-1 Topics with different results (hydrogen production)

Field	Topic	Importance index	Forecasted realization time
Resources	64 Practical use of thermochemical decomposition processes for hydrogen production.	59	2019
Production	55 Practical use of technologies for mass-producing hydrogen by decomposing organic substances through application of solar energy and biological systems.	78	2021
Materials	107 Practical use of processes for water decomposition by the sunlight.	85	2017

(2) Nursing care robots (similar topics)

In “information,” considered to be the field that provides this technology, the degree of importance is quite high at 81, but in “urbanization” and “health,” fields that cover homes and hospitals where the robots will be used, it is only around 60. The forecasted realization times are generally similar at between 2010 and 2014. It is earliest in “information” at 2010, but we believe this can be put down to the fact that the topic in this field deals with the practical use of the technology, whereas in the other two fields the topics talk about its widespread use.

Table 8.3-2 Topics with different results (nursing care robots)

Field	Topic	Importance index	Forecasted realization time
Urbanization	46 Widespread use in Japan of houses equipped with robots and other devices that assist senior citizens and disabled people with everyday tasks, including eating meals, bathing, going to the toilet, and having entertainment, to carry these out without human assistance.	56	2014
Health	90 Widespread use of robots that care for people with severe physical and mental disabilities.	60	2012
Information	54 Practical use of robots which provide medical care support in homes, hospitals, etc.	81	2010

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9. Comparison with forecasted realization time and degree of importance results in the 5th survey

Arranging the 1,072 topics in this survey relative to the topics of the previous survey reveals the following.

i) Topics that have remained unchanged from the previous survey because of their continuing high importance — 380 topics (identical topics)

ii) Topics for which a higher target value has been set or the technological stage has become more advanced (elucidation - development - practical use - widespread use) — 233 topics (revised topics)

iii) New topics — 459 topics (new topics)

Here we shall compare the forecasted realization time and degree of importance for identical and revised topics between the last and the current survey.

9.1 Trends by field

We divided the identical topics into their fields, and calculated the average forecasted realization time and importance index. Table 9.1-1 shows the comparison between this and the previous survey. For this comparison, we excluded topics with a forecasted realization time of after 2026 (after 2021 for the previous survey). Overall, the importance index has dropped by 5.8 points, and the realization time is later by 6.3 years. Considering the five-year gap between surveys, we can say this lag in forecasted realization time is indeed considerable. By field, identical topics in the “production,” “electronics” and “marine science” fields are later by a substantial degree in realization time, and topics in the “space,” “urbanization” and “health” fields have dropped by at least ten points in the importance index.

Table 9.1-1 Comparison with the 5th Survey (identical topics)

Field	Number of topics	Degree of importance index / forecasted realization time		
		This survey	Previous survey	Difference
Materials	51	59.5 / 2012.4	63.8 / 2006.1	-4.3 / 6.3
Electronics	7	65.5 / 2014.2	62.4 / 2005.5	3.1 / 8.7
Information	15	64.9 / 2010.7	66.9 / 2006.8	-2.0 / 3.9
Life science	24	65.8 / 2017.2	72.4 / 2011.6	-6.6 / 5.6
Space	20	52.8 / 2015.2	67.6 / 2009.9	-14.8 / 5.3
Marine science	39	67.5 / 2012.0	69.0 / 2003.9	-1.5 / 8.1
Resources	49	60.7 / 2015.8	67.0 / 2008.4	-6.3 / 7.4
Environment	23	70.8 / 2012.8	77.1 / 2005.3	-6.3 / 7.5
Agriculture etc.	27	63.2 / 2011.5	69.3 / 2007.5	-6.1 / 4.0
Production	20	65.0 / 2014.7	67.3 / 2005.9	-2.3 / 8.8
Urbanization	32	54.9 / 2013.4	67.2 / 2005.9	-12.3 / 7.5
Communication	19	59.3 / 2009.2	60.2 / 2004.6	-0.9 / 4.6
Transportation	21	59.1 / 2010.3	60.3 / 2005.2	-1.2 / 5.1
Health	35	62.5 / 2012.4	73.2 / 2007.5	-10.7 / 4.9
Total identical topics	382	61.9 / 2013.1	67.7 / 2006.8	-5.8 / 6.3

Note: The reason there are 382 topics in the table is that six of the 380 identical topics were surveyed in two fields in the previous survey and here we have compared them separately, and we excluded four topics with a realization time later than 2026.

9.2 Topics with earlier/later forecasted realization times

Of the 382 topics, 38 have roughly the same (within three years) forecasted realization time, 342 topics are least three years later, and two are at least three years earlier. Table 9.2-1 shows the five topics that are later by the largest margin. Of these, three are in the “production and machinery” field, and all three deal with technology aimed at the industrial application of biological functions. The degree of importance of these topics is roughly the same or higher.

Table 9.2-1 Topics later by the largest margin in forecasted realization time

Topic (this survey)	Degree of importance index / forecasted realization time		Topic (previous survey)
	This survey	Previous survey	
(Production and machinery) 53 Development of technology to synthesize protein from carbon dioxide and ammonia, via a bioreactor.	66/2018	73/2003	(Production) 14 Development of technology to synthesize protein from carbon dioxide and ammonia, via a bioreactor.
(Production and machinery) 55 Practical use of technologies for mass-producing hydrogen by decomposing organic substances through application of solar energy and biological systems.	78/2021	74/2006	(Production) 16 Practical use of technologies for mass-producing hydrogen by decomposing organic substances through application of solar energy and biological systems.
(Production and machinery) 54 Practical use of technologies for producing glucide by artificial photosynthesis applying the mechanism of natural photosynthesis.	70/2019	59/2005	(Production) 15 Practical use of technologies for producing glucide by artificial photosynthesis applying the mechanism of natural photosynthesis.
(Urbanization and construction) 71 Elucidation of the impact of living in a super high-rise building (around 1,000 m tall) on human physiology and psychology.	32/2018	44/2005	(Lifestyles and culture) 33 Elucidation of feasibility of living in hyper high-rise buildings (500m to 1,000m) with respect to the physiological and psychological aspects of human being.
(Marine science and earth science) 60 Development of technology capable of forecasting the occurrence of major earthquakes (magnitude 7 or above) several days in advance.	92/2023	94/2010	(Marine science and earth science) 73 Development of technology capable of forecasting the occurrence of major earthquakes (magnitude 7 or above) several days in advance.

The following table shows topics whose forecasted realization time is earlier in this survey, and of these, three are in “agriculture etc.” and two are in “resources and energy.”

Table 9.2-2 Topics earlier in forecasted realization time

Topic (this survey)	Degree of importance index / forecasted realization time		Topic (previous survey)
	This survey	Previous survey	
(Agriculture, forestry and fisheries) 10 Development of prevention systems against crop damage by cold-weather, such as localized climate control, that respond to weather forecasts.	66/2018	75/2009	(Agriculture, forestry and fisheries)15 Development of cold damage prevention systems based on highly accurate medium and log term weather forecasts.
(Health, medical care and welfare) 73 Practical use of gene therapy for genetic disorders.	58/2012	74/2016	(Health, medical care) 84 Practical use of gene therapy for a number of gene disorders.
(Resources and energy) 14 Development of exploration technology capable of estimating the economic feasibility of mineral deposits with virtually no drilling.	61/2017	56/2020	(Mineral and water resources) 13 Development of exploration technology capable of estimating the economic feasibility of mineral deposits with virtually no drilling.
(Materials and processing) 01 Development of artificial muscle-like material that responds to stimuli reversibly.	51/2012	66/2014	(Materials and processing) 15 Development of a material having a flexible function equivalent to that of human muscles.
(Agriculture, forestry and fisheries) 55 Development of production regulation systems as a step toward management of resources and fisheries once it becomes possible to predict the long term (10 to 20 years) changes major fishery resources.	84/2016	81/2018	(Agriculture, forestry and fisheries) 61 Development of production regulation systems as a step toward management of resources and fisheries once it becomes possible to predict the long term (10 to 20 years) changes major fishery resources.
(Agriculture, forestry and fisheries) 51 Practical use of selective fishing methods for catching desired size and species of fish, and of inductive fishing for catching in desirable area through the development of technologies that are able to control the behavior of a shoal of fish.	72/2013	60/2015	(Agriculture, forestry and fisheries) 56 Practical use of selective fishing methods for catching desired size and species of fish, and of inductive fishing for catching in desirable area through the development of technologies that are able to control the behavior of a shoal of fish.
(Information) 26 Development of equipment for automatic preparation of summaries and abstracts of books and other documents (degree of condensation can be adjusted as necessary).	60/2009	60/2010	(Information and electronics) 94 Development of equipment for automatic preparation of summaries and abstracts of books and other documents (degree of condensation can be adjusted as necessary).
(Resources and energy) 20 Practical use of inducing artificial rainmaking in event of drought.	57/2014	57/2015	(Mineral and water resources) 20 Practical use of inducing artificial rainmaking in event of drought.

Among the revised topics, the following table gives some examples of those that have advanced in the technological development stage, e.g. from development to practical use, but have not shown any substantial delay in forecasted realization time.

Table 9.2-3 Topics with a more advanced technological development stage but without a significant delay in forecasted realization time

Topic (this survey)	Degree of importance index / forecasted realization time		Topic (previous survey)
	This survey	Previous survey	
(Health, medical care and welfare) 43 Widespread use of gene therapy for familial hypercholesterolemia.	54/2014	65/2011	(Health, medical care) 54 Development of gene therapy for familial hypercholesterolemia.
(Communication) 41 Widespread use of binocular stereoscopic TV broadcasts that can be enjoyed at home.	39/2011	49/2008	(Communication) 64 Practical use of stereoscopic broadcasting based on development of displays for stereoscopic home television, witch can be viewed without glasses.
(Information) 09 Widespread use of sound field shielding technology capable of isolating a specific spatial area from the surrounding noise.	52/2009	54/2006	(Information and electronics) 79 Practical use of sound field shielding technology capable of isolating a specific spatial area from the surrounding noise.
(Information) 21 Widespread use of computer networks in which a virtual space can be shared in real time by a large number of unspecified, geographically dispersed persons.	60/2008	51/2005	(Information and electronics) 88 Practical use of computer networks in which a virtual space can be shared by a large number of unspecified, geographically dispersed persons.
(Resources and energy) 74 Widespread use of high energy density (200 Wh/kg: 5 times the energy density of a conventional lead acid battery) secondary batteries (Ni-MH, Li, etc.).	71/2010	70/2007	(Energy) 40 Practical use of high energy density (200 Wh/kg: 5 times the energy density of a conventional lead acid battery) secondary batteries (Ni-MH, Li, etc.).

9.3 Topics with a significant change in degree of importance

Of the 382 topics, 266 have generally the same importance index (difference of ± 10 points), 106 topics have a lower index by at least 10 points, and ten have a higher index by at least 10 points. Table 9.3-1 shows the five topics with the largest drop in importance index. Two are in the “space” field, and it should also be noted that the degree of importance of topics connected with the global environment, such as the prevention of desertification and management of tropical rain forests, has dropped.

Table 9.3-1 Topics with a considerably lower degree of importance index

Topic (this survey)	Degree of importance index / forecasted realization time		Topic (previous survey)
	This survey	Previous survey	
(Materials and processing) 23 Practical use of devices that enable X-ray structural analysis of supramolecular-biopolymer crystals in real time.	49/2011	81/2006	(Particles) 39 Practical use of equipment capable of realtime X-ray structure analysis for large bio-macromolecular crystals, including the collection and analysis of diffraction data.
(Space) 50 Practical use in Japan of isotope batteries for probing deep space.	44/2011	75/2004	(Space) 26 Practical use of isotope batteries for probing deep space.
(Life science) 92 Practical application of breeding techniques for plants resistant to dry and saline conditions aimed at desertification prevention.	61/2014	92/2009	(Life science) 94 Practical use of (breeding methods to produce) plants with drought and salt tolerance at a high degree to stop the spread of desert environment.
(Space) 31 Development of high-pressure (1 atmosphere), flexible space suit for use outside of a spaceship.	46/2009	76/2006	(Space) 42 Development of high-pressure, flexible space suit for use outside of a spaceship.

Topic (this survey)	Degree of importance index / forecasted realization time		Topic (previous survey)
	This survey	Previous survey	
(Agriculture, forestry and fisheries) 80 Practical use of technologies for efficient management and use of tropical forest and the organisms living there through elucidation of the mechanisms of structure and functions of forest ecosystems in tropical regions.	55/2016	83/2014	(Agriculture, forestry and fisheries) 73 Practical use of technologies for efficient management and use of tropical forest and the organisms living there through elucidation of the mechanisms of structure and functions of forest ecosystems in tropical regions.

The following table shows some of the topics with a higher degree of importance index in this survey.

Table 9.3-2 Topics with a considerably higher degree of importance index

Topic (this survey)	Degree of importance index / forecasted realization time		Topic (previous survey)
	This survey	Previous survey	
(Marine science and earth science) 01 Practical use of Tsunami forecasting systems based on tide and Tsunami observation through satellites and on other data including shelf topography.	91/2007	71/2001	(Marine science and earth science) 01 Practical use of Tsunami forecasting systems based on tide and Tsunami observation through satellites and on other data including shelf topography.
(Materials and processing) 20 Practical use of rechargeable polymer batteries having a volume-specific capacity of 400 Wh/liter. (Capacity of current Ni-Cd batteries: 180 Wh/liter)	82/2011	63/2008	(Materials and processing) 36 Practical use of rechargeable polymer batteries having a volume-specific capacity of 400 Wh/liter. (Capacity of current Ni-Cd batteries: 180 Wh/liter)
(Transportation) 55 Practical use of floating off-shore airports.	78/2009	62/2008	(Transportation) 53 Practical use of floating off-shore airports.
(Environment) 29 Development of low-noise engines and tires, and sound-absorbing construction materials, leading to the reduction of automobile noise within the environmental standard for the area specified to be for resident.	76/2011	61/2006	(Environment) 37 Development of low-noise engines and tires, and sound-absorbing construction materials, reducing automobile noise within the environmental standard for the area specified to be for resident.
(Agriculture, forestry and fisheries) 51 Practical use of selective fishing methods for catching desired size and species of fish, and of inductive fishing for catching in desirable area through the development of technologies that are able to control the behavior of a shoal of fish.	72/2013	59/2015	(Agriculture, forestry and fisheries) 56 Practical use of selective fishing methods for catching desired size and species of fish, and of inductive fishing for catching in desirable area through the development of technologies that are able to control the behavior of a shoal of fish.

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10. Assessment and analysis of the results of the 1st and 2nd surveys

10.1 Purpose

The significance of technology forecasts is that, through their assessment and analysis of realization time and importance of various topics, they give an indication of the direction and objectives of research and development, and this in turn provides the foundations for the promotion and development of science and technology. To make the technology forecast survey more effective, we have to incorporate certain assessments and analyses from past surveys into the examinations of current and future surveys. All technology forecast surveys have focused on the period from the present to 30 years in the future. Already 26 and 21 years have passed since the first (1971) and second (1976) surveys were carried out, so it is now possible to assess whether the topics forecasted in those two surveys have been realized or not. An assessment of the results of the first survey was carried out when the fifth survey was done in 1992, and this is contained at Appendix 1 of NISTEP Report No. 25, *The Fifth Technology Forecast Survey, Future Technology in Japan*; but it is now five years later and we believe it is important to reassess those results in the light of developments that have taken place since then.

10.2 Assessment method

We distributed all topics from the first and second surveys to the different subcommittees according to topic content, and asked them to determine the state of realization for each. The subcommittees examined their allocated topics, and divided them into one of the following three realization classifications.

Realized	: Realized by 1996
Partially realized	: A part of the topic had been realized by 1996
Unrealized	: Neither of the above

Based on this, the subcommittees then calculated the following for analysis.

Realization rate	: Percentage of “realized” topics to the total number of topics
Realization rate including partially realized topics	: Percentage of “realized” and “partially realized” topics to the total number of topics
Unrealized rate	: Percentage of “unrealized” topics to the total number of topics

“Partially realized” is defined as follows.

- Cases where a single topic contains two or more aspects, and while one or more aspects have been realized, there remains at least one aspect that has not been realized.
- Cases where an expression (including adjectives describing performance) in the topic is not quantitatively defined, and its realization is open to interpretation.
- Cases where a part of the requirement described in the topic has been realized.

In this assessment and analysis we looked at topics whose forecasted realization time was 1996 (the year of the assessment) or earlier, and topics whose forecasted realization time was 1997 or later but which had already been realized (including partially realized topics).

Table 10.2-1 Classification of all topics and assessed topics in the first technology forecast survey by division and field

Division/Field	Set topics	Assessed topics
Social development — total	136	130
Improvement of clothing standards	22	20
Improvement of housing standards	19	18
Leisure	20	20
National land and urban development	19	17
Improvement of traffic and transportation	21	20
Prevention of pollution	20	20
Improving education	15	15
Information — total	111	105
Socioeconomic demands	41	40
Information technology	52	47
Basic technology	18	18
Health and medical care — total	103	83
Progress of medical diagnosis and treatment	50	37
Development of preventive medicine	9	9
Development of the medical care system	12	12
Elucidation of life phenomena	12	9
Humans and the environment	10	10
Medical education	6	5
Others	4	1
Food and agriculture — total	100	96
Development of food material	31	30
Systems development	33	33
Development of control methods	21	20
Machinery development	15	13
Industry and resources — total	194	174
Space development	29	23
Marine development	29	25
Energy development	31	24
Resources development	30	27
Increasing mining production	38	38
Material development	37	37
Total	644	588

Table 10.2-2 Classification of all topics and assessed topics in the second technology forecast survey by field

Field	Set topics	Assessed topics
Food resources	70	69
Forest resources	14	11
Mineral resources	24	19
Water resources	9	8
Energy	33	21
Environment	48	47
Safety	22	18
Family life	33	29
Leisure	11	10
Education	25	24
Health and medical care	58	41
Labor	10	10
Transportation	27	20
Information	60	53
Construction	29	20
Industrial production	59	54
Space development	32	18
Marine development	35	28
Life science	27	22
Software science	30	27
Total	656	549

10.3 Analysis of realization rate

10.3.1 First survey

Of the assessed topics in the first survey, 151 are “realized,” 225 “partially realized” and 212 “unrealized,” resulting in a realization rate, realization rate including partially realized topics, and unrealized rate of 26%, 64% and 36% respectively.

By division, information has the highest realization rate, followed by food and agriculture, industry and resources, health and medical care, and social development. The realization rate including partially realized topics is highest in health and medical care, followed by food and agriculture, information, industry and resources, and social development.

Table 10.3-1 Realization rate of assessed topics in the first technology forecast survey

Division	Field	Assessed topics	Realized	Partially realized	Unrealized	Realization rate (%)	Realization rate including partially realized topics (%)	Unrealized rate (%)
Social development	Improvement of clothing standards	20	6	9	5	30	75	25
	Improvement of housing standards	18	3	5	10	17	44	56
	Leisure	20	5	6	9	25	55	45
	National land and urban development	17	0	11	6	0	65	35
	Improvement of traffic and transportation	20	2	3	15	10	25	75
	Prevention of pollution	20	2	10	8	10	60	40
	Improving education	15	2	6	7	13	53	47
	Subtotal	130	20	50	60	15	54	46
Information	Socioeconomic demands	40	8	20	12	20	70	30
	Information technology	47	19	10	18	40	62	38
	Basic technology	18	9	2	7	50	61	39
	Subtotal	105	36	32	37	34	65	35
Health and medical care	Progress of medical diagnosis and treatment	37	9	20	8	24	78	22
	Development of preventive medicine	9	1	4	4	11	56	44
	Development of the medical care system	12	3	9	0	25	100	0
	Elucidation of life phenomena	9	1	8	0	11	100	0
	Humans and the environment	10	1	7	2	10	80	20
	Medical education	5	0	4	1	0	80	20
	Others	1	1	0	0	100	100	0
	Subtotal	83	16	52	15	19	82	18
Food and agriculture	Development of food material	30	10	11	9	33	70	30
	Systems development	33	8	19	6	24	82	18
	Development of control methods	20	6	12	2	30	90	10
	Machinery development	13	4	4	5	31	62	38
	Subtotal	96	28	46	22	29	77	23
Industry and resources	Space development	23	8	5	10	35	57	43
	Marine development	25	6	10	9	24	64	36
	Energy development	24	3	3	18	13	25	75
	Resources development	27	3	6	18	11	33	67
	Increasing mining production	38	13	10	15	34	61	39
	Material development	37	18	11	8	49	78	22
	Subtotal	174	51	45	78	29	55	45
Total		588	151	225	212	26	64	36

10.3.2 Second survey

Of the assessed topics in the second survey, 114 are “realized,” 232 “partially realized” and 203 “unrealized,” resulting in a realization rate, realization rate including partially realized topics, and unrealized rate of 21%, 63% and 37% respectively.

Fields with a high realization rate are space development, information, industrial production, family life, and food resources, while those with a low realization rate are water resources, software science, transportation, environment, and forest resources. The realization rate including partially realized topics is high in space development and health and medical care, and low in software science and energy.

Table 10.3-2 Realization rate of assessed topics in the second technology forecast survey

Field	Assessed topics	Realized	Partially realized	Unrealized	Realization rate (%)	Realization rate including partially realized topics (%)	Unrealized rate (%)
Food resources	69	18	32	19	26	72	28
Forest resources	11	1	7	3	9	73	27
Mineral resources	19	3	8	8	16	58	42
Water resources	8	0	3	5	0	38	63
Energy	21	3	2	16	14	24	76
Environment	47	3	23	21	6	55	45
Safety	18	3	10	5	17	72	28
Family life	29	8	9	12	28	59	41
Leisure	10	1	3	6	10	40	60
Education	24	3	12	9	13	63	38
Health and medical care	41	7	27	7	17	83	17
Labor	10	2	5	3	20	70	30
Transportation	20	1	7	12	5	40	60
Information	53	22	12	19	42	64	36
Construction	20	3	11	6	15	70	30
Industrial production	54	16	21	17	30	69	31
Space development	18	8	9	1	44	94	6
Marine development	28	6	14	8	21	71	29
Life science	22	5	12	5	23	77	23
Software science	27	1	5	21	4	22	78
Total	549	114	232	203	21	63	37

10.4 Relationship between degree of importance and realization rate

While there is little difference between topics with a high degree and those with a low degree of importance in the realization rate, there is a significant difference in the realization rate including partially realized topics, with the more important topics showing a much higher rate. Among topics with a degree of importance index of 50 or more (calculated according to the formula described under v) of Section 4. “Reading the survey results” of Chapter 1), there is no major difference, and for topics with a low degree of importance, the realization rate including partially realized topics is quite low indeed.

Table 10.4-1 Degree of importance and realization rate

Degree of importance index	Number of topics		Realization rate (%)		Realization rate including partially realized topics (%)		Unrealized rate (%)	
	First survey	Second survey	First survey	Second survey	First survey	Second survey	First survey	Second survey
More than 90	100	65	24	18	78	63	22	37
90 - 80	120	100	25	16	59	58	41	42
80 - 70	45	83	11	23	56	57	44	42
70 - 60	98	124	26	22	61	61	39	39
60 - 50	172	144	28	15	59	49	41	51
50 - 40	59	74	19	14	42	43	58	57
Less than 40	50	66	16	14	32	33	68	67

Note: Covers all set topics.

10.5 Forecasted realization time and realization rate

Here we classified the topics by forecasted realization time, and calculated the realization rate for each time classification. In both the first and second surveys, the earlier the topic forecasted realization time, the higher the realization rate and the realization rate including partially realized topics. Moreover, topics that recorded a high percentage of "will not be realized" responses have an extremely high unrealized rate.

Table 10.5-1 Forecasted realization time and realization rate (first survey)

Forecasted realization time	Number of topics	Realization rate (%)	Realization rate including partially realized topics (%)	Unrealized rate (%)
- 1980	29	45	86	14
1981 - 1985	212	37	76	24
1986 - 1990	244	20	59	41
1991 - 1995	75	9	35	65
1996 - 2000	47	9	26	74
2001 -	37	3	22	78
Unrealized *	72	3	19	81

* Topics with a "will not be realized" response rate of 30% or more

Note: Covers all set topics.

Table 10.5-2 Forecasted realization time and realization rate (second survey)

Forecasted realization time	Number of topics	Realization rate (%)	Realization rate including partially realized topics (%)	Unrealized rate (%)
- 1985	15	40	87	13
1986 - 1990	217	28	71	29
1991 - 1995	239	16	54	46
1996 - 2000	130	7	30	70
2001 - 2005	42	2	21	79
2006 -	13	0	8	92
Unrealized *	20	0	10	90

* Topics with a "will not be realized" response rate of 30% or more

Note: Covers all set topics.

10.6 Unrealized topics

The range of reasons that topics have not been realized is indeed broad, and it is by no means a simple task to narrow this range down to a representative few, but the subcommittees have decided on the five general reasons of technological problem, social problem, insufficient need, cost problem, and emergence of alternative technologies. Technological problems is by far the main factor in why topics have not been realized, followed by cost problems, social problems, and insufficient need. This pattern is common to both surveys. In this section, we shall examine the "energy" and "traffic and transportation" fields, where the realization rate is low, the "information" field, where the private sector plays a leading role in technological development, and the "space" field, which is for all intents and purposes a national program.

10.6.1 Energy

In both the first and second surveys, the realization rate for energy was low. Many topics in this field were forecasted to be realized after 1997: seven of 31 topics in the first survey and 13 of 33 topics in the second survey.

The main reason topics in the first survey have not yet been realized is technological problem (realization of superconductive power transmission), but insufficient need (practical use of portable microcapsulated liquid fuel) is also an important factor.

In the second survey, technological problem (practical use of hydrogen systems (including fuel cells) in certain regions), cost problem (practical use of coal liquefaction technology) and social problem (practical use of nuclear cells with an output of 1kW and a service life of at least ten years, and their application in remote areas and oceans) are all at about the same level. Many of the topics for which cost problem is a key factor deal with alternative fuel technologies. The reason many of the topics contain reference to alternative fuels is thought to be that the survey was taken soon after the oil crisis, but because the skyrocketing oil prices later settled down, cost became an important factor that hindered the technology's realization. Many of the topics in which social problem is a key factor are connected with nuclear power. The second survey was conducted in a climate in which reducing the dependence on petroleum for energy was an urgent matter, so it has many more topics dealing with the diversification of energy resources than the first survey.

10.6.2 Traffic and transportation

In the first survey, many of the topics have not been realized because of a technological problem (practical use of a fully automatic system for controlling train speed, starting and stopping, and response in an emergency through the adoption of a stopping system in trains) and a cost problem (practical use of nonpolluting community cars (small and safe personal transportation vehicles)).

In the second survey, the main reasons that topics have not been realized are technological problem (widespread use of electric cars for transportation within cities) and cost problem (practical use of high-speed passenger transportation networks, such as large hovercraft and large hydrofoil craft for long-distance coastal transportation). In both surveys, a characteristic of this field is that the cost problem is much more of a factor in the non-realization of topics than in other fields.

10.6.3 Information

In the first survey the reason for unrealized topics is overwhelmingly technological problem (development of chemical calculation devices suitable for mass information processing), followed by social problem (most judgement work, such as the granting of permits and licenses, will be standardized and computerized) and emergence of alternative technologies (practical use of highly sensitive (same or higher than film) optical memory devices that can be erased and reused freely).

In the second survey, the main reasons are technological problem (practical use of random access memory using laser holography) and social problem (practical use of systems that allow an individual to search through various public statistical data banks easily and at any time). In the second survey there are more topics that are unrealized because of social problems than in the first survey.

10.6.4 Space

The space field has a comparatively high realization rate, and programs in it are more often than not carried out as a form of national policy.

In the first survey, the main reasons for unrealized topics are technological problem (probe of the moon's surface in a manned spacecraft), cost problem (realization of manned flights into outer space), and social problem (realization of the disposal of radioactive waste in space).

In the second survey, only one topic has not been realized because of insufficient need (launch of a large-scale stationary scientific satellite to observe the earth and surrounding space); all other topics have been realized, including those partially realized.

10.7 Topics realized early

The first and second survey topics listed in the following table were realized early.

Table 10.7-1 Topics realized early (first survey)

Topics	Importance index	Forecasted realization year
102047: Development of technology that can detect smells and tastes (kind, concentration, etc.)	47	1997
104003: Realization of useful animals and plants (excluding microorganisms) through cell fusion or cell nucleus fusion	50	1997
103080: Elucidation of the mechanism by which tissue antigens can be synthesized based on genetic type	55	1997
103035: Possibility of external fertilization, ectogenesis, or artificial womb;	30	2001 or later

Table 10.7-2 Topics realized early (second survey)

Topics	Importance index	Forecasted realization year
214053: Possibility to a certain degree of working at home through the use of TV-telephones, telefaxes, etc.	31	1998
201002: Practical use of biomolecular methods for improving the shape and quality of useful plants (excluding microorganisms)	57	1998
214030: Development of technologies that translate foreign documents (English)	62	1999
217009: Acquisition of observation data from unmanned probes around Uranus, Neptune, Pluto and outside the solar system	32	1999
203016: Development of optical communication technology that can realize substantial savings in the use of copper and aluminum	60	1999
202001: Development of improved major tree varieties that display excellent disease-, insect- and weather-resistant characteristics	72	2000
205015: Development of high-temperature rock power-generating systems in which heat energy is drawn out artificially from high-temperature rock base for power generation	53	2000
201003: Development of useful animals and plants (excluding microorganisms) through cell fusion or cell nucleus fusion	49	2001

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1. Survey results in "Materials and processing"

1.1. Trends in noteworthy domains

In the fifth technology forecast survey we identified four domains expected to draw attention in this field: 1) Structural control and computer simulation at the atomic/molecular level; 2) interface control and function manifestation; 3) state-of-the-art materials and compounding and hybrid design; and 4) chemical processes. For this survey we have identified the following four items.

1) Precision synthesis and structural control through the manipulation of atoms and molecules

2) Incorporation of high-level computer science into materials and processing design

3) Elucidation of biofunctions and their incorporation into the development of highly functional materials and processes

4) Development of materials and processes connected with global problems

Since precision synthesis at the atomic/molecular level has at last come into a realistic field of vision, we have positioned it as the most important theme. And accompanying steady advances in computer science are growing expectations about the simulation of material functions, and elucidation of catalytic action, biofunctions and solid state functions and operations. So in recognition of their importance, we have separated them into two distinct items. At the same time, advances have been seen in the elucidation of biofunctions, so the biomimetic approach has become a concrete theme. We have taken up these as noteworthy domains with the understanding that the materials and processing field has a vital role to play in the increasingly urgent issues of the global environment, resources and energy.

1.1.1. Precision synthesis and structural control through the manipulation of atoms and molecules

The concept of controlling the structure of materials at the atomic/molecular level has been rapidly taking shape since it was highlighted as the most important issue in advanced materials in the 21st century in a briefing at the CHEMRAWN VI world conference of the International Union of Pure and Applied Chemistry (IUPAC) at Tokyo in 1987, and has been taken up in recent years as the basis of numerous national projects.

Especially since silicon devices are not able to increase their degree of integration above present levels because of optical wave length limits, a breakthrough in a new and different concept became necessary. From this, attempts were started on the development of new devices operated at the atomic/molecular level. One is the quantum functional device that uses the quantum effect of the super lattice, started as a ten-year project by the Ministry of International Trade and Industry (MITI) in 1991. The following year saw the start of the atom technology project, aimed at the ultimate device. This was an attempt to develop ultimate electronic devices through the development of technology for self-organization and reciprocal control that manipulates single atoms and single molecules and creates nano-scale structures collectively while recognizing chemical species. These days we are now able to manipulate this kind of atom/molecule through advances in tunneling microscopes, and the possibility of molecular devices is growing rapidly. Topics 75, 76 and 81 tackle this kind of development.

Research into precision high polymer began in 1994, and from 1996 an industrial and academic research structure began to take shape as a major pioneering research project into highly functional materials by MITI. This research is aimed at developing new high-performance polymer material through the rigid control of the primary structure of polymer at the atomic/molecular level, and the higher order structure, and through this, drawing out new functions. Topics 29–32 deal with precision polymer. Achieving the precision control of high polymer structures would boost the possibility of high-polymer superconductors and organic ferromagnetic substances, and with this in mind, we devised topics 14, 15 and 18. Moreover, if the supra-molecular structure of high polymers can be controlled, it will open the door to the subtle functions seen in organisms, such as self-organization and physiological activity. Precision control at the atomic/molecular level is also an important theme in ceramics and metals, so in this light, we set topics 40, 45, 46 and 60 dealing with the control of mezo- and nano-structures. Elucidation at the atomic and molecular level is also necessary for the development of post-silicon devices, such as diamond and cubic boron nitride devices. As for precision control of composite materials, we devised topics 90, 92 and 94 dealing with control of nano-structure. Topics 98–103 also deal with precision control. In synthetic chemistry, advances are being made in the elucidation of reaction points at the molecular level, and coupled with the elucidation of the nature of catalysts, this is bringing the atomic/molecular control of highly selective solid catalysts, molecular catalysts, etc. into the realm of possibility. Topics 24–28 were set against such a backdrop.

1.1.2. Incorporation of high-level computer science into materials and processing design

Advances in computer science make various kinds of simulation possible. By calculating the first-principle electron condition, we can elucidate the behavior and function of atoms and molecules, determine stable structures in atomic and molecular groups, and understand the characteristics of electrons. This enables us to understand the behavior of atoms and molecules in dynamic phenomena such as crystallization and chemical reaction through molecular dynamics simulation and Monte Carlo simulation. The powerful computer systems required for such large figure calculations are being realized, but we need more efficient computer methods that go beyond the Car-Parinello method and parallel computing technology. This theme is raised in topics 73 and 97.

Computer technology has come to play a vital role in the development of various materials, chemical processes and biotechnology. In material design, advances have been seen in the finite element method and various kinds of computer simulation. Progress has also been seen in the compilation of a S&T materials database, and in computer-aided material design and process design support systems. Topics 95 and 96 are related to this theme. Advancement in computer chemistry has made the design of molecular structures and the low molecular substances that act on those molecules possible, rationalizing to a significant degree the screening of drugs and agricultural chemicals. Combinatorial chemistry is a new technology that has grown around peptide synthesizing technology using the solid-phase method, and is an efficient screening system (high through-put screening system: HTS) in which tens to tens of thousands of compounds are synthesized at once through the combining of various blocks of chemical synthesizing processes under the principle of permutations and combinations. Moreover, it is being automated through robot technology, facilitating the development of a drug producing system with a high processing capability.

1.1.3. Elucidation of biofunctions and their incorporation into the development of highly functional materials and processes

Synthetic chemistry has delivered to the marketplace a diverse range of synthetic compounds that do not appear in nature, such as various kinds of plastics, synthetic fibers, and synthetic rubber. These synthetic products are still very much in the infant stages compared to the subtle mechanisms of living bodies. Conversely though, by learning the mechanisms of living organisms we may develop highly functional materials and synthesizing processes. But our insufficient understanding of biofunctions has made the realization of such advanced synthesizing technology extremely difficult. Recently though there have been major advances in the biomimetic approach, and we are beginning to see an opening for the skilled incorporation of the subtle mechanisms of living organisms. Expectations in this area can be seen in topics in the biotechnology domain, including “01: Muscle-like material,” “02: Artificial organs,” “03: Protein synthesizing,” “04: Materials that promote development of biological tissues,” “05: Missile drugs” and “06: Membranes similar to those in living bodies;” in the organic polymer domain, including “21: Self-healing polymers” and “22: Control of protein aggregates;” in ceramics, including “40: Self-organizing materials” and “42: Self-repairing turbines;” and in electronics and composite materials, including “71: Materials that incorporate sensor functions,” “72: Nerve function of transmitting information,” “91: Materials with self-diagnosis and self-repairing functions” and “92: Organic hybrid materials.” Meanwhile, human genome analysis projects have been moving ahead, and with this, information about human genes is beginning to accumulate rapidly, enabling researchers to steadily identify genes associated with specific diseases. Technology to elucidate the functions of genes that have to date been unknown has also been developed. So if researchers can specify the genes to be targeted by drugs, they will be able to highlight those genes and develop new bioassay systems for them.

1.1.4. Development of materials and processes connected with global problems

It has already been a quarter century since the Rome Club pointed out in 1972 the finite nature of the earth, and warned that the population explosion and the economic expansion of developed countries could plunge the world into a serious crisis. Unable to put the brakes on the exploding population and the massive expansion of economic consumption, we have seen over these past 25 years the irreversible emergence of various global-level problems. To tackle resource, energy and environmental issues, a range of chemical processes is necessary, as are various kinds of high-performance and highly functional materials. Put in another way, resolving various global problems is highly dependent on materials and chemical processes. There is growing support for mandatory recycling of resources to make their use more effective and ease some of the load on the environment, but discarding used goods and materials has always been the cheaper option. Recovering resources seeks to reduce the growing entropy from the laws of thermodynamics, so it requires more energy, and naturally it costs more. That is, we must understand that from an economics viewpoint, recycling generates a negative added value.

In the materials and processing technology forecasts, the development of energy materials has traditionally been one of the major topics, but topics dealing with ways of resolving various global problems have increased considerably. This has gone hand in hand with a much greater recognition of the importance of this theme compared to other themes. As well as topics 84 and 85 dealing with solar cells, we set numerous topics that covered energy, such as “107: Generation of hydrogen through water decomposition by sunlight” and “59: Hydrogen cars,” and global environmental issues, such as “33: Biodegradable plastics,” “34: Plastic recycling,” “35: Waste disposal,” “36: Biomass,” “108: Carbon dioxide fixation” and “109: Desert afforestation.” This theme accounted for 10% of all topics.

One point that has to be examined in relation to global environmental problems is the biodegradability of synthetic polymers. Various kinds of synthetic polymers, especially the plastics we use today, are produced as a part of the petrochemical processes, so they are not biodegradable and are therefore causing a major problem in the global environment. The world’s oil reserves are finite, so it is important to develop processes by which environment-friendly general-purpose polymers can be produced from non-oil resources. The general line of thinking is that precision polymerization technology developed through a biomimetic route would be useful for this. Moreover, we are reaching the stage where we can develop new microorganisms and enzymes that can break down synthetic compounds that do not exist in the natural world through technology that accelerates the evolutionary process. The development of chemical processes that generate less waste and use less energy in industrial production is attainable, and it is believed that we will begin to see advances in such evolutionary molecular engineering technology from now on.

In conclusion, in many cases the forecasted realization times for topics in this survey are five years or more later than those for corresponding topics in the fifth survey. This signifies that as research becomes more tangible, respondents are coming to the understanding that realization of the various topics in the domains highlighted above is much more difficult than originally thought, and also indicates just how hard reading the future of developmental research in materials and processing technology can be. The sudden realization of a ceramics superconductor in the previous survey is a good example of this. Technological development, however, forges its own path, and by following the locus formed by a series of developments, we should be able to make a more accurate forecast of realization times. In the light of the above trends, the topics in the highlighted domains will be realized between 2010 and 2030. These technologies include advanced materials, molecular devices, biotechnology and chemical processes revolving around developments at the atomic/molecular level, and technological developments connected with new energy and global environmental issues. It is forecast that we will see almost a simultaneous blossoming of these technological innovations, peaking around 2030. But we are approaching a fairly critical period, and there is some concern about whether these technologies will be realized in time to resolve the various global issues we are facing.

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1.2. Forecast topic framework

In the course of compiling forecast topics, a framework representing the organization of technologies in tabulated matrix form was drawn up for each field, with objectives and technological domains defining the rows and columns of the table, respectively. The framework is designed to present an overall picture of technological development in each field in terms of future prospects, importance, etc. as seen from the present perspective, and is also used as a working framework for future reviews of forecast topics.

Table 1.2-1 Forecast Topic Framework for Materials and Processing Field

Domain / Objective	Biological	Organic and high polymer	Ceramic	Metal	Semiconductor and electronics	Composite	Other
High performance		11 12	37 38 39	51 52		88 89 90	
Functionality	01 02 03 04 05 06	13 14 15 16 17 18 19 20 21 22	40 41 42 43 44	53 54	61 62 63 64 65 66 67 68 69 70 71 72	91 92	
Analysis, measurement and simulation	07	23	45	55	73 74 75 76		95 96 97 98 99 100 101 102 103 104
Chemical processes	08	24 25 26 27 28 29 30 31 32	46 47 48	56 57 58	77 78 79 80 81 82 83	93 94	105 106
Global-scale problems, environment, resources and energy	09	33 34 35 36		59	84 85		107 108 109
Processing methods, devices and systems	10		49 50	60	86 87		

* Figures appearing in the table represent topic numbers.

1.3. Topics with high degree of importance

Degree of importance index scores (Note 1) averaged at 58.1 for topics in the materials and processing field as a whole. Topics considered of particular importance to Japan (top 20 topics in terms of degree of importance index score) are listed in the table below. Notably, as many as 8 topic featuring in the top 20 related to the environment.

Table 1.3-1 Top 20 Topics in Terms of Degree of Importance Index

Topic	Degree of importance index	Forecasted realization time (year)
84 Practical use of multi-layer solar cells with a conversion efficiency of more than 50%.	91	2016
85 Practical use of large-area amorphous silicon solar cells with a conversion efficiency of more than 20%.	91	2011
34 Establishment and practical use of plastic recycling technology.	91	2007
62 Development of memory capacity of 1 terabit per chip.	86	2013
107 Practical use of processes for water decomposition by the sunlight.	85	2017
108 Practical use of carbon dioxide fixation technology necessary for protecting global environments.	84	2016
44 Development of superconductive materials with a transition temperature around room temperature.	83	2020

Topic	Degree of importance index	Forecasted realization time (year)
20 <u>Practical use</u> of <u>rechargeable polymer batteries</u> having a volume-specific capacity of 400 Wh/liter. (Capacity of current Ni-Cd batteries: 180 Wh/liter)	82	2011
05 <u>Widespread use</u> of signal-responsive missile drugs capable of efficiently reaching targeted parts such as tumor cells.	81	2011
33 Biodegradable plastics will <u>account for 10%</u> of all plastics.	76	2009
35 <u>Practical use</u> of composite systems capable of garbage disposal based on the high-temperature methane fermentation technology and of waste combustion disposal.	76	2008
82 <u>Development</u> of innovative single crystal silicon manufacturing technology.	75	2011
41 <u>Construction</u> of large-scale structures (bridges, high-rise buildings, etc.) using concrete (cement and fibers, steel bars, etc.) whose strength deterioration is predictable.	75	2009
49 <u>Widespread use</u> of industrial electric machines which employ superconductive materials having a critical temperature of <u>liquid nitrogen (77 K) or more</u>.	72	2014
59 Production of automobiles powered by hydrogen fuel stored in hydrogen-occlusive alloys <u>exceeds 10%</u> of the total automobile production.	70	2017
25 <u>Development</u> of selective catalytic cracking technology for naphtha.	70	2010
65 <u>Practical use</u> of semiconductor UV lasers.	66	2010
55 <u>Development</u> of diagnostic technologies, which enable in-situ estimation of <u>remaining life</u> of metallic materials structures and components depending on service conditions, by non-destructive inspection for fatigue.	65	2010
72 <u>Elucidation</u> of the information transmission structure of sensory nerves.	65	2015
22 <u>Development</u> of technology which create the desired functions through the <u>complete</u> control of two- and three-dimensional structures of protein complex.	64	2018

Note 1: Degree of importance index = (number of “high” responses × 100 + number of “medium” responses × 50 + number of “low” responses × 25 + number of “unnecessary” responses × 0) ÷ total number of degree of importance responses

1.4. Forecasted realization times

Forecasted realization times were distributed as shown in the diagram below.

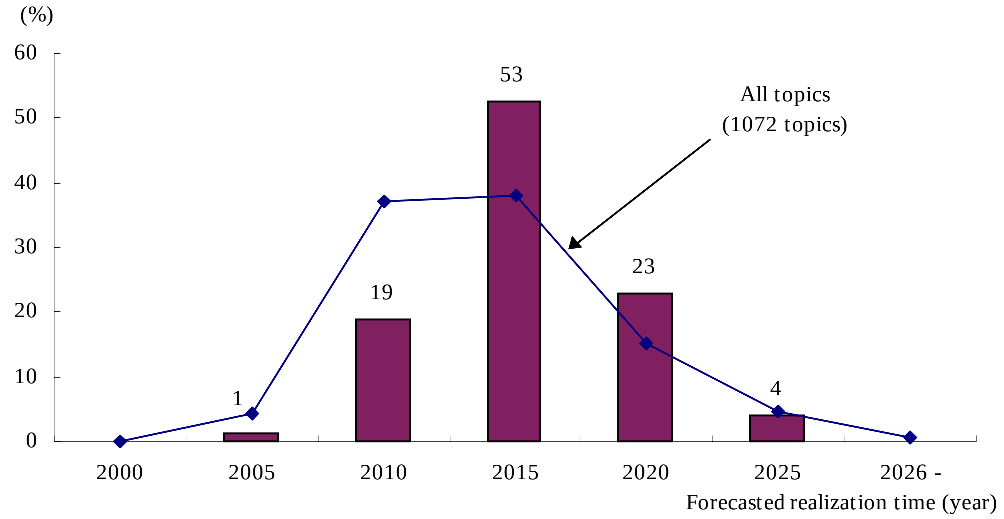


Fig. 1.4-1 Trends in Forecasted Realization Times

With more than half the topics in the materials and processing field forecasted to be realized between 2011 and 2015 and none before 2005 or after 2021, the distribution of forecasted realization times exhibited a sharper peak than the general trend covering all the topics included in the latest survey. The earliest forecasted realization time was 2007, which was given to the following 3 topics: 07. Practical use of non-invasive monitoring of blood components, 26. Development of mass-synthesizing technology for fullerene carbon compounds and 34. Establishment and practical use of plastic recycling technology. The latest forecasted realization time was 2020, which was given to the following two topics: 44. Development of room temperature superconductors and 106. Development of technology to produce materials of a condition in which single-lattice bonding is fused ($sp^{2.5}$, etc.).

1.5. Current leading countries etc.

Responses to the question concerning current leading countries etc. were as shown in the diagram below. Named by 72.6% of the respondents, the U.S. ranked No. 1 in the materials and processing field as a whole, followed by Japan (63.7%) and the EU (24.9%), with virtually no other country or region chosen.

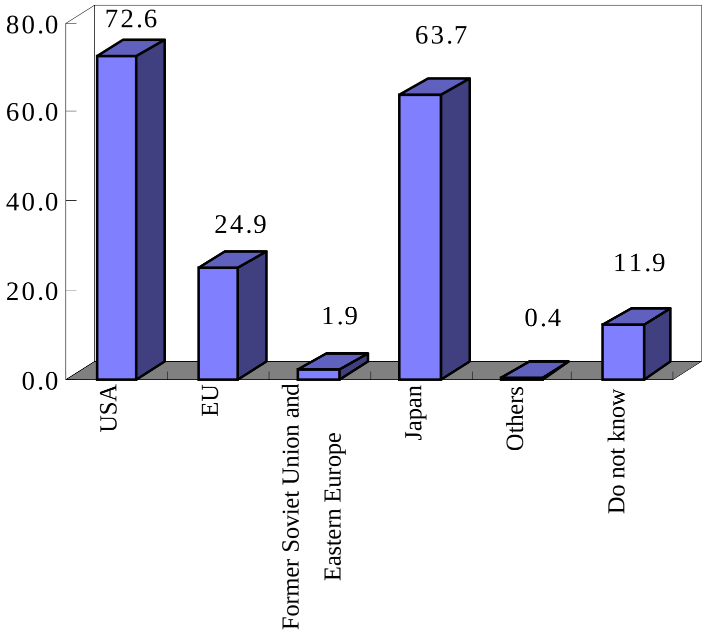


Fig. 1.5-1 Current Leading Countries etc. (%)

1.6. Comparison with the 5th Survey (previous survey)

Of the 109 topics included in the latest survey, 51 (47%) were identical to the previous survey, 20 (18%) were modified, and 38 (35%) were newly introduced. For identical topics, the results of the latest survey were compared with those of the previous survey in terms of degree of importance index scores and forecasted realization times, as shown in the table below.

Degree of importance index scores rose for 11 topics, fell for 38 topics and remained the same for 2 topics. 20. Practical use of rechargeable polymer batteries having a volume-specific capacity of 400 Wh/liter saw the greatest jump in the degree of importance index score, up 19 points, while 23. Practical use of devices that enable real-time X-ray structural analysis of supramolecular-biopolymer crystals saw the greatest drop, down 32 points. Incidentally, Topic 23 belonged to the particles field in the 5th Survey, so, among the topics already included in the materials and processing field in the previous survey, the fall was greatest with 01. Development of artificial muscle-like material that responds to stimuli reversibly (15 points).

Forecasted realization times were all pushed back from the 5th Survey, except for 2 topics , one brought forward and the other remaining unchanged. In particular, 67. Development of microwave cathode elements able to operate at 7 A/cm^2 for a life-time of one year saw its forecasted realization time pushed back 11 years.

Table 1.6-1 Comparison with 5th Survey for Identical Topics

Topic	Degree of importance index/forecasted realization time (year)	
	6th survey	5th survey
01 Development of artificial muscle-like material that responds to stimuli reversibly.	51/2012	66/2014
02 Practical use of hybrid artificial organs in which cells are immobilized on materials such as high polymer plastics.	64/2014	71/2007
04 Practical use of artificial materials that promote development of biological tissues and organogenesis	60/2013	66/2006
06 Practical use of membranes that are similar to those in living bodies, and which have an active transport function and receptors for signals.	53/2014	55/2009
07 Practical use of non-invasive monitoring of blood components.	53/2007	53/2004
10 Practical use of supersmall-sized medical accelerators with an energy of 200 MeV and a diameter of less than 5 m.	53/2009	57/2003
14 Development of organic superconductor having a transition temperature higher than 77 K.	58/2018	70/2009
16 Practical use of high-polymer materials offering a coloring and luminescence when supplied with energy and sustaining for at least 3,000 hours.	60/2009	51/2005
17 Practical use of organic materials with the photo-sensitivity and resolution of silver chloride.	53/2012	58/2007
19 Practical use of high-polymer ferroelectrics whose piezoelectric constant is as high as PZT.	47/2012	48/2007
20 Practical use of rechargeable polymer batteries having a volume-specific capacity of 400 Wh/liter. (Capacity of current Ni-Cd batteries: 180 Wh/liter)	82/2011	63/2008
23 Practical use of devices that enable X-ray structural analysis of supramolecular-biopolymer crystals in real time.	49/2011	81/2005
35 Practical use of composite systems capable of garbage disposal based on the high-temperature methane fermentation technology and of waste combustion disposal.	76/2008	66/2001
37 Development of Si_3N_4 sintered material having robustness at least equivalent to cast iron at room temperatures.	53/2009	57/2007
42 Development of ceramic materials for high-temperature gas turbines (1,400°C or higher), which have a self-repairing ability for damage (e.g., preventing cracks, corrosion, etc.) in a combustion atmosphere.	57/2016	63/2016
44 Development of superconductive materials with a transition temperature around room temperature.	83/2020	92/2017
45 Practical use of non-destructive testing technology which is detectable minute cracks of less than 10 μm in ceramics.	55/2008	63/2003
46 Development of a technique enabling solid-phase sintering process using ultra fine particles at temperatures around 800°C to produce SiC-based or Si_3N_4 -based heat-resistant ceramics.	48/2010	52/2004
47 Practical use of a technique producing cBN (cubic boron nitride) tools using vapour deposition coating.	48/2008	52/2001
48 Development of technology for manufacturing diamond fiber.	48/2013	51/2009
49 Widespread use of industrial electric machines which employ superconductive materials having a critical temperature of liquid nitrogen (77 K) or more.	72/2014	83/2008
50 Practical use of a plastic forming technology for processing of structural ceramics (e.g., alumina, zirconia, silicon nitride, and silicon carbide).	53/2013	59/2005
51 Widespread use of super-heat-resistant intermetallic compounds for mechanical components such as aircraft, engines, turbines and etc..	61/2012	59/2005
53 Development of magnetic materials of which maximum energy product exceeds 70 Mega-Gauss Oersted (MGSOe). (Current maximum value of Fe-Nd-B alloy : 64 MGSOe)	54/2009	62/2002

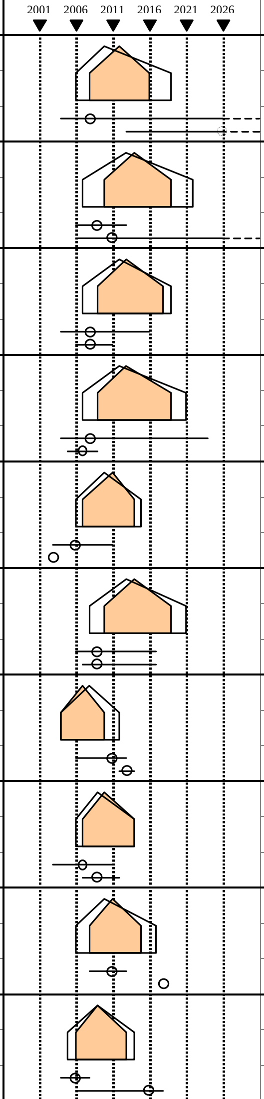
Topic	Degree of importance index/forecasted realization time (year)	
	6th survey	5th survey
54 Development of bulky magnetic materials of which magnetic saturation density exceed 3 Tesla. (Current maximum value: 2.4 Tesla.)	51/2012	61/2003
55 Development of diagnostic technologies, which enable in-situ estimation of remaining life of metallic materials structures and components depending on service conditions, by non-destructive inspection for fatigue.	65/2010	75/2004
56 Development of economical manufacturing process for ultra-high purity steel with 6-N (99.9999%).	48/2013	46/2006
57 Development of new titanium refining process lowering the manufacturing cost on a par with that of aluminum.	55/2015	63/2009
59 Production of automobiles powered by hydrogen fuel stored in hydrogen-occlusive alloys exceeds 10% of the total automobile production.	70/2017	64/2011
60 Practical use of processing technology for super-smooth-surface finished metal with the level of nano-meter surface roughness. (Current limit : 0.1 μ).	49/2010	55/2003
61 Development of high performance switching elements made of nonlinear optical material of the third order.	63/2010	61/2003
67 Development of microwave cathode elements able to operate at 7 A/cm^2 for a life-time of one year.	53/2016	46/2005
70 Development of photo-refractive material that can change its photo-refractive index by more than 0.1.	53/2013	60/2005
71 Development of intelligent materials which incorporate sensor functions, programming functions and effector functions.	59/2014	63/2010
73 Practical use of computer simulation technology for growing thin films according to the first principle computation.	50/2008	59/2004
75 Development of technology for controlling the structures and properties of solid interfaces at the atomic level.	62/2011	75/2005
77 Development of a technique for manufacturing of p-n junctions of diamond.	53/2010	56/2005
78 Development of a heteroepitaxial technology for growing any semiconductor material on silicon substrate.	62/2010	67/2004
79 Development of the technology to fabricate large-area (inch order) compound semiconductor single crystal film on glass substrates.	58/2011	60/2005
80 Development of heteroepitaxial technology for growing large-area (inch order) diamond thin films on hetero-substrates.	55/2011	61/2004
81 Development of technology for embedding impurities, and repairing defective crystallized silicon surfaces by STM-associated technology.	54/2008	59/2003
84 Practical use of multi-layer solar cells with a conversion efficiency of more than 50%.	91/2016	91/2010
85 Practical use of large-area amorphous silicon solar cells with a conversion efficiency of more than 20%.	91/2011	86/2004
86 Development of X-ray free electron lasers with a wave-length of a few dozen Å.	52/2012	60/2004
89 Practical use of oxidation-resistant carbonfiber reinforced carbon composite materials.	55/2010	58/2004
93 Practical use of a bonding technology of ceramics and metals which resists to the repetition of temperature change over 500°C.(So far less than 400°C)	57/2010	66/2003
95 Practical use of computer-aided material design of solid catalysts with specified composition, organization, and physical properties.	52/2013	66/2008
96 Development of computer simulation technology enabling the precise prediction of structures and physical properties in an isothermal equilibrium state, provided element compositions are given in materials made more than one element.	55/2014	67/2011

Topic	Degree of importance index/forecasted realization time (year)	
	6th survey	5th survey
102 Practical use of online processing technology systems capable of forecasting and controlling size and shape with an accuracy in the order of 10Å.	61/2012	60/2004
107 Practical use of processes for water decomposition by the sunlight.	85/2017	80/2009
108 Practical use of carbon dioxide fixation technology necessary for protecting global environments.	84/2016	87/2008

Note: Up until the 5th Survey, realization meant realization in Japan unless otherwise specified. However, this was changed to mean realization somewhere in the world in the 6th Survey. Therefore, care should be taken when comparing forecasted realization times from the two surveys.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Will not be realized (%)	Do not know (%)	Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources			USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Biological	1	Development of artificial muscle-like material that responds to stimuli reversibly.	1	171	2	24	74	56	20	64	16	0	34	6	88	16	3	8	57	14	2	40	0	29	53	48	17	6	46	1	1	3	10	20	5
			2	146	2	21	77	51	11	72	17	0	28	1	92	9	1	5	66	6	1	44	0	25	62	53	10	6	55	1	1	3	14	35	3
			X	3	100	0	0	33	0	33	67	0	33	0	100	0	0	33	67	33	0	100	0	0	33	67	0	33	67	0	33	0	0	0	0
	2	Practical use of hybrid artificial organs in which cells are immobilized on materials such as high polymer plastics.	1	140	4	16	80	66	39	50	10	1	24	3	96	7	3	7	71	18	0	39	0	21	53	50	15	13	41	13	0	4	19	48	3
			2	118	3	14	83	64	33	55	12	0	19	3	97	2	0	8	78	9	0	41	0	15	66	51	8	10	47	7	0	3	19	67	2
			X	4	100	0	0	69	50	25	25	0	25	0	100	0	0	0	100	25	0	75	0	0	50	75	25	0	50	0	0	0	0	50	0
	3	Development of biomimetic systems that synthesize proteins using natural and non-natural amino acids.	1	104	8	19	73	52	19	52	26	3	42	42	38	26	2	5	65	26	2	36	0	21	46	33	19	24	35	4	0	30	9	21	2
			2	89	4	19	76	51	14	64	23	0	42	40	42	16	0	7	74	18	1	42	0	20	60	35	13	22	40	2	0	40	8	19	0
			X	4	100	0	0	50	0	100	0	0	0	25	100	0	0	0	100	25	0	50	0	0	100	50	0	0	0	0	0	50	0	0	0
	4	Practical use of artificial materials that promote development of biological tissues and organogenesis	1	128	4	21	75	61	31	53	14	2	23	2	88	9	3	9	61	15	1	33	0	24	44	46	21	13	38	5	0	6	12	29	4
			2	115	3	15	83	60	26	63	12	0	23	3	94	4	3	6	70	9	0	37	0	20	51	50	14	10	43	3	0	3	20	44	2
			X	3	100	0	0	100	100	0	0	0	100	33	100	0	0	0	100	33	0	67	0	0	100	100	0	0	100	0	0	33	33	100	0
	5	Widespread use of signal-responsive missile drugs capable of efficiently reaching targeted parts such as tumor cells.	1	136	3	18	79	77	57	39	2	2	27	1	96	6	0	4	75	24	0	49	0	14	38	49	19	21	42	13	1	3	13	14	4
			2	116	1	15	84	81	63	34	3	0	27	0	94	2	0	3	81	16	0	59	0	10	39	63	10	16	42	9	1	2	22	18	3
			X	1	100	0	0	100	100	0	0	0	0	0	100	0	0	0	100	100	0	100	0	0	100	100	0	0	100	0	0	0	0	0	0
	6	Practical use of membranes that are similar to those in living bodies, and which have an active transport function and receptors for signals.	1	99	6	15	79	52	20	53	24	3	35	27	74	10	3	8	61	21	0	46	0	18	53	39	24	7	39	4	0	3	10	9	6
			2	82	4	16	80	53	18	57	25	0	32	23	79	7	2	4	68	16	0	61	0	12	62	44	15	4	39	1	0	2	16	13	2
			X	3	100	0	0	83	67	33	0	0	0	67	33	0	0	0	100	33	0	100	0	0	67	67	33	0	33	0	0	0	0	0	0
	7	Practical use of non-invasive monitoring of blood components.	1	60	8	22	70	55	23	55	18	3	28	3	92	5	2	12	60	17	0	43	0	23	32	48	17	17	30	10	0	0	17	12	5
			2	49	4	22	73	53	16	65	16	2	20	4	96	6	0	8	78	14	0	53	0	10	33	65	4	12	43	8	0	0	24	10	2
			X	2	100	0	0	75	50	50	0	0	50	0	100	0	0	0	100	0	0	0	0	0	50	100	0	0	50	0	0	0	0	0	0
	8	Practical use of highly selective oxidation processes using biomimetic catalysts (modeled after enzymes in biochemical reactions)	1	116	6	31	63	56	21	61	16	2	48	63	15	18	0	8	53	28	2	45	1	21	51	34	20	6	41	1	1	16	3	3	5
			2	92	3	33	64	55	16	72	12	0	49	71	9	14	0	4	71	22	1	62	0	14	60	39	13	3	45	0	0	22	3	1	4
			X	3	100	0	0	50	0	100	0	0	100	67	0	33	0	0	100	33	33	100	0	0	100	0	33	0	100	0	0	0	0	0	0
	9	Practical use of biodesulfurization technology.	1	110	2	24	75	57	29	48	18	5	25	88	13	4	3	8	43	16	2	45	0	25	30	37	18	13	43	7	2	32	5	1	4
			2	83	1	18	81	61	30	54	14	1	19	93	6	2	0	5	52	8	1	63	0	20	39	43	8	8	59	4	1	40	4	1	0
			X	1	100	0	0	100	100	0	0	0	0	100	0	100	0	0	100	0	0	100	0	0	100	0	100	0	100	0	0	0	0	0	0
	10	Practical use of supersmall-sized medical accelerators with an energy of 200 MeV and a diameter of less than 5 m.	1	98	5	19	76	54	20	56	21	2	28	9	88	8	1	5	67	34	6	45	0	10	24	41	32	1	47	9	1	7	23	6	3
			2	75	5	13	81	53	18	58	25	0	24	3	93	7	0	5	80	31	1	59	0	9	27	48	32	0	52	7	0	5	39	1	1
			X	4	100	0	0	100	100	0	0	0	50	0	75	25	0	0	100	0	0	50	0	0	0	100	25	0	50	25	0	0	25	0	0

Forecasted realization time



(Note) See page 7 for the interpretation of the graphs.

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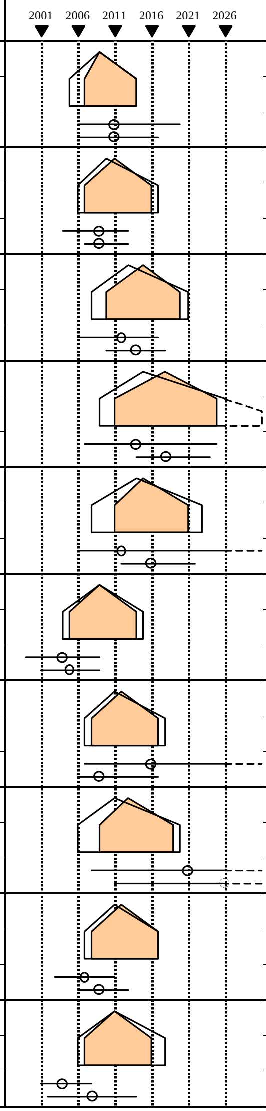
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources			USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Organic and high polymer	11	Development of heat-resistant polymer capable of continuous use at temperatures of up to 450 °C.	1	243	14	37	49	62	32	52	15	1	81	40	14	12	4	9	72	25	4	44	0	17	52	47	25	4	46	0	2	30	6	1	4
			2	202	9	39	51	60	28	59	13	1	86	36	13	9	3	4	79	15	2	50	0	14	59	48	17	3	52	0	2	41	4	0	3
			X	19	100	0	0	68	39	56	6	0	89	63	11	5	0	0	95	16	0	79	0	0	68	47	21	0	63	0	0	26	0	0	0
	12	Development of polymeric fiber with a tear resistance of 40% of the theoretical value and a modulus of 90% of the theoretical value (the theoretical values are assumed to be 20 GPa for resistance and 250 GPa in modulus of elasticity).	1	185	15	37	49	60	28	59	11	2	82	24	19	16	4	6	69	28	3	49	1	16	50	40	27	6	49	1	2	19	4	3	4
			2	154	11	34	55	57	23	62	14	1	86	22	16	10	5	2	79	17	1	55	0	12	58	42	19	2	59	0	1	27	3	2	3
			X	17	100	0	0	78	56	44	0	0	88	41	12	18	6	0	82	41	0	82	0	0	59	41	29	6	82	0	0	12	0	0	0
	13	Practical use of polymer materials with electrical conductivity and resistance to the environment equal to copper at room temperature.	1	226	12	31	58	59	31	49	18	3	75	45	11	22	17	12	57	26	3	43	1	27	50	42	23	3	38	0	3	18	3	2	6
			2	190	8	31	62	58	27	52	19	2	75	45	9	16	17	6	62	20	2	50	0	23	58	41	18	2	44	0	3	23	3	1	4
			X	15	100	0	0	77	53	47	0	0	87	80	13	7	7	7	93	40	0	87	0	0	80	53	27	7	60	0	0	20	0	0	7
	14	Development of organic superconductor having a transition temperature higher than 77 K.	1	205	7	33	60	60	32	46	19	3	65	48	10	44	14	11	68	36	5	55	0	16	58	39	25	5	46	0	1	12	4	2	5
			2	169	5	34	62	58	27	54	17	2	69	44	7	41	15	12	68	27	3	59	0	18	62	37	19	4	46	0	3	19	4	0	4
			X	8	100	0	0	63	25	75	0	0	63	63	0	50	13	25	75	38	13	88	0	13	50	50	38	0	63	0	0	13	13	0	0
	15	Development of superconducting materials of conjugated polymer.	1	182	13	29	58	54	24	48	25	3	65	40	10	40	9	16	66	34	4	50	0	19	58	40	21	4	45	0	1	12	4	3	4
			2	149	9	30	61	53	18	57	23	1	68	38	7	38	7	15	74	30	3	60	0	13	65	39	19	3	47	0	1	22	3	1	3
			X	14	100	0	0	64	29	71	0	0	71	43	0	43	0	21	93	36	7	79	0	7	64	43	7	0	71	0	0	21	7	0	0
	16	Practical use of high-polymer materials offering a coloring and luminescence when supplied with energy and sustaining for at least 3,000 hours.	1	180	14	28	58	62	33	51	16	1	83	26	22	16	2	6	66	28	1	67	1	14	52	50	18	3	39	1	2	14	3	3	6
			2	151	11	26	62	60	27	60	13	1	83	20	22	13	0	7	72	20	1	72	0	9	56	54	13	1	45	0	1	21	2	1	5
			X	17	100	0	0	69	41	53	6	0	88	24	18	12	0	6	71	24	0	94	0	0	71	82	6	6	47	0	0	6	0	0	0
	17	Practical use of organic materials with the photo-sensitivity and resolution of silver chloride.	1	155	10	21	69	54	24	47	27	2	77	28	19	10	12	8	61	23	1	55	0	23	39	46	19	3	35	2	1	17	5	2	5
			2	122	8	21	70	53	21	52	25	2	83	29	16	8	8	7	70	20	1	66	0	17	48	47	15	2	34	0	2	26	2	1	3
			X	10	100	0	0	68	40	50	10	0	90	30	10	0	30	20	80	20	0	70	0	10	50	60	10	10	50	0	0	10	0	0	0
	18	Development of organic ferromagnetic substances.	1	182	4	27	69	50	19	47	32	2	71	23	13	36	8	13	57	24	14	49	1	20	53	44	18	3	45	1	1	9	5	2	3
			2	152	3	19	78	48	14	51	34	1	76	16	11	35	5	12	66	19	9	57	1	12	57	43	13	3	48	0	0	16	1	1	3
			X	5	100	0	0	60	40	20	40	0	60	20	20	40	0	20	100	60	0	40	0	0	60	60	0	20	60	0	0	0	0	0	0
	19	Practical use of high-polymer ferroelectrics whose piezoelectric constant is as high as PZT.	1	166	5	35	60	49	13	60	27	1	80	20	16	22	7	9	59	22	4	47	0	21	43	45	17	3	43	1	1	10	2	2	5
			2	136	7	29	64	47	7	69	23	2	83	17	11	19	4	11	64	14	1	55	0	18	51	44	13	1	47	0	1	19	1	1	4
			X	9	100	0	0	53	11	78	11	0	89	33	33	44	11	11	78	33	0	67	0	0	44	33	11	0	67	0	11	0	0	0	0
	20	Practical use of rechargeable polymer batteries having a volume-specific capacity of 400 Wh/liter. (Capacity of current Ni-Cd batteries: 180 Wh/liter)	1	157	8	28	64	79	61	34	3	1	75	69	25	8	6	6	66	30	2	64	1	11	44	56	21	3	52	3	2	22	4	3	5
			2	133	5	24	71	82	65	32	3	0	78	65	23	5	4	6	74	18	0	72	0	9	47	57	14	2	56	2	4	28	2	1	5
			X	7	100	0	0	86	71	29	0	0	86	71	29	0	0	0	71	29	0	100	0	0	71	57	0	0	57	0	0	0	0	0	14

Forecasted realization time

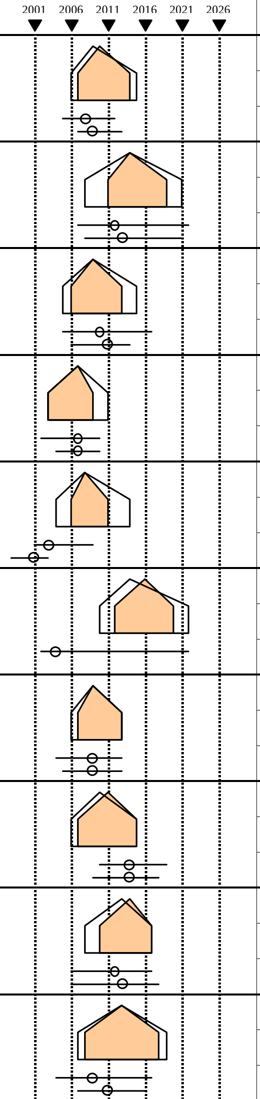


(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic development	Expected effect: Resolution of global problems	Expected effect: People's needs	Expected effect: Expansion of intellectual resources	Forecasted realization time (2001 2006 2011 2016 2021 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Organic and high polymer	21	Development of self-healing high polymers.	1	157	5	32	62	54	24	47	27	2	64	28	41	35		10	17	54	24	1	42	1	29	57	41	18	3	44	0	2	16	5	4	6
			2	135	4	27	68	51	15	62	22	1	63	16	44	33		9	15	65	15	0	50	0	23	67	46	13	3	47	0	1	24	4	1	6
			X	6	100	0	0	71	50	33	17	0	67	33	33	50		0	17	83	50	0	83	0	0	50	83	0	17	100	0	0	0	17	0	0
	22	Development of technology which create the desired functions through the complete control of two- and three-dimensional structures of protein complex.	1	106	8	26	66	65	38	47	15	1	62	34	37	49		11	8	74	40	1	46	1	15	56	34	24	20	41	1	0	20	6	16	4
			2	92	5	23	72	64	35	53	12	0	65	17	38	53		9	10	82	34	1	51	0	11	67	39	23	21	49	1	0	26	8	17	2
			X	5	100	0	0	90	80	20	0	0	60	0	60	60		0	20	100	80	0	80	0	0	40	80	20	40	40	0	0	0	0	0	0
	23	Practical use of devices that enable X-ray structural analysis of supramolecular-biopolymer crystals in real time.	1	163	7	23	71	52	19	51	29	1	37	9	26	69		2	7	65	37	3	50	1	17	41	37	39	10	48	1	1	7	5	4	6
			2	129	5	23	72	49	10	65	24	1	36	2	18	82		1	4	76	36	2	59	1	9	49	26	40	6	52	0	1	9	5	2	3
			X	6	100	0	0	50	17	67	0	17	50	17	0	83		0	0	100	67	0	67	0	0	50	17	50	17	67	0	17	0	0	0	0
	24	Use of catalytic oxidation and hydrogenation with much less by-production of inorganic salts in place of the majority of reagent oxidation and reduction reactions in the synthesis of fine chemicals.	1	96	10	29	60	57	27	49	22	2	55	64	11	22		2	7	60	50	4	51	1	20	58	42	17	4	42	1	2	16	1	0	5
			2	82	10	27	63	55	18	66	16	0	56	65	7	17		0	7	70	48	5	52	0	15	68	43	12	1	45	0	0	23	0	0	4
			X	8	100	0	0	75	50	50	0	0	38	88	0	63		0	13	88	75	13	100	0	0	75	63	0	0	88	0	0	0	0	0	0
	25	Development of selective catalytic cracking technology for naphtha.	1	89	11	33	56	67	44	40	15	1	58	76	8	12		1	3	76	36	3	54	0	10	48	52	25	1	54	4	1	15	1	0	4
			2	77	5	36	58	70	45	45	11	0	58	79	5	13		3	6	84	26	3	57	0	10	48	58	17	0	61	1	1	19	0	0	4
			X	4	100	0	0	88	75	25	0	0	75	100	0	50		0	0	100	25	0	75	0	0	75	75	0	0	100	0	0	0	0	0	0
	26	Development of mass-synthesizing technology for fullerene carbon compounds.	1	180	5	29	66	42	10	44	42	4	63	19	6	45		2	9	71	42	6	64	0	9	46	45	24	2	46	1	2	14	3	3	5
			2	151	3	26	72	40	5	48	44	3	66	9	3	51		1	11	77	34	3	66	0	11	48	44	19	2	44	0	1	17	1	1	4
			X	4	100	0	0	38	0	50	50	0	75	0	0	75		0	0	100	50	0	100	0	0	75	50	0	0	75	0	0	0	0	0	0
	27	Practical use of technology for direct synthesis of phenol from benzene.	1	92	15	25	60	51	19	52	27	2	59	53	7	17		1	10	57	43	7	49	0	20	42	51	17	1	45	1	1	12	1	1	3
			2	75	13	24	63	49	11	64	25	0	69	53	5	16		0	8	71	39	4	61	0	16	48	51	11	1	49	0	3	13	0	0	4
			X	10	100	0	0	60	20	80	0	0	80	70	0	40		0	0	70	60	20	80	0	0	50	60	10	0	60	0	10	0	0	0	10
	28	Widespread use of new organic synthetic processes using photocatalysts.	1	135	10	27	63	55	26	46	26	2	67	58	5	25		2	7	60	35	1	57	0	16	56	50	20	1	48	0	1	16	3	0	4
			2	109	6	24	70	50	14	59	26	1	67	61	2	18		1	6	69	23	1	65	0	15	58	54	14	1	44	0	2	18	1	0	3
			X	7	100	0	0	64	29	71	0	0	71	43	0	14		0	0	86	29	14	57	0	0	57	14	14	0	29	0	0	14	0	0	0
	29	Development of precision polymerization processes that can freely control stereoregularity, chain structure and molecular weight and its distribution of polymer in addition polymerization reactions.	1	128	23	33	45	65	37	49	13	2	76	26	13	42		3	5	77	45	1	70	0	8	60	45	21	2	52	1	1	9	1	1	8
			2	98	21	35	44	63	34	52	14	0	85	16	7	48		1	7	82	44	0	76	0	7	68	47	18	1	61	0	1	10	0	0	4
			X	21	100	0	0	85	70	30	0	0	90	14	10	62		0	0	81	52	0	81	0	0	76	67	38	5	62	0	0	0	0	0	0
	30	Development of technology that can freely control molecular weight and its distribution in condensation polymer.	1	129	20	28	52	60	30	53	16	2	73	19	11	39		5	5	68	39	1	61	0	14	62	40	20	2	49	0	0	8	2	1	5
			2	99	20	28	52	57	21	65	13	0	87	12	8	39		3	5	78	32	1	69	0	11	71	45	15	2	53	0	0	11	0	0	2
			X	20	100	0	0	78	55	45	0	0	85	15	15	35		5	5	65	25	0	85	0	0	75	50	30	5	65	0	0	5	0	0	0

(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic development	Expected effect: Resolution of global problems	Expected effect: People's needs	Expected effect: Expansion of intellectual resources	Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	Leading countries: EU	Leading countries: Former Soviet Union and Eastern Europe	Leading countries: Japan	Leading countries: Other countries	Leading countries: Do not know	Measures the government should adopt (%): Foster human resources	Measures: Promote exchanges among industrial, academic and government sectors and different fields	Measures: Upgrade advanced facilities and equipment	Measures: Develop a research base	Measures: Increase government research funding	Measures: Adjust regulations (relax/toughen)	Measures: Others	Potential problems (%): Adverse effect on the natural environment	Potential problems: Adverse effect on safety	Potential problems: Adverse effect on morals, culture or society	Potential problems: Other adverse effects
Organic and high polymer	31	Development of technology that can freely control the tacticity of polyvinyl chloride and polyvinyl acetate.	1	114	18	28	54	50	16	54	28	3	69	21	12	26		2	11	61	39	1	59	0	18	49	40	18	3	39	0	3	16	2	1	6
			2	91	15	27	57	50	12	63	24	0	78	13	8	27		1	13	75	32	0	70	0	11	63	44	14	1	44	0	3	25	0	0	3
			X	14	100	0	0	71	50	36	14	0	79	36	14	43		7	7	79	50	0	86	0	7	57	43	29	0	64	0	0	14	0	0	0
	32	Development of technology that can freely control the supra-molecular structure of polymers (higher order functional structure).	1	141	17	31	52	64	34	55	8	3	72	18	11	50		6	9	67	40	4	55	1	16	57	40	23	2	44	1	1	11	2	2	6
			2	117	14	32	55	60	24	68	6	2	83	13	7	56		5	9	76	44	2	68	0	11	70	45	22	3	53	1	0	19	3	2	3
			X	16	100	0	0	81	63	38	0	0	81	19	31	56		6	6	75	81	0	94	0	0	69	56	50	0	69	0	0	0	0	0	0
	33	Biodegradable plastics will account for 10% of all plastics.	1	213	9	23	67	71	48	41	9	2	44	89	21	6		6	4	58	59	1	57	0	11	32	42	16	6	42	28	3	46	3	4	2
			2	176	8	23	69	76	56	35	8	1	37	93	14	5		4	3	66	68	1	67	0	5	35	54	13	4	52	30	3	53	2	1	2
			X	14	100	0	0	75	57	29	14	0	29	100	21	7		7	0	64	79	0	64	0	0	21	57	14	0	57	29	0	21	0	0	0
	34	Establishment and practical use of plastic recycling technology.	1	259	11	26	63	85	72	24	3	0	51	92	17	4		0	3	46	64	1	52	1	11	31	51	20	5	46	34	2	37	4	7	3
			2	211	7	28	65	91	82	15	2	0	47	93	13	2		0	2	50	74	0	63	0	6	31	63	15	1	54	34	0	43	3	2	2
			X	15	100	0	0	100	100	0	0	0	73	93	20	7		0	0	67	87	0	73	0	0	27	67	13	0	53	27	0	27	20	0	0
	35	Practical use of composite systems capable of garbage disposal based on the high-temperature methane fermentation technology and of waste combustion disposal.	1	113	5	16	79	73	51	39	8	1	39	90	17	4		2	4	34	41	3	52	1	22	30	46	17	3	50	27	0	39	3	4	3
			2	96	2	14	84	76	54	39	6	0	32	93	14	4		0	1	31	38	2	70	0	18	25	59	13	0	64	27	1	51	1	3	1
			X	2	100	0	0	75	50	50	0	0	50	100	50	0		0	0	0	50	0	50	0	50	50	50	0	0	100	0	0	50	0	0	0
	36	Biomasses will exceed 10% of chemical materials.	1	114	3	19	78	59	33	42	23	3	36	92	12	7		8	11	52	39	4	32	7	22	37	34	15	8	44	23	3	33	0	4	3
			2	97	0	15	85	58	27	53	19	1	33	94	5	3		4	5	63	39	2	35	5	19	39	42	11	4	53	16	2	38	0	2	1
			X	0	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ceramic	37	Development of Si_3N_4 sintered material having robustness at least equivalent to cast iron at room temperatures.	1	173	19	38	43	55	21	58	19	2	80	44	8	13		6	10	61	21	8	68	1	10	45	49	28	5	48	1	2	14	4	2	5
			2	149	16	34	50	53	16	63	19	1	84	32	8	7		6	7	59	11	4	77	1	7	52	56	19	3	56	1	1	19	3	1	3
			X	24	100	0	0	68	38	58	4	0	88	46	4	4		4	0	79	17	0	88	0	0	54	58	21	0	79	0	0	17	4	0	0
	38	Development of large-scale architectural window glass for which there is time enough to take prior safety countermeasures against a qualitative deterioration in strength.	1	135	14	34	52	50	17	55	24	4	56	20	59	6		2	11	59	21	1	54	1	17	36	48	14	4	35	11	2	7	22	3	6
			2	117	10	32	57	50	12	64	21	3	56	10	66	3		1	9	68	12	1	62	1	15	40	58	6	3	41	9	1	5	32	0	3
			X	12	100	0	0	66	36	55	9	0	50	17	92	0		0	0	75	17	0	92	0	0	83	75	0	8	67	0	0	0	33	0	0
	39	Practical use of power generator turbines made primarily from high-strength, heat-resistant ceramics.	1	198	16	34	50	65	37	49	12	2	58	76	8	7		5	8	65	30	4	67	1	11	43	55	27	4	54	2	2	11	10	1	4
			2	169	15	31	54	63	31	59	9	1	64	75	4	5		2	4	64	21	2	74	1	8	46	62	16	2	65	2	1	12	13	0	4
			X	25	100	0	0	73	48	48	4	0	68	88	0	0		0	0	88	16	0	72	0	4	48	52	12	0	84	8	0	12	12	0	0
	40	Development of inorganic materials which exhibit self-organization phenomenon with specific nano-scale structure/characteristics.	1	186	16	38	46	54	23	51	22	5	72	31	8	45		5	8	67	31	4	58	0	12	55	49	24	5	48	0	1	8	5	3	5
			2	154	14	35	51	51	16	60	20	4	75	24	7	43		4	6	69	20	2	68	0	11	65	47	19	3	56	0	0	13	6	2	3
			X	21	100	0	0	65	33	62	5	0	76	38	5	48		0	10	71	14	0	67	0	5	52	38	19	5	62	0	0	10	0	5	0



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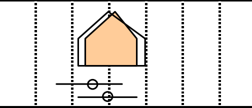
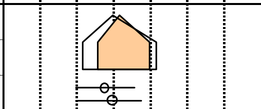
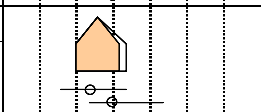
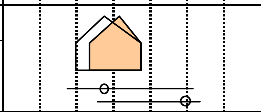
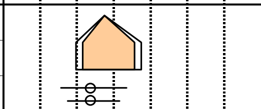
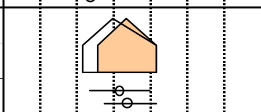
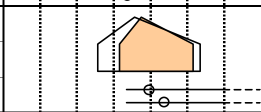
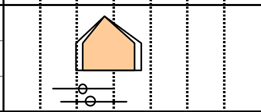
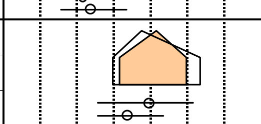
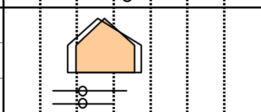
Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%) High	Degree of expertise (%) Medium	Degree of expertise (%) Low	Importance (index, %) Index	Importance High	Importance Medium	Importance Low	Importance Unnecessary	Expected effect (%) Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Forecasted realization time (2001 2006 2011 2016 2021 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%) USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%) Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%) Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Ceramic	41	Construction of large-scale structures (bridges, high-rise buildings, etc.) using concrete (cement and fibers, steel bars, etc.) whose strength deterioration is predictable.	1	164	12	34	54	72	50	40	9	1	68	35	59	3		2	5	40	10	1	66	0	20	33	59	21	3	39	22	1	16	26	2	5
			2	140	7	34	59	75	55	38	7	1	78	24	59	4		1	4	46	6	1	79	0	15	27	71	16	2	49	19	1	14	36	1	4
			X	10	100	0	0	83	67	33	0	0	70	60	50	0		0	0	70	10	0	80	0	10	40	60	0	0	50	30	0	20	20	10	0
	42	Development of ceramic materials for high-temperature gas turbines (1,400°C or higher), which have a self-repairing ability for damage (e.g., preventing cracks, corrosion, etc.) in a combustion atmosphere.	1	175	19	35	45	62	31	55	13	1	61	66	13	11		13	10	61	23	2	58	1	18	50	51	25	5	51	1	1	10	7	2	3
			2	146	17	31	52	57	21	68	11	1	66	66	6	10		9	10	68	17	1	64	0	16	60	55	17	1	60	0	1	16	5	1	2
			X	25	100	0	0	68	36	64	0	0	64	80	0	8		20	0	76	24	0	68	0	16	60	36	8	4	64	0	4	4	8	0	0
	43	Practical use of fluoride glass fibers for optical communications.	1	158	9	27	64	60	29	54	15	1	91	19	23	7		3	9	66	20	3	71	0	13	42	45	25	3	37	4	2	11	10	2	4
			2	131	5	31	65	58	22	65	13	0	92	11	24	6		2	7	70	10	1	74	0	9	50	58	18	3	37	2	1	13	13	1	2
			X	6	100	0	0	63	33	50	17	0	100	0	50	17		0	17	83	33	0	67	0	0	50	67	17	17	50	0	0	0	0	0	17
	44	Development of superconductive materials with a transition temperature around room temperature.	1	220	9	32	59	80	65	28	7	1	83	69	9	49		12	28	74	48	10	67	0	12	55	41	32	6	51	0	0	12	7	3	4
			2	188	9	27	64	83	71	22	5	2	86	59	4	43		14	20	76	40	6	71	1	9	64	38	26	3	58	0	0	16	5	1	3
			X	16	100	0	0	83	75	13	6	6	88	69	13	44		13	25	81	44	19	63	0	0	56	38	44	0	63	0	0	13	6	0	0
	45	Practical use of non-destructive testing technology which is detectable minute cracks of less than 10μm in ceramics.	1	190	17	38	45	56	26	49	24	1	68	28	26	15		1	4	61	25	4	64	1	16	45	50	27	5	41	0	1	3	7	2	4
			2	162	14	35	52	55	19	60	21	0	78	22	23	9		1	3	69	19	1	74	0	14	52	59	20	2	43	0	1	2	10	0	4
			X	22	100	0	0	67	41	45	14	0	86	36	14	5		0	5	73	14	0	73	0	9	45	45	18	0	55	0	0	5	0	0	0
	46	Development of a technique enabling solid-phase sintering process using ultra fine particles at temperatures around 800°C to produce SiC-based or Si_3N_4 -based heat-resistant ceramics.	1	177	19	32	49	51	17	56	24	4	75	46	6	14		7	8	60	23	7	64	1	13	47	44	25	5	43	0	1	6	5	2	4
			2	146	14	32	53	48	10	65	23	2	86	37	5	9		3	4	70	14	3	71	0	10	57	45	14	3	51	0	0	7	4	1	2
			X	21	100	0	0	64	29	71	0	0	95	57	5	14		0	0	90	24	5	76	0	5	52	48	29	0	62	0	0	0	5	0	5
	47	Practical use of a technique producing cBN (cubic boron nitride) tools using vapour deposition coating.	1	161	17	27	56	49	16	49	34	1	83	19	8	7		1	5	57	25	12	66	1	13	39	48	24	3	37	0	2	4	3	2	6
			2	126	13	29	58	48	10	63	27	1	86	15	7	5		0	1	61	16	6	76	1	10	41	63	19	2	42	0	1	6	2	1	4
			X	17	100	0	0	60	24	71	6	0	82	41	12	12		0	0	82	18	12	100	0	0	53	71	35	0	53	0	0	0	12	0	0
	48	Development of technology for manufacturing diamond fiber.	1	158	13	26	61	51	20	44	33	2	82	18	11	21		5	20	53	20	11	44	0	24	43	40	27	3	40	1	3	5	4	2	4
			2	132	8	27	65	48	12	59	28	1	88	14	11	23		1	13	68	17	5	55	0	17	52	42	20	3	48	0	1	9	2	1	4
			X	10	100	0	0	48	10	60	30	0	60	50	10	40		0	20	80	30	20	80	0	0	90	40	20	0	60	0	0	10	10	0	0
	49	Widespread use of industrial electric machines which employ superconductive materials having a critical temperature of liquid nitrogen (77 K) or more.	1	208	9	32	59	72	48	44	7	2	84	66	13	12		3	8	72	37	6	72	0	10	43	56	24	4	53	4	0	8	5	4	2
			2	172	9	28	63	72	48	44	7	1	86	56	12	6		2	4	78	24	2	78	0	6	44	64	16	3	66	1	0	9	6	1	2
			X	16	100	0	0	81	69	25	0	6	94	69	19	6		6	0	88	25	0	94	0	0	50	69	31	6	69	6	0	0	6	0	0
	50	Practical use of a plastic forming technology for processing of structural ceramics (e.g., alumna, zirconia, silicon nitride, and silicon carbide).	1	176	19	32	49	57	26	53	19	2	82	31	11	15		3	7	56	24	4	68	0	14	48	49	29	5	48	1	0	5	4	2	4
			2	149	12	30	58	53	16	66	17	1	88	19	7	12		1	6	60	15	1	78	0	11	48	58	16	2	52	0	0	9	1	1	3
			X	18	100	0	0	69	44	44	11	0	83	50	6	22		0	6	67	17	0	83	0	0	56	56	17	6	56	0	0	6	0	0	0

(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic development	Expected effect: Resolution of global problems	Expected effect: People's needs	Expected effect: Expansion of intellectual resources	Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Metal	51	Widespread use of super-heat-resistant intermetallic compounds for mechanical components such as aircraft, engines, turbines and etc..	1	163	17	34	49	63	34	50	14	1	73	58	9	5		5	7	82	33	8	58	0	9	44	44	26	6	48	4	1	12	10	2	4
			2	137	18	28	55	61	31	53	15	1	80	53	6	5		4	4	88	25	3	63	0	6	50	47	20	5	57	2	1	13	11	1	3
			X	24	100	0	0	70	46	46	4	4	75	67	4	0		8	0	96	8	0	67	0	4	50	46	29	13	42	4	0	13	8	0	4
	52	Development of heat resisting alloys which tolerate under the load of 150 N/mm^2 , at ambient temperatures of 1,050°C and beyond 1,000 hours for service.	1	137	20	33	47	60	29	56	14	1	70	59	11	6		6	9	72	28	12	50	1	12	52	45	30	7	56	2	1	11	7	1	4
			2	113	21	27	52	60	25	64	11	0	79	58	4	4		3	6	80	21	6	58	0	10	59	38	23	4	65	1	0	15	5	0	3
			X	24	100	0	0	71	42	58	0	0	88	63	0	4		4	0	79	17	0	75	0	4	63	29	29	8	67	0	0	21	0	0	0
	53	Development of magnetic materials of which maximum energy product exceeds 70 Mega-Gauss Oersted (MGSOe). (Current maximum value of Fe-Nd-B alloy : 64 MGSOe)	1	109	9	36	55	59	28	51	20	1	76	27	17	22		0	9	50	27	9	66	0	14	48	42	30	6	37	0	1	11	7	2	6
			2	85	7	33	60	54	14	73	13	0	86	18	12	18		0	8	60	20	6	73	0	11	59	44	21	4	39	0	0	14	2	0	4
			X	6	100	0	0	58	17	83	0	0	100	33	17	50		0	0	67	33	0	83	0	0	67	17	0	0	50	0	0	17	0	0	0
	54	Development of bulky magnetic materials of which magnetic saturation density exceed 3 Tesla. (Current maximum value: 2.4 Tesla.)	1	101	12	34	54	55	26	46	27	2	70	26	8	26		4	14	50	27	9	59	0	12	46	39	29	5	36	0	1	6	5	2	6
			2	76	8	30	62	51	15	62	22	1	84	16	4	20		0	9	64	22	4	74	0	4	55	36	20	3	38	0	0	8	0	1	7
			X	6	100	0	0	63	33	50	17	0	83	17	17	67		0	0	67	0	0	100	0	0	67	17	17	0	67	0	0	0	0	17	0
	55	Development of diagnostic technologies, which enable in-situ estimation of remaining life of metallic materials structures and components depending on service conditions, by non-destructive inspection for fatigue.	1	166	25	32	43	67	40	49	10	1	69	37	45	13		4	7	64	39	7	63	2	12	52	46	30	12	41	2	1	4	13	2	4
			2	140	21	28	51	65	34	59	7	0	78	31	41	4		1	1	70	24	1	76	0	8	56	54	20	9	44	1	1	3	13	1	4
			X	30	100	0	0	76	55	38	7	0	77	37	53	3		0	3	70	30	0	87	0	3	57	53	23	10	67	0	0	3	10	3	3
	56	Development of economical manufacturing process for ultra-high purity steel with 6-N (99.9999%).	1	129	15	26	59	51	19	49	30	2	76	24	8	35		5	16	32	25	8	62	1	21	43	36	33	6	47	2	1	6	3	2	7
			2	107	14	24	62	48	12	55	30	2	82	18	6	32		2	10	40	21	3	75	0	12	57	38	28	4	54	0	1	8	1	0	4
			X	15	100	0	0	61	29	64	0	7	80	27	7	60		7	0	40	40	0	87	0	0	60	33	20	7	67	0	0	27	7	0	7
	57	Development of new titanium refining process lowering the manufacturing cost on a par with that of aluminum.	1	128	14	23	63	60	29	52	17	2	84	42	20	13		14	16	57	21	11	46	1	25	48	40	27	6	38	0	2	11	8	2	5
			2	108	14	20	66	55	23	56	18	3	88	32	18	8		11	16	67	16	7	56	1	19	66	39	20	4	45	0	0	14	3	0	3
			X	15	100	0	0	58	33	47	7	13	87	33	0	20		27	7	67	7	20	67	0	13	73	33	13	7	53	0	0	27	0	0	0
	58	Development of molding technologies for making new alloys utilizing mechanical alloying technology.	1	126	16	30	54	48	13	54	31	2	75	29	7	18		2	10	62	28	6	57	1	16	50	41	28	6	38	0	2	6	6	3	4
			2	99	15	33	52	47	11	58	29	2	79	20	3	18		1	6	76	20	5	64	0	11	69	43	23	1	41	0	0	8	3	0	3
			X	15	100	0	0	55	27	47	20	7	80	40	0	13		7	0	80	13	7	67	0	0	67	40	13	7	53	0	0	13	7	0	7
	59	Production of automobiles powered by hydrogen fuel stored in hydrogen-occlusive alloys exceeds 10% of the total automobile production.	1	184	7	18	74	70	47	40	13	0	54	92	15	6		8	10	55	34	3	59	1	20	28	54	21	2	49	22	1	18	17	2	3
			2	151	5	18	77	70	46	40	13	0	52	93	11	3		5	8	66	30	2	74	0	15	30	64	13	1	62	20	1	24	21	1	2
			X	8	100	0	0	91	88	0	13	0	38	75	13	0		13	13	75	13	0	88	0	13	50	63	25	0	63	0	0	25	25	0	0
	60	Practical use of processing technology for super-smooth-surface finished metal with the level of nano-meter surface roughness. (Current limit : 0.1μ).	1	158	10	32	58	52	21	46	33	0	80	9	11	25		5	3	53	28	4	61	1	16	49	41	37	4	41	3	3	4	4	2	3
			2	126	10	33	57	49	15	55	30	1	90	3	5	26		2	2	59	20	1	80	0	9	63	44	33	1	44	2	1	6	4	1	2
			X	12	100	0	0	54	25	42	33	0	92	8	0	25		0	0	67	0	0	83	0	0	67	33	50	0	33	0	0	8	0	0	0

(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic development	Expected effect: Resolution of global problems	Expected effect: People's needs	Expected effect: Expansion of intellectual resources	Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Semiconductor and electronics	61	Development of high performance switching elements made of nonlinear optical material of the third order.	1	140	10	33	57	63	37	43	18	1	83	10	8	28		1	9	76	39	5	65	0	9	51	48	26	2	46	0	0	3	4	2	5
			2	117	9	31	60	63	32	53	15	0	85	8	8	23		0	8	84	33	0	68	0	7	58	56	20	2	55	0	0	3	5	1	2
			X	11	100	0	0	82	64	36	0	0	91	27	9	27		0	0	91	27	0	91	0	0	64	73	27	0	73	0	0	0	9	0	0
	62	Development of memory capacity of 1 terabit per chip.	1	142	11	29	61	83	69	25	4	1	92	13	20	21		3	6	75	9	0	82	2	5	46	54	36	1	52	2	1	2	3	8	4
			2	113	9	28	63	86	74	21	4	0	92	6	17	10		1	4	73	4	0	83	3	5	50	64	29	1	57	0	0	4	2	5	2
			X	10	100	0	0	95	90	10	0	0	100	10	30	0		0	0	90	0	0	100	10	0	40	90	30	0	50	0	0	0	0	10	0
	63	Development of radiation- and heat-resistant logic integrated circuits capable of use with nuclear reactors.	1	89	10	28	62	57	26	51	19	4	54	60	13	9		6	16	66	22	2	45	0	15	38	38	31	4	54	2	1	10	11	7	3
			2	75	8	23	69	55	19	63	18	0	55	75	11	5		4	11	81	11	3	47	0	11	39	43	24	3	69	0	1	12	15	4	1
			X	6	100	0	0	75	50	50	0	0	67	100	17	0		0	0	100	17	17	50	0	0	17	100	0	17	83	0	0	0	33	0	0
	64	Practical use of quantum-effect interferometer for flux measurement.	1	95	9	33	58	53	21	52	26	1	72	9	8	42		2	15	79	37	4	62	1	8	51	47	21	0	40	0	1	2	2	2	5
			2	77	9	22	69	50	12	65	23	0	77	5	3	42		3	10	86	34	1	70	0	4	68	58	13	0	44	0	1	1	0	1	4
			X	7	100	0	0	61	29	57	14	0	57	29	0	71		0	29	100	57	14	100	0	0	71	43	29	0	71	0	0	0	0	0	14
	65	Practical use of semiconductor UV lasers.	1	130	13	32	55	66	38	49	12	1	88	17	13	24		0	7	70	26	5	65	0	15	48	48	28	2	50	0	0	2	5	4	4
			2	105	16	27	57	66	36	57	7	0	95	10	10	19		0	5	80	17	2	72	0	8	57	59	22	0	54	0	1	4	3	1	2
			X	17	100	0	0	72	47	47	6	0	94	6	0	35		0	0	88	12	0	76	0	0	59	71	29	0	65	0	0	6	0	0	0
	66	Practical use of operational circuits comprising Josephson junctions.	1	119	8	30	61	55	27	45	23	5	80	11	10	25		4	7	71	29	2	69	0	6	42	45	26	2	52	0	1	1	2	2	4
			2	99	9	25	66	53	20	53	24	2	90	6	5	23		7	5	78	17	0	74	0	7	57	54	18	2	58	0	1	1	0	1	2
			X	9	100	0	0	64	33	56	11	0	78	0	11	11		11	0	89	11	0	89	0	0	56	33	11	0	67	0	0	0	0	0	0
	67	Development of microwave cathode elements able to operate at 7A/cm^2 for a life-time of one year.	1	45	2	24	73	51	19	50	29	2	84	16	16	11		0	27	69	24	0	49	0	16	36	44	16	4	47	0	0	0	2	2	11
			2	41	2	12	85	53	17	61	22	0	85	5	7	12		2	10	78	10	0	49	0	15	39	54	17	2	44	0	0	5	0	2	5
			X	1	100	0	0	50	0	100	0	0	100	0	0	0		0	0	100	0	0	100	0	0	0	100	0	0	100	0	0	0	0	0	0
	68	Development of PHB (Photochemical Hole Burning) memory devices.	1	136	10	28	63	59	29	49	19	2	87	10	12	24		8	9	71	38	4	65	1	10	43	47	25	3	49	0	1	2	2	3	3
			2	114	6	23	71	58	26	55	18	1	91	6	10	23		7	4	81	30	2	73	0	6	51	55	19	4	53	0	0	5	3	1	1
			X	7	100	0	0	75	50	50	0	0	100	14	0	29		0	0	71	57	14	100	0	0	71	57	43	0	71	0	0	0	0	0	0
	69	Development of elements (memory, magnetic heads, etc.) which utilize colossal magnetic resistance effect (variance of 10^{10} or more).	1	58	14	36	50	58	27	52	20	2	84	9	10	19		0	10	72	28	2	64	0	10	40	57	19	0	38	0	0	0	2	3	5
			2	47	11	30	60	53	15	66	19	0	83	6	9	13		2	9	77	11	2	62	0	11	43	60	15	0	43	0	0	6	2	4	2
			X	5	100	0	0	70	40	60	0	0	80	0	20	0		0	0	100	0	0	60	0	0	20	40	40	0	60	0	0	0	0	0	0
	70	Development of photo-refractive material that can change its photo-refractive index by more than 0.1.	1	106	9	30	60	55	22	57	19	2	84	8	12	33		3	17	63	32	3	57	0	19	47	44	20	2	44	0	0	1	2	4	5
			2	89	8	28	64	53	16	66	18	0	91	2	10	30		3	12	81	27	2	70	0	11	64	54	12	1	54	0	0	2	0	1	3
			X	7	100	0	0	71	43	57	0	0	100	0	14	14		0	0	100	14	14	100	0	0	57	71	0	0	57	0	0	0	0	0	0

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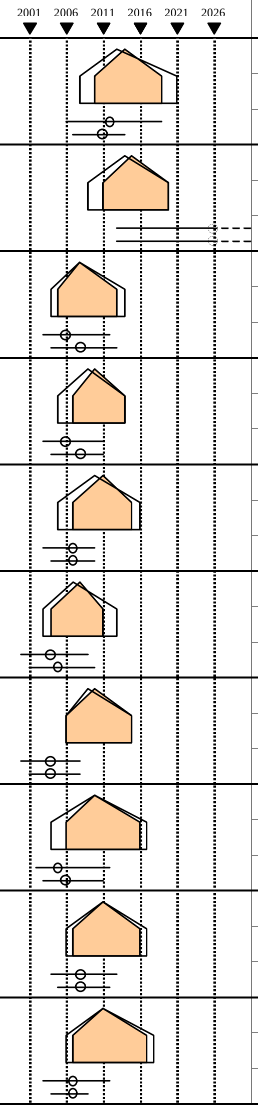
Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic development	Expected effect: Resolution of global problems	Expected effect: People's needs	Expected effect: Expansion of intellectual resources	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Semiconductor and electronics	71	Development of intelligent materials which incorporate sensor functions, programming functions and effector functions.	1	156	10	29	61	61	32	50	15	3	81	17	36	24	8	10	64	24	2	54	1	21	58	54	24	4	57	1	1	6	6	4	3
			2	123	9	29	62	59	27	56	15	2	89	7	35	25	7	7	72	20	0	61	0	15	62	56	20	3	61	1	2	7	3	3	1
			X	11	100	0	0	82	64	36	0	0	91	9	27	36	9	0	82	18	0	82	0	9	45	91	18	9	55	0	0	9	0	0	0
	72	Elucidation of the information transmission structure of sensory nerves.	1	106	5	13	82	63	31	59	9	1	52	5	56	70	2	4	74	45	5	42	1	20	64	39	22	16	47	0	0	1	7	15	3
			2	89	2	11	87	65	33	61	7	0	54	2	60	69	1	1	84	49	1	42	1	16	79	43	16	11	58	0	1	2	3	22	1
			X	2	100	0	0	100	100	0	0	0	50	0	50	50	0	0	100	50	0	50	0	0	50	50	0	0	100	0	0	0	0	50	0
	73	Practical use of computer simulation technology for growing thin films according to the first principle computation.	1	139	16	29	55	51	21	45	32	3	63	11	4	60	2	8	76	30	4	55	1	14	50	38	24	12	47	1	0	1	2	3	7
			2	110	12	26	62	50	16	54	29	1	69	5	2	58	2	4	81	27	0	60	1	13	62	35	19	6	48	0	1	2	0	3	3
			X	13	100	0	0	75	54	38	8	0	62	31	0	69	0	0	100	62	0	92	0	0	77	38	38	8	62	0	0	0	0	8	0
	74	Elucidation of the crystallization growth mechanism using femto-second technology.	1	129	16	29	56	49	18	47	31	4	53	8	2	75	2	11	76	35	2	57	1	13	57	36	32	4	48	2	1	2	2	2	4
			2	104	13	26	62	48	14	50	34	2	49	1	0	81	3	6	86	26	0	63	1	11	63	40	27	2	55	1	0	2	0	1	1
			X	13	100	0	0	73	54	31	15	0	62	8	0	92	0	8	100	54	0	92	0	0	77	69	23	8	69	0	0	0	0	0	0
	75	Development of technology for controlling the structures and properties of solid interfaces at the atomic level.	1	213	26	27	46	65	38	50	12	1	76	15	8	62	1	4	76	41	3	66	1	9	56	47	35	4	54	0	0	2	2	2	4
			2	168	23	25	52	62	31	57	11	1	79	5	4	66	0	3	83	36	1	74	1	8	65	48	32	4	59	1	0	2	1	1	2
			X	38	100	0	0	80	61	39	0	0	79	8	3	61	0	0	82	53	3	89	0	3	63	53	32	8	66	0	0	3	0	0	3
	76	Development of technology to analyze the chemical species of solid surface atoms.	1	208	23	29	49	57	25	52	22	1	60	11	6	67	0	3	72	50	2	57	1	12	48	38	35	8	50	0	0	1	2	3	4
			2	165	22	25	52	55	19	62	17	1	65	4	3	72	0	2	85	44	1	67	1	8	56	38	30	6	59	0	0	2	2	2	2
			X	37	100	0	0	69	43	46	11	0	68	5	0	65	0	0	89	54	0	70	0	3	54	46	27	11	59	0	0	3	0	3	0
	77	Development of a technique for manufacturing of p-n junctions of diamond.	1	148	11	29	59	55	22	55	20	3	83	27	6	28	3	7	75	33	15	68	1	7	49	50	27	2	49	0	2	2	3	1	3
			2	113	12	27	60	53	15	67	17	1	87	19	4	28	1	4	86	25	7	81	1	4	54	58	21	3	54	0	0	1	2	1	1
			X	14	100	0	0	73	50	43	7	0	79	29	0	43	7	0	100	43	21	93	0	0	71	71	14	7	64	0	0	0	0	0	0
	78	Development of a heteroepitaxial technology for growing any semiconductor material on silicon substrate.	1	161	17	34	48	66	39	49	11	2	85	22	8	35	6	9	76	36	6	75	1	9	53	47	30	2	48	0	2	4	2	1	5
			2	126	17	29	54	62	29	60	10	1	94	11	3	33	2	9	81	28	1	83	1	6	63	51	24	2	51	0	0	6	0	0	2
			X	22	100	0	0	88	77	18	5	0	91	18	0	36	5	5	82	23	0	95	0	0	68	41	27	5	59	0	0	9	0	0	0
	79	Development of the technology to fabricate large-area (inch order) compound semiconductor single crystal film on glass substrates.	1	157	14	32	54	62	32	54	13	1	83	28	11	25	3	9	63	27	5	63	1	18	49	50	25	2	46	1	1	6	1	2	5
			2	126	14	27	59	58	22	66	10	2	90	15	10	21	2	6	71	21	1	73	2	13	60	62	18	3	54	0	0	6	0	1	2
			X	18	100	0	0	74	50	44	6	0	89	22	17	28	6	0	78	22	0	89	0	6	56	67	22	6	61	0	0	6	0	0	0
	80	Development of heteroepitaxial technology for growing large-area (inch order) diamond thin films on hetero-substrates.	1	157	13	32	55	58	25	58	16	1	83	22	8	27	2	8	71	28	12	67	1	11	50	50	31	1	43	0	1	2	1	3	4
			2	122	12	29	59	55	17	71	12	0	92	14	5	21	1	3	81	20	6	76	2	8	61	65	23	2	49	0	0	3	0	2	2
			X	15	100	0	0	73	47	53	0	0	87	27	7	27	0	0	93	33	0	87	0	0	73	73	27	7	53	0	0	7	0	0	0

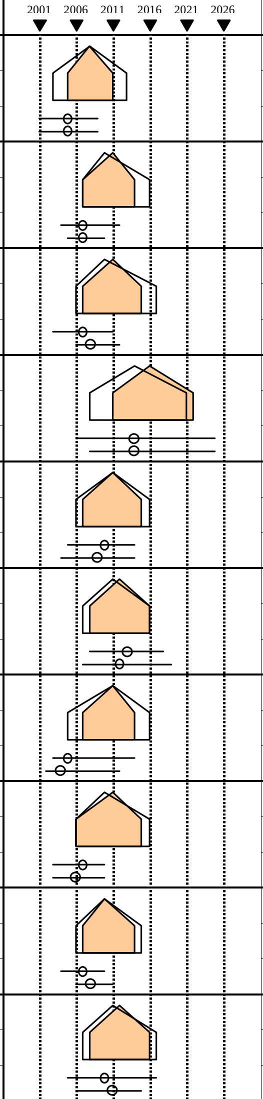
Forecasted realization time



(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic development	Expected effect: Resolution of global problems	Expected effect: People's needs	Expected effect: Expansion of intellectual resources	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	Leading countries: EU	Leading countries: Former Soviet Union and Eastern Europe	Leading countries: Japan	Leading countries: Other countries	Leading countries: Do not know	Measures the government should adopt (%): Foster human resources	Measures: Promote exchanges among industrial, academic and government sectors and different fields	Measures: Upgrade advanced facilities and equipment	Measures: Develop a research base	Measures: Increase government research funding	Measures: Adjust regulations (relax/toughen)	Measures: Others	Potential problems (%): Adverse effect on the natural environment	Potential problems: Adverse effect on safety	Potential problems: Adverse effect on morals, culture or society	Potential problems: Other adverse effects
Semiconductor and electronics	81	Development of technology for embedding impurities, and repairing defective crystallized silicon surfaces by STM-associated technology.	1	166	17	30	53	56	25	50	23	1	78	9	4	41	4	5	75	38	2	66	2	8	52	43	38	1	43	1	0	2	1	2	6
			2	136	13	32	54	54	18	61	20	1	85	4	3	41	4	4	85	34	0	77	1	5	64	45	32	1	49	0	0	0	0	1	2
			X	18	100	0	0	63	33	50	17	0	78	11	6	50	6	6	100	56	0	94	0	0	67	50	39	6	50	0	0	0	0	0	0
	82	Development of innovative single crystal silicon manufacturing technology.	1	139	16	27	58	74	53	39	8	0	87	43	9	22	4	20	60	26	8	58	2	19	45	45	29	2	40	1	1	7	1	3	5
			2	117	12	29	59	75	56	34	10	0	91	33	3	18	1	14	73	21	4	72	2	10	56	56	25	3	48	1	1	5	0	1	3
			X	14	100	0	0	86	71	29	0	0	93	50	7	36	0	7	79	43	7	93	7	0	57	71	14	7	57	0	0	0	0	0	7
	83	Practical use of technology for constructing material through the employment of ions and particle beams with controlled characteristics.	1	159	14	31	55	56	24	54	20	1	88	16	8	33	3	9	72	37	6	61	1	13	47	44	39	4	45	0	2	4	2	2	5
			2	124	14	31	56	56	23	58	18	2	87	8	4	36	1	6	84	27	1	70	1	8	59	48	38	2	53	0	0	1	0	1	2
			X	17	100	0	0	72	50	38	13	0	88	24	6	35	0	6	100	47	0	82	0	0	59	65	41	6	53	0	0	0	0	0	0
	84	Practical use of multi-layer solar cells with a conversion efficiency of more than 50%.	1	177	10	24	66	84	71	25	4	1	67	88	19	16	13	14	67	30	5	71	1	10	42	53	32	4	51	7	1	12	2	4	4
			2	150	9	21	71	91	83	15	2	0	74	89	16	13	8	10	73	21	1	83	1	8	51	66	18	2	69	5	2	11	1	1	1
			X	13	100	0	0	100	100	0	0	0	54	100	23	8	0	0	92	46	8	92	8	0	69	92	8	8	69	8	0	23	0	0	0
	85	Practical use of large-area amorphous silicon solar cells with a conversion efficiency of more than 20%.	1	183	10	25	65	84	70	27	3	0	64	86	19	10	3	7	63	27	2	78	1	8	39	54	27	4	50	8	1	10	1	2	4
			2	144	8	24	68	91	82	16	1	0	65	88	13	6	1	7	71	19	1	83	1	6	47	67	16	3	69	6	1	10	1	0	1
			X	12	100	0	0	86	73	27	0	0	50	92	17	8	0	0	75	25	17	83	0	0	42	92	17	0	50	8	0	17	0	0	0
	86	Development of X-ray free electron lasers with a wave-length of a few dozen Å.	1	98	6	20	73	57	28	45	26	1	67	17	2	56	1	16	78	33	10	43	2	14	47	44	30	3	50	0	1	8	8	2	2
			2	75	7	13	80	52	21	47	32	0	68	8	1	60	1	7	88	33	1	49	1	7	60	40	24	3	61	0	0	4	5	1	1
			X	5	100	0	0	88	75	25	0	0	60	40	0	80	0	0	100	60	0	80	0	0	60	100	20	20	80	0	0	0	0	0	0
	87	Practical use of industrial equipment that produces high-power excimer lasers in the order of 10kW.	1	88	7	16	77	53	17	61	21	1	81	17	5	22	0	14	73	42	8	51	1	9	38	52	28	3	44	1	1	6	8	2	2
			2	72	4	15	81	50	10	70	20	0	85	10	1	18	0	8	89	35	3	50	1	6	39	64	25	1	46	0	0	4	3	0	1
			X	3	100	0	0	75	50	50	0	0	100	33	0	33	0	0	100	67	33	67	0	0	33	100	0	33	67	0	0	0	0	0	0
Composite	88	Practical use of function-gradient materials that have undergone successive transformation from metallic to ceramic properties.	1	238	17	27	56	58	25	58	18	0	81	39	13	17	2	6	55	25	6	65	2	16	53	54	32	7	46	1	0	8	4	3	4
			2	198	15	26	59	56	20	64	16	0	87	32	7	12	1	6	58	16	3	80	1	11	62	61	23	2	50	0	1	9	3	2	3
			X	30	100	0	0	63	32	54	14	0	77	47	13	17	3	3	67	20	3	93	0	0	57	50	20	3	53	0	0	17	3	3	3
	89	Practical use of oxidation-resistant carbonfiber reinforced carbon composite materials.	1	184	22	27	51	58	27	51	21	1	84	40	14	14	3	8	65	23	4	61	1	11	47	49	27	5	49	0	1	9	4	3	3
			2	158	18	25	57	55	19	63	18	0	91	29	7	9	2	6	75	16	3	68	1	8	51	58	15	2	58	0	1	11	3	1	2
			X	29	100	0	0	69	42	50	8	0	83	48	7	7	7	0	83	24	7	66	0	0	52	52	24	7	59	0	0	17	7	0	3
	90	Practical use of organic and inorganic composite materials (nano-composites) with constituent parts in the order of tens to hundreds of Å.	1	224	15	38	47	54	19	60	21	0	83	23	16	30	3	5	63	32	3	65	1	14	50	53	29	4	49	0	1	6	3	3	4
			2	181	13	38	49	52	12	72	16	0	88	12	7	32	2	4	70	22	1	74	1	12	63	62	23	1	57	0	1	9	2	2	3
			X	24	100	0	0	59	18	82	0	0	79	21	8	33	0	0	79	29	0	83	0	0	63	54	21	4	50	0	0	13	0	4	4

Forecasted realization time



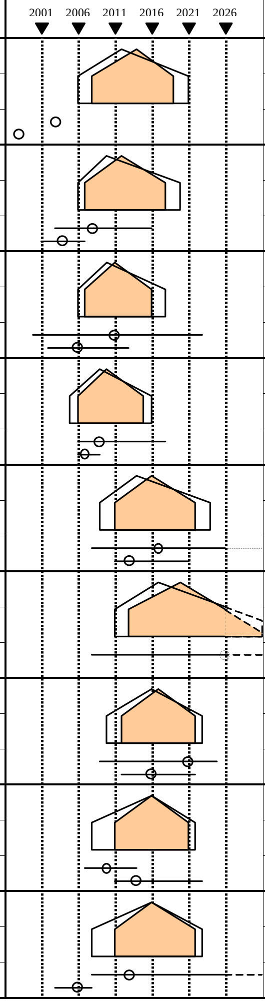
(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic development	Expected effect: Resolution of global problems	Expected effect: People's needs	Expected effect: Expansion of intellectual resources	Forecasted realization time (2001 2006 2011 2016 2021 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Composite	91	Widespread use of intelligent materials which have the ability to perform self-diagnostics and repair.	1	226	16	28	55	61	31	53	14	1	81	30	39	23		10	10	64	24	1	61	0	17	54	54	23	5	49	1	2	6	7	4	4
			2	188	13	28	59	59	26	59	14	1	86	22	33	22		11	7	69	14	0	63	1	15	62	59	16	3	56	2	2	5	10	1	2
			X	24	100	0	0	70	46	46	4	4	92	17	38	38		8	4	71	17	0	79	4	4	46	46	25	0	63	4	0	0	8	0	0
	92	Practical use of organic hybrid composite materials of a controlled structure at the monomolecular level.	1	182	14	31	55	54	20	60	19	1	83	21	16	36		3	8	63	38	2	56	1	20	59	47	24	4	37	1	2	7	2	2	5
			2	145	12	32	57	53	13	72	13	1	83	14	7	41		3	1	69	30	0	63	1	19	68	55	16	1	47	0	1	8	1	1	2
			X	17	100	0	0	63	29	65	6	0	88	12	12	47		6	0	76	53	0	88	0	0	59	65	12	6	53	0	0	6	0	0	0
	93	Practical use of a bonding technology of ceramics and metals which resists to the repetition of temperature change over 500°C.(So far less than 400°C)	1	180	18	27	56	58	26	55	19	1	82	47	17	9		2	3	67	31	7	66	0	14	48	47	34	6	49	1	1	8	3	2	4
			2	149	15	26	59	57	21	65	14	0	86	35	11	5		1	5	73	17	2	69	0	11	52	49	23	3	55	0	1	9	2	1	4
			X	23	100	0	0	74	48	52	0	0	83	61	9	13		4	0	83	17	4	70	0	4	48	35	26	9	57	0	0	4	9	4	4
	94	Development of a technology to manufacture composite materials and products with nano-scale level structures, using the phase of super-plasticity.	1	136	18	26	56	51	17	55	26	2	86	22	7	23		3	9	65	29	5	63	0	14	46	48	29	4	44	1	1	5	3	1	6
			2	106	13	25	61	47	9	63	25	2	91	13	2	25		4	5	70	14	0	72	0	8	58	53	20	2	58	0	0	7	1	1	3
			X	14	100	0	0	54	21	50	29	0	86	21	0	21		7	0	64	21	0	79	0	0	57	43	14	7	50	0	0	0	0	0	0
Other	95	Practical use of computer-aided material design of solid catalysts with specified composition, organization, and physical properties.	1	138	9	24	67	59	26	58	14	2	75	33	7	38		7	7	72	38	3	49	1	17	54	43	22	28	41	0	1	6	2	1	5
			2	108	9	21	69	52	11	76	12	1	76	22	5	44		6	8	81	28	0	50	1	15	72	39	15	25	42	0	1	5	1	0	4
			X	10	100	0	0	58	20	70	10	0	60	20	20	80		0	20	90	50	0	90	0	0	60	60	10	40	60	0	0	0	0	0	10
	96	Development of computer simulation technology enabling the precise prediction of structures and physical properties in an isothermal equilibrium state, provided element compositions are given in materials made more than one element.	1	176	9	27	65	60	29	54	16	1	68	20	5	66		6	11	72	38	4	48	1	16	56	36	22	27	44	0	0	3	1	3	5
			2	140	3	29	68	55	18	67	15	0	71	11	2	71		3	9	81	29	2	52	1	14	74	36	17	24	51	0	1	1	0	1	4
			X	4	100	0	0	75	50	50	0	0	75	0	0	50		25	0	100	25	0	25	0	0	50	50	25	25	25	0	0	0	0	0	0
	97	Development of first-principle computer simulation technology (new algorithm) of 10,000 atom scale.	1	136	11	23	66	53	19	55	23	2	42	11	5	80		1	11	78	43	4	49	1	13	60	26	29	12	52	1	0	2	1	2	5
			2	111	4	21	76	49	11	64	24	1	49	6	3	82		1	12	83	28	2	45	1	8	70	20	23	12	54	0	0	1	0	1	5
			X	4	100	0	0	63	25	75	0	0	75	0	0	75		0	0	100	50	0	100	0	0	100	0	50	0	100	0	0	0	0	0	0
	98	Establishment of technology to detect a single nuclear spin.	1	80	11	16	73	45	14	41	39	5	28	5	3	88		9	19	66	38	3	31	1	16	54	30	24	6	43	3	0	3	4	4	5
			2	63	5	25	70	44	13	40	45	2	29	3	2	92		6	16	84	38	2	32	2	11	70	35	24	3	60	0	0	2	0	2	3
			X	3	100	0	0	50	0	100	0	0	67	0	0	100		0	0	67	0	0	33	0	33	100	33	0	0	100	0	0	0	0	0	0
	99	Practical use of equipment capable of ultra-micro-analysis up to the ppt level (in the order of 10^{-12}; e.g. oxygen, carbon and nitrogen).	1	143	7	25	68	57	26	53	21	1	64	22	6	55		4	4	69	52	3	54	1	13	48	41	35	8	41	1	1	3	2	3	4
			2	116	6	23	71	54	17	65	18	0	77	14	3	62		1	3	78	52	1	66	1	9	59	51	34	5	51	0	1	1	1	1	3
			X	7	100	0	0	82	71	14	14	0	71	43	0	71		0	0	86	43	0	57	0	14	86	43	43	14	43	0	0	0	0	0	0
	100	Development of technology for inducing and measuring ultra-high vacuums in the order of 10^{-14} torr.	1	139	12	27	61	57	26	49	24	1	63	6	4	67		1	9	69	42	2	50	1	14	55	40	34	4	49	1	1	2	2	3	5
			2	110	9	27	64	53	19	56	24	1	66	1	1	71		1	5	81	35	0	61	1	10	66	40	33	3	65	0	2	1	0	1	3
			X	10	100	0	0	70	50	30	20	0	80	0	0	60		0	0	70	30	0	70	0	0	80	30	30	10	60	0	10	10	0	0	0

(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Medium	Low	Importance (index, %): Index	High	Medium	Low	Unnecessary	Expected effect (%): Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Other	101	Establishment of technology to measure minute levels of force (10^{-19} neutons or less).	1	77	3	30	68	47	15	46	36	3	38	5	4	78	4	10	68	38	8	38	0	16	51	30	30	3	51	0	0	1	3	3	9
			2	56	2	38	61	46	11	50	39	0	43	2	2	82	2	5	82	39	2	43	0	11	64	36	32	4	63	2	0	0	0	2	5
			X	1	100	0	0	100	100	0	0	0	100	0	0	100	0	0	100	0	0	100	0	0	100	100	0	0	0	0	0	0	0	0	0
	102	Practical use of online processing technology systems capable of forecasting and controlling size and shape with an accuracy in the order of 10Å.	1	128	7	24	69	62	33	51	13	2	84	8	5	32	5	7	63	29	2	63	0	13	46	40	34	4	48	2	0	4	2	3	5
			2	99	5	19	76	61	30	52	18	0	86	3	2	33	4	5	71	18	1	77	0	10	60	44	24	4	57	0	0	2	0	1	3
			X	5	100	0	0	90	80	20	0	0	100	0	0	0	0	0	80	20	0	60	0	0	20	40	20	0	60	0	0	0	0	0	0
	103	Practical use of technology for identifying the morphology of solid configurations in the order of molecular level.	1	120	9	29	62	55	23	53	24	1	61	12	9	69	1	11	73	40	3	56	1	13	43	33	29	5	48	0	1	3	2	3	7
			2	101	8	19	73	52	16	59	25	0	64	3	6	77	0	10	85	32	1	67	0	9	61	33	25	5	57	0	1	1	1	1	6
			X	8	100	0	0	59	25	63	13	0	88	13	13	75	0	0	63	25	0	75	0	13	63	50	38	13	63	0	0	0	0	0	0
	104	Development of technology to control magnetic flux in super-conductors.	1	81	7	31	62	54	22	51	27	0	69	31	6	51	1	6	72	43	11	62	0	12	53	35	32	1	48	1	0	4	4	2	5
			2	56	7	29	64	52	16	61	23	0	73	21	5	57	0	7	79	36	5	63	0	13	63	32	25	4	45	2	0	0	2	0	4
			X	4	100	0	0	50	25	25	50	0	100	0	25	100	0	0	100	75	25	100	0	0	75	50	50	0	50	0	0	0	0	0	0
	105	Widespread use of technology to directly synthesize hydrogen superoxide from hydrogen and oxygen.	1	76	11	25	64	51	18	51	30	1	58	59	4	22	1	14	54	32	3	42	1	28	39	38	28	4	33	1	0	7	4	0	9
			2	61	8	26	66	50	11	66	23	0	66	57	2	16	0	13	62	23	0	49	0	25	46	51	20	3	46	0	2	8	0	0	7
			X	5	100	0	0	70	40	60	0	0	100	40	0	20	0	20	100	60	0	80	0	0	40	40	20	0	60	0	0	0	0	0	0
	106	Development of technology to produce materials of a condition in which single-lattice bonding is fused (sp2.5, etc.), in a terapascal-level (10 million atmospheres) or greater environment.	1	56	9	29	63	46	17	39	41	4	52	7	2	80	9	14	64	27	21	38	0	18	54	27	27	5	41	0	0	7	2	2	5
			2	39	0	26	74	41	8	42	47	3	49	3	0	79	5	18	74	23	15	44	0	18	62	26	31	3	51	0	0	3	0	3	3
			X	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	107	Practical use of processes for water decomposition by the sunlight.	1	163	8	26	66	79	63	30	5	2	50	90	13	20	6	12	55	33	4	55	1	20	47	38	27	3	52	2	1	14	4	2	4
			2	143	5	23	72	85	73	24	1	1	47	88	7	15	4	10	64	27	1	69	1	17	52	36	18	1	66	1	1	20	2	1	3
			X	7	100	0	0	100	100	0	0	0	57	100	0	14	14	0	71	43	0	100	0	0	43	71	43	0	86	0	0	14	0	0	0
	108	Practical use of carbon dioxide fixation technology necessary for protecting global environments.	1	189	8	24	68	78	61	33	5	2	42	95	10	11	6	11	52	39	2	56	2	23	46	42	23	5	60	10	2	23	1	2	3
			2	153	6	22	72	84	72	24	3	1	37	94	4	8	4	6	61	34	1	69	1	20	53	49	15	0	75	7	1	26	1	1	1
			X	9	100	0	0	75	63	13	25	0	33	100	11	33	11	22	67	56	0	100	0	0	33	56	22	0	78	22	0	11	0	0	0
	109	Widespread use of desert afforestation technology through the advancement of water retention technology and biotechnology.	1	167	5	11	84	62	38	34	27	1	39	94	16	7	2	8	41	24	5	39	5	32	46	39	18	8	59	6	6	30	2	2	3
			2	142	1	10	89	62	36	42	21	1	33	96	7	2	2	4	58	24	1	52	3	27	57	39	10	4	78	3	4	32	2	1	2
			X	2	100	0	0	100	100	0	0	0	100	100	50	50	0	0	100	100	0	100	0	0	0	50	0	0	50	0	0	50	0	0	0

Forecasted realization time



(Note) See page 7 for the interpretation of the graphs.

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2. Survey results in “Electronics”

2.1. Trends in noteworthy domains

In 1996 sales by Japan’s electronics industry amounted to more than 21 trillion yen, of which semiconductors, computers and household electrical appliances accounted for about one third. The growth in sales of the first two over the past few years has been remarkable. We divided the overall field into the following four classifications based on industrial scale and potential for future development, and drew up forecast topics using a table listing various technological levels from the discovery of new phenomena to the widespread use of the technology.

(a) Microelectronics

(b) Optoelectronics

(c) Molecular, sensor and bioelectronics

(d) Storage and display electronics

Here we shall review each of the domains, and look behind the formulation of forecast topics in the future.

(Ken-ichi Iga)

2.1.1. Microelectronics

(1) Basic technology

Electronic devices that incorporate microelectronics technology are growing smaller and smaller, and the ultimate destination in this quest for minuteness is the atom, the smallest unit of substance, molecule and cell. Very rarely do they display the necessary functions for electronics by themselves, but the development of extreme technology that can observe, measure and manipulate these units of substance, and research aimed at incorporating mezoscopic singular phenomena into electronics by making full use of these technologies is a dream of researchers and engineers who explore the extremes. And the progress in scanning probe microscopes (tunneling microscope, interatomic microscope, etc.), lithographic technology and materials and processing technology over the past five years has served to further fuel their enthusiasm. “01: Development of technology capable of manipulating single atoms and single molecules” is a fairly typical example of such technology. Topics such as “02: Practical use of quantum-phase devices” and “03: Practical use of LSIs using single-electron transistors” represent this technological dream, and do not necessarily indicate the direction we expect this kind of technology to proceed. Rather, we wanted to gauge the thoughts of respondents as to whether this could become one of the courses along which science and technology will travel. Similarly, we included “04: Artificial realization of the mechanism by which single-cell organisms etc. respond to external stimuli” as one technological dream of basic biosensor elements. At times technological innovation and new discoveries push basic microelectronics technology well beyond our expectations, but until this technology becomes highly reliable and can be incorporated stably within systems, we look forward to a range of challenging elemental technology leads, and to the efforts of experts who tackle the verification of such leads with far-reaching vision.

(Koji Kajimura)

(2) Highly integrated, high-capacity, ultra-small, large-scale

Semiconductor integrated circuits are the “nervous system” of our information-based society, and miniaturization has enabled the industry to increase both their density and speed. Design rules are such that size decreases by a factor of ten every 15 years. A size of 10μm in 1970 became 1μm in 1985. In 1995 it became 0.35μm, so we can expect it to become 0.1μm in 2000. Considering 0.04μm devices are in operation today, it is believed there are no physical limitations at least, but there are doubts as to whether lithographic technology in the post-0.1μm era lends itself to mass production.

Therefore forecasting the realization time of “05: Practical use of technology which allows mass processing of 10nm patterns" is crucial to the semiconductor industry.

As for increasing density, in DRAM a fourfold increase every three years has been maintained: 1Kb in 1970 was 64Kb in 1980, so 64Mb in 1995 can be expected to be 1Gb in 2001. So whether topic "06: Practical use of VLSI with as much as 256 Gbits of memory per chip" can be achieved at the forecasted time is a critical point.

As for wafer size, 50mm in 1970 increased to 125mm in 1980, so 200mm in 1995 can be expected to increase to 300mm in 2001. In this light, it is important to have a feel for when the topic "07: Widespread use of wafers one meter in diameter," as basic semiconductor technology, will be realized.

EEPROM, a type of nonvolatile memory, began at 4Mb in 1992 and shifted to a 64Mb mass-production structure in 1996. Consequently, the realization time, including usage, of topic "08: Practical use of non-volatile random access semiconductor memory with more than 100 Gbits capacity" is important.

(Kazuo Tsubouchi)

(3) Low power consumption, user-friendly, high productivity

The rapid progress of semiconductor technology continues to hasten the advent of a multimedia world. This is a world crisscrossed by information networks offering an array of services, accepted by society and designed to make the life of the individual and the group richer and more fulfilling. And in leisure, art and other aspects that form the essence of human life, new and vivid cultures will take shape.

Most information transmission, storage and processing is done through semiconductors. So in this sense, semiconductor technology forms the very foundations upon which our information society grows and prospers. History to date has shown us that each step semiconductor technology takes forward is accompanied by the emergence of new information services. We can say that the progress of semiconductor LSI has two sides: 1) the development of chip architecture, and 2) the cultivation of more minute and faster domains through the introduction of new structures and new materials.

The aim of R&D in microelectronics technology is to "readily produce user-friendly high-performance LSI," and in this light, we set topics 17–30.

Topics 17, 18 and 19 tackle microelectronics from an energy perspective. Demand for LSI processing function as a tool for information processing and transmission continues to rise, so if we are to maintain its ease of use, we have to improve the degree of integration while significantly reducing its energy consumption, and from this viewpoint, we set topic "19: Development of processor LSIs with 10 GIPS performance and power consumption of 10 milliwatts or less."

Topics 20–25 asked how close the superior capabilities of semiconductor LSIs can get to human functions. We set several topics with different levels of human-like functions, such as voice recognition, automatic interpretation, housekeeping, and understanding emotions.

Topics 26–30 took up the theme of LSI productivity. While there may be some concern that topic "28: Practical use of systems in which LSI chips are produced automatically from LSI design data," which looks at the possibility of producing LSI chips from advanced design technology and especially top conceptual designs, may be a little too general, the topic asks experts whether they believe the dreams of present-day SiLSI engineers can be realized.

The following are some comments about the survey results.

Interest in solar cells as a substitute for fossil-based energy is high. The extent of interest in "18: Development of solar cells capable of maintaining 15% efficiency for at least 10 years without light convergence" and "30: Practical use of solar cells which make the cost of power generation facilities less than 100 yen/watt" is an indication that respondents are looking to electronics technology to contribute to the development of clean energy, and through this, play an important role in the fight against global warming. Both topics set concrete targets, and both are expected to be realized between 2010 and 2012.

A similar interest can be seen in energy in topic "19: Development of processor LSIs with 10 GIPS performance and power consumption of 10 milliwatts or less." This reflects the respondents' awareness that as tools for information processing and transmission, semiconductor devices have to be portable. But considering the substantial gap between the high target in the topic and current LSI performance, the topic's realization is not expected until 2014. Additionally, quite a few respondents indicated that it would not be realized at all.

We believe the level of interest in "24: Widespread use of a portable multimedia wireless terminal which can be used throughout the world" can be put down to the mobile communication boom over the past few years and its enormous impact on our life culture. "Following the telephone is the image," and against this technological catch-phrase, expectations of wireless terminals that can be used over a wide area are high. And in the forecasted realization time of 2011, we can see the optimism with which the respondents view this technology.

As for application of SiLSI, while some skepticism could be seen in forecasts about technology that could bring LSI functions close to human functions as a total system, as seen in topics dealing with artificial intelligence (topic 21), housekeeping robots (topic 25) and the like, respondents did forecast the early realization of personal aids with limited functions, such as voice recognition (topic 22) and automatic translation systems (topic 23).

(Hiroyuki Abe)

(4) High speed, super-paralleling, high sensitivity, high performance

Fifty years have passed since the transistor was invented, and throughout this time, the pursuit of higher speeds and higher frequencies has been an enduring theme. There is no application significance in the speed of simple basic gate circuits alone, so we focused on LSI speed in topic "09: Practical use of semiconductor LSIs that operate at a switching speed of 1 ps or less." As for frequency, we set topic "10: Practical use of wide-band solid-state amplifiers operated at high frequencies of around 100-1,000GHz," which differs little from the previous survey.

Developing new devices that can take over from transistors in the next era is a crucial challenge facing the microelectronics industry, and in this light, we set topics "11: Development of super-conducting three-terminal devices with amplification capabilities" and "12: Development of high-speed, highly-integrated devices that switch by the movement of a single atom."

Microprocessor performance is improving in rapid strides, and is forecasted to reach 1,000–2,000 MIPS (mega-instructions per second) in 2000. The greater speeds and performance that advances in microprocessor technology have given to computers and various other systems have impacted enormously on our socioeconomic lives, and forecasts here are important, so we set topic "13: Practical use of TIPS (tera-instruction per second) level microprocessors." As for improvements in sensitivity and resolution, we set topic "14: Development of X-ray microscopes capable of 10-100nm resolution," which differs little from the previous survey.

From the viewpoint of high performance, high function, system integration and intellectual integration, we assumed a neuron scale that enables high-level recognition, and set topic "15: Practical use of semiconductor neural network chips on the order of one million neurons." And regarding the effective use of high-temperature superconducting materials, we set "16: Widespread use of high-temperature superconducting materials in passive circuits for millimeter-wave communication systems."

Topics 13 and 09 are ranked 5th and 8th in importance to Japan among the 74 topics in this field, and at 95%, the assessment regarding their contribution to socioeconomic development is extremely high. Topic 13 is forecasted to be realized in 2018, and has the highest response rate. For leading country assessment, the USA is well above the other countries and regions with 93% (Japan is around 50%), indicating the USA's dominant position in this domain. As for measures, the government first has to "foster researchers, engineers and research assistants," and the higher the level of expertise of the respondents, the greater the demands for increased government research funding. As for topic 09, the forecasted realization time is 2015, Japan and USA are at roughly the same level in leading countries with about 80%, and the government has to "foster researchers, engineers and research assistants." For topics 14 and 12, highest expectations among the respondents are in "expansion of intellectual resources," and realizations times are, respectively, 2015 and 2018.

(Tetushi Sakai)

2.1.2. Optoelectronics

This domain began with the appearance of the laser in 1960. Various types of lasers covering a broad spectrum from infrared to ultraviolet through various media have been produced, and from this have emerged a range of technologies and industries. In 1995 the output of Japan's optoelectronics-related industries amounted to four trillion yen.

Optical fiber communication has been the engine driving research and technological development in this domain, and for 20 years from 1970, the bulk of international communication through land-line and submarine cable depended on optical fiber networks. In the 1992 survey the practical use of submarine cables exclusively for optical relay was forecasted at 2007, but it was completed by 1996. Technological development to produce greater capacities and faster speeds surged ahead from about 1996, and studies into clock speeds of 10 Gbits/s (gigabits/second) and multiplexing 100 channels or more led to the realization at the research level of a transmission capacity equivalent to more than 2 Tbits/s (terabits/second) through a single optical fiber. Also from about 1996 optoelectronics technology made its way into computers, and from here important advances have been seen in optical interconnecting technology that allows transmission speeds of more than 1 Gbits/s at a lower cost.

Optical memory achieves the largest sales in the optoelectronics industry. Compact disks began kicking analog records off the shelves from about 1984, and from here, the small size and light weight of digital technology found its way into portable electronic devices and automobiles. And through a linkage of GPS and the optical fiber gyroscope, a booming market for automobile navigation systems had been created. It is well known that large analog optical disks are used for *karaoke* music, but in the latter half of 1996, development work into the digital videodisk (DVD) was for the most part completed, and the commercialization of this new technological application began. Contributing to this has been the practical application of red semiconductor lasers. From 1996 research into blue semiconductor lasers gained momentum with a view to higher capacity optical disks, and with this we have begun to see the possibilities for gallium nitride materials. Thus we set several topics in expectation of the emergence of what is perhaps best described as the file electronics domain whose key is the high-capacity optical disk. GaN blue LEDs and green LEDs have already been put to practical use, and from 1996 they began to be applied in large panel displays and traffic lights. And considering their high efficiency, we have now entered an era in which we can realistically look at semiconductors for lighting, and we have included related topics to reflect this.

Another major domain is optoelectronics equipment, such as laser printers and copiers, and improvements in the performance of computers and their ever-increasing reach are expanding the market, and generating demand among users for faster speeds. In 1996 multi-beam systems using surface light-emitting laser arrays were looked at for the first time, and research into memory based on optical interconnection became more active, so we set topics to reflect this.

Sensing and control technology using light is one domain that shows tremendous promise. Though the market is still only quite small, there is no doubt that it will expand and achieve considerable reach. Optical operation is also an interesting theme, so we included a related topic in this survey as well. But we are not sure how this will change once devices that apply this technology appear in the market. There are numerous other domains, such as the medical application of light, optical processes, energy development, and display and art, but looking at industrial scale, we did not include a large number of topics in this survey.

(Ken-ichi Iga)

2.1.3. Molecular, bio, sensor electronics

(1) Molecular electronics

Research interest in the molecular devices proposed in the beginning of the 1980s faded for a while because of a lack of a way to access individual molecules, but advances in scanning tunneling microscopes and interatomic microscope in the mid 1990s are beginning to provide the access means, and once again research in this area is gathering pace. Over the past couple of years, research institutions in Europe and the U.S. in particular have been locked in fierce competition to be the first to gain access to single molecules, an achievement that would lay the first block in the construction of molecular electronics, and international conferences are being held frequently.

In Japan, molecular devices are being approached from two angles. The first is to functionally replace the current inorganic material, making effective use of the flexibility of molecules and their size adaptability, while the other is to realize ultra-high performance devices, focusing on the functions of single molecules. In this survey there are eight topics dealing with molecules, while in the previous survey there were only three, indicating a growing awareness about the importance of molecule-related technology. Three topics cover the first approach — “35: Practical use of lasers, optical switches, and other devices by means of solid organic materials,” “69: Practical use of high-efficiency light energy converters utilizing organic materials” and “71: Development of super-large-scale flat panel displays utilizing organic materials”; and five cover the second approach — “01: Development of technology capable of manipulating single atoms and single molecules,” “12: Development of high-speed, highly-integrated devices that switch by the movement of a single atom,” “51: Development of logic LSIs and memory LSIs in which the basic switching element is a single molecule,” “58: Practical use of biosensors capable of identifying single molecules” and “66: Development of a storage system in which one atom or molecule corresponds to 1 bit.”

Among these, topics 01 and 12 are ranked in the top five in degree of importance regarding the expansion of intellectual resources, and topic 69 is in the top three regarding the resolution of global problems, which backs up the high expectations of molecular electronics as the next paradigm to follow the present semiconductor electronics. To realize these research topics, “foster researchers, engineers and research assistants” (topic 58) and “ increase government research funding” (topic 66), are in the top five in degree of importance as effective measures the government should take, indicating a recognition among respondents that measures to promote research are essential in this area.

(Yasuo Wada)

(2) Bioelectronics

In the early 1980s the concepts of molecular devices, bio-devices and biocomputers attracted the S&T spotlight around the world, and since then the three bioelectronics domains of 1) molecular and super-molecular structures, 2) cells and cell tissue, and 3) brain and nervous system have evolved independently at their own levels.

R&D on biodevices made up of molecular and super-molecular structures is closely linked to that on molecular devices, but biodevices are highly distinctive in that protein is the main structural element. Although there were various problems along the way, an important turning point came in the early 1990s with the mass production as practical devices of biosensors designed to give full play to the electronics functions of proteins. And the future looks bright for R&D in the construction of biodevices by artificially altering proteins through protein engineering and other pioneering technologies.

Rapid progress is being made in R&D into the construction of biodevices using cells or cell tissue, and though expectations are high, there is still much to do. Attention is being drawn to conceptual R&D into technology to access life functions by applying advanced electronics technologies or optoelectronics technologies, such as scanning probing microscope methods, to cell structures.

In brain and nervous system bioelectronics as well, a major goal of R&D is to design technologies that allows us to access brain functions.

We set ten topics (50, 52, 54, 55, 58, 59, 62, 63, 64 and 65) to reflect these developments.

(Masuo Aizawa)

(3) Sensor electronics

Sensing technology is absolutely crucial in various industries, basic science, disaster prevention, the environment and various other areas, and its principles are indeed diverse, including photonics, superconductors, semiconductors, and quantum effect. Therefore, the production of individual sensor types or sensing technologies is not always in large volumes, and the industrial scale is comparatively small. Technology-intensive and expensive sensors in particular are more often than not produced only in small amounts. In this light, it is not easy to select topics that strike a good balance across the entire technological domain. In this survey we leaned toward the molecular, bio and sensor electronics area, so most of our topics cover these technologies. However, we also gave consideration to topics connected with sensor electronics in the microelectronics and optoelectronics domains.

The importance index for the molecular, bio and sensor electronics domain is lower than for other electronics domains, and we can probably attribute this to its relative low economic effect because of the demand factors mentioned above. In fact a look at the assessment of expected effect shows that while "contribution to socioeconomic development" ranks highest in the other domains, in molecular, bio and sensor electronics, "response to people's needs" is at the top. Among the items classified by objective, expectations of "expand intellectual resources" is quite high in the "high sensitivity and high resolution" item, which consist mainly of sensing-related topics over the entire electronics field. This can also be put down to the above-mentioned factors in the sensing domain. And in fact, topic "40: Development of high-sensitivity sensing technology using technology to control the quantum condition of light" assumes gravitational wave detection technology.

In any event, sensing technology is vital in a wide range of technological fields, and the technology-intensive high-sensitivity sensing technology in particular is essential in fields that are not necessarily talked about only in terms of economic effect, such as space and aviation, disaster prevention, and environment. Topic "60: Practical use of multiplexed sensing methods for materials with self-diagnostic capabilities" is one example of this. Sensor electronics is one domain where measures to promote R&D, such as injecting public funds into research as necessary, should be considered. If we look at the topics by objective, it is worth noting that the United States is dominant in "high sensitivity and high resolution," and also that voices calling for the government to "increase government research funding" are quite strong among the respondents.

(Kazuo Hotate)

2.1.4. Storage and display electronics

(1) Storage electronics

The development of magnetic memory technology for external memory use in computer systems did not always go smoothly in the 1980s, and memory capacity per unit area roughly doubled every five years. But advances over recent years have been remarkable to say the least, with capacity at least doubling every year, and now the per-bit cost of magnetic memory is less than one hundredth that of semiconductor memory. The 2.5-inch and 3.5-inch magnetic hard disks used in personal computers have a memory capacity of 1–5 Gbits and high access speed, and are highly reliable, so they are used for housing system software. Currently a magnetic memory density of 10Gbits per square inch is within reach, and topic "67: Development of a magnetic memory hard disk capable of recording 1,000 Gbits density per square inch" is forecasted to be realized around 2017.

The ubiquitous floppy disk has been a popular removable memory device, but of late it is beginning to be replaced by the IC memory card, which uses flash memory technology.

These days almost all personal computers are equipped with CD-ROM drives, so the production of optical disk memory is now around the 50 million a year mark. The DVD, which was developed in Japan, has about seven times the memory capacity of the CD, and if blue laser diodes can be used, it jumps to more than 25 times as great. Currently DVDs in the ROM form are used for replaying movies and in computer ROM devices, but in the future with the development of writable DVD-RAM, the scope of their use will expand enormously to such areas as music, digital broadcast recording, *karaoke*, films, and games, so world demand is projected to be around the 120 million mark in 2000. And realization of topic "68: Practical use of optical memories with recording density of 10^{11}b/cm^{2}" is expected around 2016.

While technology for parallel storage devices that arrange tens of small magnetic disk or optical disk storage devices is already being used in the construction of highly reliable high-capacity computer memory systems, topic "70: Practical use of small read/write optical filing systems with at least 1 terabyte capacity per system" is forecasted to be realized around 2012. (Ken-ichi Mori)

(2) Display electronics

The Cathode Ray Tube (CRT) has maintained its importance, and in 1996, 45 million units were produced earning 1.7 trillion yen. High-definition CRT with 1600×1200 and even 7680×4320 resolution for work stations and computer terminals have been developed, and with this, screens are becoming larger, and demand is shifting from 14-inch to 15- and 17-inch screens.

LCD technology is advancing rapidly. Full-color TFT-LCD has been developed, and its use in notebook computers has pushed production up to very close to the trillion yen mark. With the development of polysilicon TFT, the scope of small displays suddenly expanded, and have found a wide range of applications, such as viewfinders, digital cameras, NC, computers, and PDA. In the same way that Sony's Walkman brought to users a mobile concert hall, these small displays look as though they could bring mobile offices and mobile photo galleries to reality. Projection displays, too, are now finding greater use in electronic presentations and teleconferences.

One technology that has been attracting attention of late is the plasma display (PDP), and following on from the marketing of 20-inch displays are plans for large-screen PDP of 40 inches and larger. As for large outdoor screens, with the development of high-resolution blue LED, full-color LED display (2.56x1.92 meters) are now being put to practical use.

Among new trends are the FED, which utilizes electrical field discharge, and MMD, which utilizes micro-mirror arrays. Research into 3D displays, especially those that do not require the viewer to wear special glasses, is progressing, but the technology is still a long way off.

One point about future developments in this area that is raising interest is just how large screens can become. We have already seen large screens in Jumbotron and the LCS projection system, but the keys to the success of this technology is low cost, light weight and shallow depth. For example, it would be interesting to know whether we will ever be able to enjoy TV with an entire wall as the screen as if we were in a theater, or hold a TV conference in which participants feel as though they are actually at the conference site. As long as glass is used, there will always be limits as to how light screens can become. One solution to this could be organic polymer displays. The future promises to be exciting.

It is also interesting to travel to the other extreme, and find out just how small and highly defined screens can become. As an ultimate, and perhaps somewhat scary, feature, one topic asked whether an imaging system incorporated into glasses that directly projects images on to the retina can be realized, and its forecasted realization time is quite early.

(Hajime Ishikawa)

2.2. Forecast topic framework

In the course of compiling forecast topics, a framework representing the organization of technologies in tabulated matrix form was drawn up for each field, with objectives and technological domains defining the rows and columns of the table, respectively. The framework is designed to present an overall picture of technological development in each field in terms of future prospects, importance, etc. as seen from the present perspective, and is also used as a working framework for future reviews of forecast topics.

Table 2.2-1 Forecast Topic Framework for Electronics Field

Domain / Objective	Microelectronics	Optoelectronics	Molecular, sensor and bioelectronics	Storage and display electronics
Pursuit of new scientific principles, new phenomena and new devices	01 02 03 04	31 32 33 34 35	50 51 52	66
High integration and high capacity	05 06 07	36	53	67
Miniaturization and expansion in size	08		54 55	68
High speed	09 10 11 12 13	37	56	
Super-parallel processing		38 39		
High sensitivity and high resolution	14	40	57 58 59	
High performance, high functionality, systems integration and knowledge accumulation	15 16	41 42 43	60 61 62 63 64	69 70
High efficiency, high output and low power consumption	17 18 19	44		
Large scale and wide area		45 46 47		71 72
Intelligence, flexibility, ease of use, human interface and portability	20 21 22 23 24 25	48	65	73 74
High productivity, high reliability, low price, and rationalization of design and testing	26 27 28 29 30	49		

Figures appearing in the table represent topic numbers.

2.3. Topics with high degree of importance

Degree of importance index scores (Note 1) averaged at 67.7 for topics in the electronics field as a whole. Topics considered of particular importance to Japan (top 20 topics in terms of degree of importance index) are listed in the table below. While the top 20 were dominated by semiconductor-related topics, two relating to manufacturing technology were also included. As many as 4 topics were given a degree of importance index score of more than 90. The topic with the lowest degree of importance index score was ì74. Practical use of miniature file devices that fit inside a pair of glasses (46 points).

Table 2.3-1 Top 20 Topics in Terms of Degree of Importance Index

Topic	Degree of importance index	Forecasted realization time (year)
06 Practical use of VLSI with as much as 256 Gbits of memory per chip.	94	2014
30 Practical use of solar cells which make the cost of power generation facilities less than 100 yen/watt.	93	2012
05 Practical use of technology which allows mass processing of patterns with minimum line width as low as 10 nanometers.	93	2013
18 Development of solar cells capable of maintaining 15% efficiency for at least 10 years without light convergence.	92	2010
13 Practical use of TIPS (Tera Instruction Per Second) level microprocessors.	89	2018
08 Practical use of non-volatile, erasable with more than 100 Gbits capacity random access semiconductor memories.	88	2017
49 Production of household-use optical fiber signal tranceiver units at a cost of around 5,000 yen.	88	2009
09 Practical use of semiconductor LSIs that operate at a switching speed of 1 ps	87	2015

Topic	Degree of importance index	Forecasted realization time (year)
or less.		
19 Development of processor LSIs with 10 GIPS performance and power consumption of 10 miliwatts or less.	87	2014
24 Widespread use of a portable multimedia wireless terminal operated on the order of 100 Mbits/sec., which can be used throughout the world.	84	2011
32 Practical use of ultraviolet, blue, and green, semiconductor lasers.	84	2004
67 Development of a magnetic memory hard disk capable of recording 1,000 Gbits density per square inch.	83	2017
38 Practical use of optical multiplexed communication equipment capable of multiplexing 200 channels of signals with 100 Gbits/sec. and transmitting them over a single optical fiber.	83	2014
68 Practical use of optical memories with recording density of 10^{11} b/cm^2.	82	2016
28 Practical use of automated production systems in which LSI chips are produced automatically by giving LSI design data.	82	2015
37 Widespread use in homes of 10 Gbits/sec. optical subscriber-type systems.	79	2015
03 Practical use of LSIs using single-electron transistors.	78	2015
70 Practical use of small read/write optical filing systems with at least 1 tera bite capacity per system.	78	2012
23 Practical use of portable automatic translation systems with a single-chip LSI.	77	2013
59 Development of non-invasive, CT-type devices capable of recognizing, in real time, excited cerebro-neural states with a resolution on the order of 1 mm.	77	2012

Note 1: Degree of importance index = (number of "high" responses × 100 + number of "medium" responses × 50 + number of "low" responses × 25 + number of "unnecessary" responses × 0) ÷ total number of degree of importance responses

2.4. Forecasted realization times

Forecasted realization times were distributed as shown in the diagram below. With more than half the topics forecasted to be realized between 2011 and 2015, the peak of the distribution of forecasted realization times in the electronics field roughly coincided with that of the general trend covering all topics, although it was sharper. The proportion of topics forecasted to be realized before the peak was smaller than the general trend. The earliest forecasted realization time was 2004, which was given to "32. Practical use of ultraviolet, blue, and green, semiconductor lasers", while the latest realization time was 2024, which was given to "21. Development of an "artificial intelligence chip" capable of understanding and sharing human emotions."

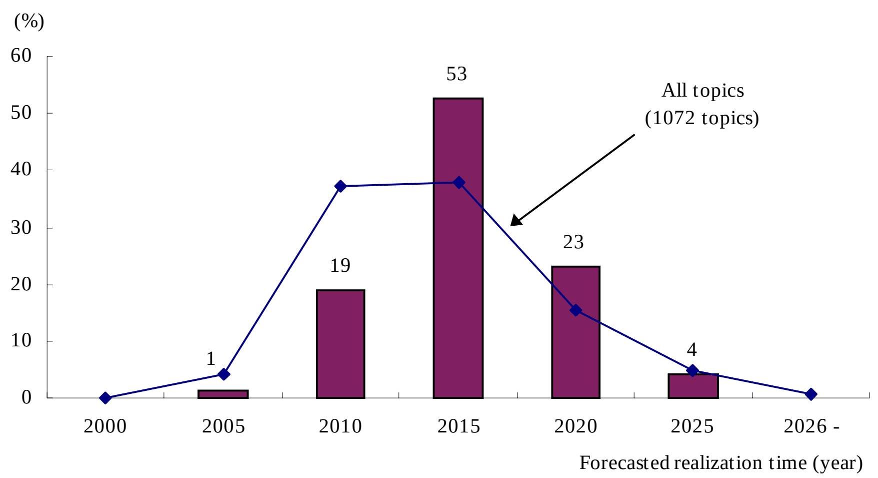

Fig. 2.4-1 Trends in Forecasted Realization Times

2.5. Current leading countries etc.

Responses to the question concerning current leading countries etc. were as shown in the diagram below. Named by 75.2% of the respondents, the U.S. ranked No. 1 in the electronics field as a whole, closely followed by Japan (69.0%). The score of the third-ranking EU was a little less than a quarter of Japans.

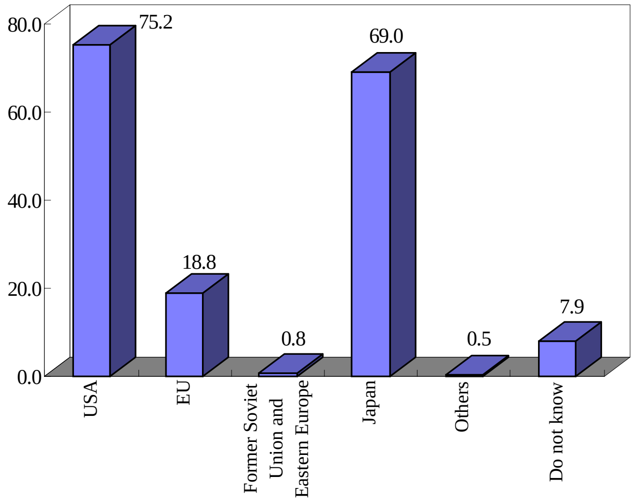

Fig. 2.5-1 Current Leading Countries etc. (%)

2.6. Comparison with the 5th Survey (previous survey)

Of the 74 topics included in the latest survey, 6 (8%) were identical to the previous survey, 18 (24%) were modified, and 50 (68%) were newly introduced. For identical topics, the results of the latest survey were compared with those of the previous survey in terms of degree of importance index scores and forecasted realization times, as shown in the table below.

There was a major procedural change in the latest survey in that the <information and electronics> field in previous surveys was broken down into <electronics> and <information> fields.

Degree of importance index scores rose for 4 topics, fell for 1 topic and remained the same for 1 topic. The only topic which experienced a drop was “65: Development of sensors that could be substituted for human sensation, capable of directly stimulating nerves” down 2 points.

From the 4th to the 5th Survey, forecasted realization times were pushed back for all but one topic (i.e. those from the electronics domain of the former electronics and information field in the case of the 4th Survey). Likewise, from the 5th to the 6th Survey, all 6 identical topics were pushed further into the future. In particular, “09: Practical use of semiconductor LSIs that operate at a switching speed of 1 ps or less”, “17: Practical use of heat-resistant logic ICs useable in high-temperature environments up to 500°C” and “26: Development of technology capable of continuous LSI production on semiconductor substrates in a sheet form” saw their forecasted realization times pushed back 10 or more years.

Topics from other fields in the 5th Survey included one which was identical to a topic from the electronics field in the 6th Survey. For this topic (from materials field), the degree of importance index score fell by 1 point, and the forecasted realization time was pushed back 9 years.

Table 2.6-1 Comparison with 5th Survey for Identical Topics

<table>
<tr><th rowspan="2">Topic</th><th colspan="2">Degree of importance index/forecasted realization time (year)</th></tr>
<tr><th>6th survey</th><th>5th survey</th></tr>
<tr><td>09 Practical use of semiconductor LSIs that operate at a switching speed of 1 ps or less.</td><td>87/2015</td><td>80/2005</td></tr>
<tr><td rowspan="2">17 Practical use of heat-resistant logic ICs useable in high-temperature environments up to 500°C.</td><td rowspan="2">51/2015</td><td>50/2005</td></tr>
<tr><td>52/2006*</td></tr>
<tr><td>22 Practical use of single-chip voice recognition integrated circuits which incorporate learning functions capable of identifying different speakers.</td><td>70/2011</td><td>64/2003</td></tr>
<tr><td>26 Development of technology capable of continuous LSI production on semiconductor substrates in a sheet form.</td><td>66/2017</td><td>57/2007</td></tr>
<tr><td>59 Development of non-invasive, CT-type devices capable of recognizing, in real time, excited cerebro-neural states with a resolution on the order of 1 mm.</td><td>77/2012</td><td>77/2005</td></tr>
<tr><td>65 Development of sensors that could be substituted for human sensation, capable of directly stimulating nerves.</td><td>55/2013</td><td>57/2008</td></tr>
</table>

* Identical topic from materials field

Note: Up until the 5th Survey, realization meant realization in Japan unless otherwise specified. However, this was changed to mean realization somewhere in the world in the 6th Survey. Therefore, care should be taken when comparing forecasted realization times from the two surveys.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time			Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001 2006 2011 2016 2021 2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Microelectronics	1	Development of technology capable of manipulating single atoms and single molecules.	1	290	12	38	50	71	48	42	10	0	62	6	7	75		1	4	85	26	0	63	0	9	60	40	45	5	53	1	1	8	2	8	2
			2	258	12	34	54	71	46	46	7	0	62	2	1	79		1	3	92	22	0	69	0	3	64	36	47	2	55	0	0	5	2	6	2
			X	30	100	0	0	91	83	13	3	0	67	3	0	93		0	3	100	37	0	77	0	0	80	47	47	0	63	0	0	0	0	0	0
	2	Practical use of quantum-phase devices that control the phases of, for example, electron waves.	1	236	10	39	51	65	36	49	14	0	74	4	3	52		6	6	86	28	1	71	0	6	55	47	43	2	48	1	1	2	2	5	2
			2	226	9	34	57	64	34	52	14	0	77	2	1	56		6	4	90	23	0	76	0	3	62	42	41	1	49	0	1	1	1	3	1
			X	21	100	0	0	77	57	38	5	0	86	5	5	71		10	0	100	19	0	90	0	0	67	67	33	0	48	0	0	0	0	0	0
	3	Practical use of LSIs using single-electron transistors.	1	275	13	40	47	74	53	34	12	0	86	11	6	43		9	7	79	34	3	80	0	4	56	47	44	1	52	0	0	2	3	4	1
			2	247	11	38	50	78	60	32	7	0	87	5	2	47		6	4	83	31	1	84	0	2	61	44	44	1	53	0	0	1	2	2	1
			X	28	100	0	0	91	82	18	0	0	100	11	0	61		14	0	86	32	4	96	0	0	61	57	32	0	61	0	0	0	4	0	4
	4	Elucidation of the mechanisms by which single-cell organisms etc. respond to external stimuli, and realization of such mechanisms artificially.	1	103	5	14	82	61	30	55	15	0	40	11	42	68		2	10	70	34	3	41	0	18	52	43	38	29	43	5	0	18	5	33	0
			2	108	3	11	86	61	29	58	13	0	31	8	37	75		2	9	76	31	1	39	0	14	63	39	34	24	43	5	0	15	5	38	0
			X	3	100	0	0	100	100	0	0	0	33	33	67	67		0	0	100	67	0	100	0	0	100	67	33	33	33	0	0	0	0	33	0
	5	Practical use of technology which allows mass processing of patterns with minimum line width as low as 10 nanometers.	1	296	25	38	38	87	75	23	2	0	92	10	10	29		0	3	76	16	1	90	3	2	47	51	53	1	50	1	0	3	1	4	2
			2	267	24	34	42	93	86	13	0	0	96	6	6	22		0	1	75	10	0	92	1	1	47	50	58	1	54	0	0	2	2	1	1
			X	63	100	0	0	98	95	5	0	0	97	8	5	32		0	0	79	19	0	97	0	0	52	44	48	2	65	0	0	3	2	0	2
	6	Practical use of VLSI with as much as 256 Gbits of memory per chip.	1	281	25	37	38	89	79	20	0	1	95	8	16	15		3	4	62	4	1	92	16	1	45	50	45	1	52	3	1	2	3	9	1
			2	251	24	35	42	94	88	11	0	1	95	3	10	11		3	1	61	2	0	96	15	0	44	51	48	1	56	2	0	0	2	6	2
			X	59	100	0	0	97	95	3	0	2	98	7	17	14		5	0	64	0	0	97	25	0	44	56	44	0	69	0	0	0	0	5	2
	7	Widespread use of wafers one meter in diameter.	1	257	18	35	47	53	29	35	27	9	80	13	5	6		39	15	43	6	0	75	3	9	25	30	32	1	35	2	3	6	2	2	1
			2	236	17	32	51	55	27	43	23	6	87	7	4	3		39	14	44	3	0	83	2	7	26	33	38	1	44	1	3	4	1	1	1
			X	40	100	0	0	64	45	33	10	13	85	8	3	5		40	5	58	5	0	88	3	0	23	40	38	0	53	3	3	3	0	3	3
	8	Practical use of non-volatile, erasable with more than 100 Gbits capacity random access semiconductor memories.	1	272	21	35	44	84	71	26	2	1	92	10	16	15		5	5	71	8	0	88	7	2	46	44	37	1	49	2	1	3	2	7	1
			2	244	22	31	47	88	78	20	1	1	93	5	9	10		4	4	72	3	0	89	6	2	48	48	36	1	52	2	0	0	1	5	1
			X	53	100	0	0	94	91	8	0	2	96	9	11	23		8	0	81	2	0	94	11	0	53	53	30	0	60	0	0	0	0	4	2
	9	Practical use of semiconductor LSIs that operate at a switching speed of 1 ps or less.	1	266	23	38	39	81	65	30	5	0	92	9	15	27		10	9	80	15	1	79	0	6	52	47	38	2	48	2	2	3	2	4	1
			2	237	22	35	43	87	74	25	1	0	95	3	8	19		7	4	84	11	0	83	0	3	60	49	37	1	52	1	0	1	0	2	1
			X	52	100	0	0	95	90	10	0	0	100	8	19	21		10	0	92	19	0	90	0	0	67	50	29	0	58	0	2	0	0	2	2
	10	Practical use of wide-band solid-state amplifiers operated at high frequencies of around 100–1,000GHz.	1	242	19	39	42	70	47	41	11	1	88	9	15	20		5	14	77	27	2	61	0	10	56	41	31	1	46	3	0	4	2	3	1
			2	224	18	38	44	77	57	38	6	0	91	4	13	18		2	8	86	22	0	72	0	5	64	46	28	0	52	2	0	1	0	1	1
			X	41	100	0	0	88	76	24	0	0	98	7	17	22		2	0	90	39	0	85	0	2	66	49	20	0	68	2	0	2	0	5	0

(Note) See page 7 for the interpretation of the graphs.

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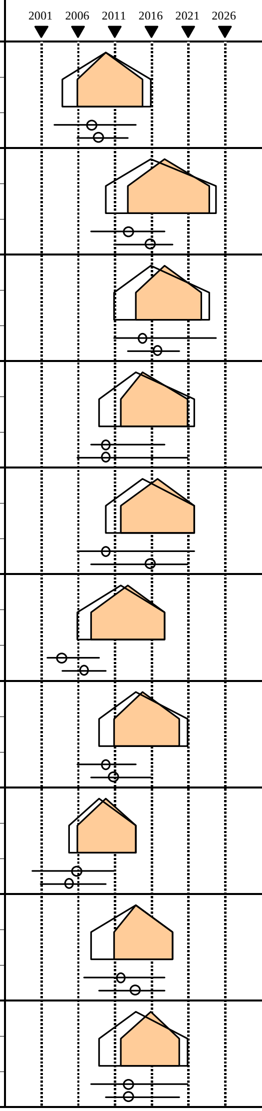
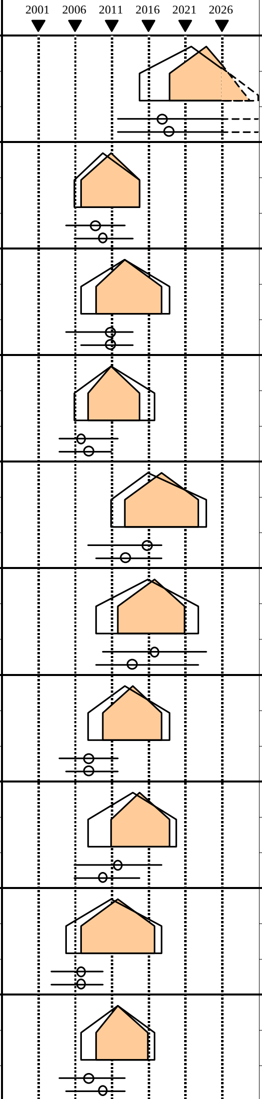
Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic development	Expected effect: Resolution of global problems	Expected effect: People's needs	Expected effect: Expansion of intellectual resources	Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Microelectronics	11	Development of super-conducting three-terminal devices with amplification capabilities.	1	209	9	32	59	51	19	50	27	4	71	14	5	39		5	16	65	29	4	71	0	9	54	42	31	2	44	1	1	2	0	3	1
			2	196	9	25	66	49	13	56	29	2	74	7	1	45		3	11	69	25	3	78	0	7	64	41	28	2	48	1	1	1	0	2	2
			X	17	100	0	0	56	24	53	24	0	82	12	0	47		6	6	59	29	0	94	0	6	59	65	41	0	53	6	0	0	0	0	6
	12	Development of atomic-scale, high-speed, highly-integrated devices switching by the movement of a single atom, such as to atom relay transistors.	1	224	9	29	63	64	38	42	17	2	67	7	5	58		16	13	72	27	2	49	0	16	57	39	34	1	43	0	0	1	1	2	3
			2	204	8	25	67	63	35	47	16	1	73	3	3	62		15	12	80	23	0	53	0	13	66	41	32	1	46	0	0	0	0	1	1
			X	17	100	0	0	85	71	29	0	0	88	0	0	65		12	6	88	35	0	76	0	6	71	59	18	0	59	0	0	0	0	0	0
	13	Practical use of TIPS (Tera Instruction Per Second) level microprocessors.	1	211	13	29	58	86	73	24	2	0	93	13	19	20		6	6	89	10	0	46	0	3	52	45	27	1	48	1	1	1	4	4	1
			2	196	12	24	64	89	79	18	3	0	95	8	14	16		4	3	93	5	1	48	0	3	66	47	21	1	54	1	1	0	3	4	1
			X	23	100	0	0	91	87	4	9	0	96	17	17	22		4	0	96	9	0	57	0	4	78	35	13	4	83	0	0	0	4	9	4
	14	Development of X-ray microscopes capable of 10-100nm resolution.	1	170	8	25	67	56	28	43	26	3	53	2	10	69		11	19	58	31	4	41	0	21	53	32	35	2	44	1	1	5	4	1	1
			2	162	7	21	72	55	24	51	22	2	52	1	6	82		6	13	70	27	1	50	0	17	67	28	36	1	52	0	0	3	5	0	1
			X	11	100	0	0	82	64	36	0	0	36	0	9	100		0	0	91	27	0	64	0	0	55	18	45	0	73	0	0	0	0	0	0
	15	Practical use of semiconductor neural network chips on the order of one million neurons.	1	176	9	24	67	63	35	51	13	2	85	6	26	35		10	14	76	20	1	59	0	10	55	50	19	1	48	2	1	1	2	11	1
			2	174	7	25	68	64	33	59	9	0	90	5	21	33		7	7	86	19	0	64	0	7	68	56	14	0	53	1	0	1	2	6	1
			X	13	100	0	0	79	62	31	8	0	92	15	23	46		8	0	92	31	0	69	0	0	69	54	15	0	85	0	0	0	8	8	8
	16	Widespread use of high-temperature superconductive materials in passive circuits for milimater-wave communication systems.	1	218	13	26	61	54	23	50	25	2	78	10	12	19		11	17	72	30	4	59	0	12	47	43	27	0	41	5	1	2	2	2	1
			2	202	12	25	63	54	19	59	20	2	86	6	11	17		10	12	79	26	0	64	0	8	59	50	21	0	46	4	0	1	2	0	1
			X	24	100	0	0	74	50	46	4	0	96	8	29	8		4	4	96	25	0	58	0	4	67	63	21	0	54	8	0	0	17	0	0
	17	Practical use of heat-resistant logic ICs useable in high-temperature environments up to 500°C.	1	212	11	29	60	50	19	46	31	3	70	26	15	19		9	14	67	19	5	44	0	18	49	40	25	3	40	2	2	4	1	1	2
			2	192	12	26	62	51	17	56	25	2	82	20	14	16		7	10	76	19	2	54	0	13	58	46	18	2	47	1	0	2	1	1	1
			X	23	100	0	0	72	43	57	0	0	87	30	35	9		0	4	83	17	0	74	0	0	65	65	9	0	61	0	0	0	0	0	4
	18	Development of solar cells capable of maintaining 15% efficiency for at least 10 years without light convergence.	1	243	8	33	59	86	73	25	2	0	59	88	21	5		2	6	65	23	2	86	1	7	40	48	27	1	56	11	1	12	1	3	2
			2	219	7	28	65	92	84	15	1	0	60	89	15	2		0	3	68	16	0	91	1	4	47	53	20	0	63	10	0	8	0	1	1
			X	15	100	0	0	97	93	7	0	0	73	93	33	0		0	0	93	27	0	100	7	0	67	73	20	0	73	7	0	0	0	0	0
	19	Development of processor LSIs with 10 GIPS performance and power consumption of 10 miliwatts or less.	1	204	20	30	50	81	64	32	3	0	92	28	23	10		5	10	88	14	0	62	0	3	56	44	26	1	45	0	0	3	2	4	2
			2	188	17	32	51	87	74	24	1	1	96	25	17	5		3	9	91	8	0	66	1	3	66	46	20	1	54	0	0	2	2	2	2
			X	32	100	0	0	94	88	13	0	0	100	31	22	13		3	0	94	16	0	75	0	0	94	44	19	0	72	0	0	3	3	3	3
	20	Practical use of multi-processor systems with advanced self-restoration capabilities.	1	190	12	26	62	72	46	48	6	0	89	6	24	19		3	8	86	21	2	36	0	8	63	47	23	2	42	0	1	2	3	6	2
			2	179	9	23	68	71	44	53	3	0	94	2	22	12		2	6	92	16	2	40	0	6	71	55	16	1	44	0	0	1	2	3	1
			X	17	100	0	0	88	76	24	0	0	94	6	12	18		0	0	94	29	0	76	0	0	88	53	6	0	76	0	0	6	6	6	6



(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic development	Expected effect: Resolution of global problems	Expected effect: People's needs	Expected effect: Expansion of intellectual resources	Forecasted realization time: Will not be realized (%)	Forecasted realization time: Do not know (%)	Leading countries (%): USA	Leading countries: EU	Leading countries: Former Soviet Union and Eastern Europe	Leading countries: Japan	Leading countries: Other countries	Leading countries: Do not know	Measures the government should adopt (%): Foster human resources	Measures: Promote exchanges among industrial, academic and government sectors and different fields	Measures: Upgrade advanced facilities and equipment	Measures: Develop a research base	Measures: Increase government research funding	Measures: Adjust regulations (relax/toughen)	Measures: Others	Potential problems (%): Adverse effect on the natural environment	Potential problems: Adverse effect on safety	Potential problems: Adverse effect on morals, culture or society	Potential problems: Other adverse effects
Microelectronics	21	Development of an "artificial intelligence chip" capable of understanding and sharing human emotions.	1	170	8	18	74	66	42	42	14	2	67	3	72	37	21	15	71	20	2	36	0	20	60	41	20	9	39	1	3	0	15	42	1
			2	162	6	15	79	64	34	54	10	1	59	0	75	36	22	10	80	15	1	36	0	16	70	43	11	6	41	1	1	0	10	50	1
			X	10	100	0	0	89	78	22	0	0	80	0	80	30	10	0	100	40	0	50	0	0	90	70	30	10	50	0	0	0	10	40	0
	22	Practical use of single-chip voice recognition integrated circuits which incorporate learning functions capable of identifying different speakers.	1	233	9	22	69	71	45	49	7	0	81	1	78	11	1	8	77	19	0	71	0	12	56	55	18	4	36	2	1	1	18	12	1
			2	217	7	19	74	70	41	56	3	0	79	0	85	8	1	3	81	10	0	76	0	8	62	60	12	1	40	1	0	0	17	7	1
			X	16	100	0	0	91	81	19	0	0	75	6	88	13	0	0	81	19	0	81	0	0	56	63	25	0	44	0	6	0	6	6	6
	23	Practical use of portable automatic translation systems with a single-chip LSI.	1	236	9	22	69	76	55	39	6	0	84	5	69	9	4	5	66	22	0	76	0	11	52	56	22	4	39	1	1	1	7	15	1
			2	224	8	21	71	77	56	41	3	0	84	4	79	5	3	3	68	15	0	82	1	8	55	61	16	2	46	1	0	1	5	15	1
			X	17	100	0	0	97	94	6	0	0	88	12	88	18	6	6	88	41	0	94	0	0	53	59	35	0	71	0	0	0	6	6	6
	24	Widespread use of a portable multimedia wireless terminal operated on the order of 100 Mbits/sec., which can be used throughout the world.	1	255	12	31	57	79	61	33	5	0	96	9	60	7	3	5	91	34	0	72	0	2	42	45	19	2	33	29	4	2	24	15	1
			2	237	12	27	61	84	69	30	1	0	93	4	69	2	0	2	93	30	0	75	0	1	47	48	11	0	34	30	3	1	26	11	1
			X	28	100	0	0	96	93	7	0	0	96	21	71	4	0	7	89	46	0	89	0	0	54	50	14	0	46	32	4	4	25	14	4
	25	Widespread use (one in every household) of "housekeeping robots" capable of cleaning, laundry, etc.	1	199	4	16	80	51	21	43	32	3	45	4	91	3	11	9	47	11	2	54	0	27	26	45	13	2	23	6	3	2	13	26	2
			2	197	3	14	83	50	18	49	30	3	41	1	94	1	11	7	50	6	0	66	0	21	30	55	8	1	28	5	4	2	11	30	2
			X	6	100	0	0	79	67	17	17	0	50	0	83	0	0	0	50	0	0	83	0	0	50	50	17	0	33	0	0	0	17	33	0
	26	Development of technology capable of continuous LSI production on semiconductor substrates in a sheet form.	1	216	17	26	57	63	40	36	19	5	82	15	12	4	20	14	45	7	2	52	1	25	43	40	25	1	30	1	0	5	1	3	1
			2	201	15	26	59	66	42	42	13	3	90	9	9	1	24	10	49	2	0	63	0	21	47	45	20	0	34	1	0	3	0	0	1
			X	30	100	0	0	70	57	17	20	7	80	23	13	3	37	3	57	3	0	67	0	13	50	40	17	0	33	0	0	3	3	0	3
	27	Practical use of virtual factory technology, in which high-performance LSI with several hundred K gates or more can be designed automatically by giving the required specifications on the system level.	1	179	13	30	57	72	49	42	8	1	89	6	9	11	3	4	85	13	0	42	1	8	65	45	21	1	36	1	2	3	1	4	2
			2	172	10	27	63	76	55	40	4	1	95	2	6	6	2	4	88	7	0	50	1	5	66	48	18	1	41	0	1	1	1	2	2
			X	18	100	0	0	97	94	6	0	0	100	6	11	0	6	0	89	17	0	67	0	0	72	61	17	0	56	0	6	0	0	6	6
	28	Practical use of automated production systems in which LSI chips are produced automatically by giving LSI design data.	1	196	13	29	58	76	56	36	7	0	89	7	8	8	5	5	80	9	1	58	2	9	47	43	26	2	32	1	2	3	2	2	2
			2	186	12	24	63	82	66	32	2	1	94	3	5	3	5	5	86	4	1	64	1	4	54	53	20	1	37	0	1	2	1	1	2
			X	23	100	0	0	98	96	4	0	0	96	9	9	4	9	0	83	9	0	57	0	0	65	52	17	0	52	0	4	4	0	0	4
	29	Practical use of device which directly detects LSI signals from an area of less than 10 nm dimension.	1	190	15	27	57	58	27	52	21	0	75	4	3	41	2	11	75	26	1	65	0	11	59	40	31	1	35	0	1	1	2	3	3
			2	175	14	29	58	57	22	62	16	1	82	2	2	40	1	6	80	22	1	70	0	7	64	40	26	1	34	0	0	1	1	1	2
			X	24	100	0	0	74	50	46	4	0	96	4	8	42	4	0	79	33	0	92	0	0	83	54	13	0	38	0	0	4	0	0	4
	30	Practical use of solar cells which make the cost of power generation facilities less than 100 yen/watt.	1	207	12	25	64	89	79	19	2	0	60	89	23	4	1	10	65	17	2	82	1	6	38	49	26	2	57	17	1	19	3	2	2
			2	197	9	25	65	93	87	12	1	0	60	90	19	2	1	7	65	11	1	90	2	3	41	51	18	1	68	13	2	16	2	1	1
			X	18	100	0	0	97	94	6	0	0	61	94	22	0	0	0	89	22	0	94	11	0	56	50	22	0	83	11	6	11	6	0	0



(Note) See page 7 for the interpretation of the graphs.

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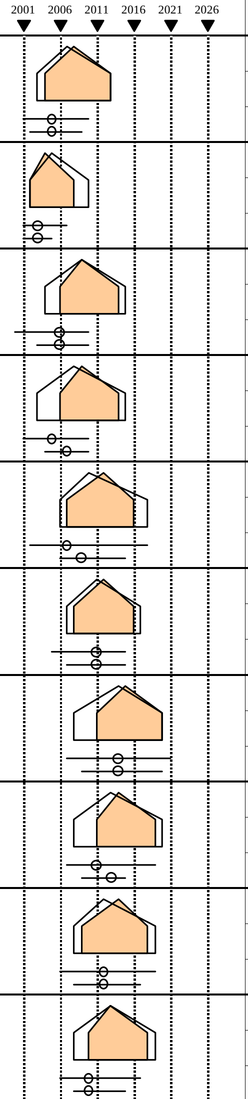
Optoelectronics	31	Development of digital optical logic circuits which carry out binary operations.	1	226	19	32	49	56	26	47	24	3	77	3	7	28		3	8	79	31	3	71	0	8	55	38	30	1	43	0	0	1	1	4	3
			2	208	15	30	54	55	21	58	20	1	79	1	2	29		4	3	86	25	1	78	0	5	67	39	22	0	47	0	0	0	0	2	1
			X	32	100	0	0	59	34	34	28	3	75	0	0	34		6	0	94	44	3	97	0	0	56	53	25	0	47	0	0	0	0	3	0
	32	Practical use of ultraviolet, blue, and green, semiconductor lasers.	1	284	24	34	43	79	60	36	4	0	94	7	21	13		0	2	61	18	2	92	1	2	54	46	28	0	38	2	1	2	3	4	2
			2	257	21	35	44	84	69	29	2	0	96	2	21	9		0	1	55	12	2	95	0	2	62	50	22	0	37	2	0	2	2	2	1
			X	54	100	0	0	89	78	22	0	0	98	2	24	15		0	0	59	17	2	98	2	0	69	61	24	0	31	2	0	0	0	2	0
	33	Development of semiconductor lasers whose oscillation wavelength is independent of temperature.	1	245	26	28	46	62	34	48	17	1	81	2	7	22		9	16	61	18	0	76	0	12	54	37	26	1	34	1	1	2	1	2	2
			2	226	23	31	47	61	29	58	13	0	87	1	7	18		6	10	63	14	0	84	0	8	65	38	20	1	35	0	1	0	1	1	1
			X	51	100	0	0	73	49	45	6	0	84	0	10	24		4	6	69	22	0	98	0	0	75	55	22	0	35	0	2	0	0	2	0
	34	Development of semiconductor lasers with no threshold by, for example, controlling spontaneous emission.	1	230	27	28	44	55	26	44	28	1	76	5	4	32		14	15	62	17	0	73	0	11	50	30	28	1	33	0	1	1	1	2	2
			2	213	24	28	48	55	22	57	20	1	82	1	2	30		12	12	66	12	0	81	0	9	64	32	21	1	35	0	0	0	1	1	1
			X	51	100	0	0	71	45	49	4	2	84	2	2	43		14	2	82	22	0	98	0	0	80	43	22	0	33	0	0	0	0	0	0
	35	Practical use of lasers, optical switches, and other devices by means of solid organic materials.	1	209	21	33	46	54	23	49	26	1	85	5	9	22		7	9	63	32	2	56	0	13	52	41	24	1	37	0	1	2	0	2	2
			2	196	19	30	51	52	17	59	24	1	88	1	3	22		5	6	70	31	0	67	0	12	66	42	20	1	41	0	1	3	1	1	2
			X	38	100	0	0	69	42	50	8	0	87	5	3	34		5	0	84	50	0	74	0	3	76	50	21	3	55	0	3	0	3	3	0
	36	Widespread use of opto-electronic integrated circuits (OEIC) in which multiple optical elements and their wave guide connections are integrated on a semiconductor substrate.	1	267	31	31	39	69	43	46	10	0	93	5	15	10		4	6	79	31	1	86	1	3	49	51	29	1	43	2	0	1	2	4	1
			2	243	26	35	39	69	41	52	7	0	95	2	13	8		4	2	82	29	1	93	0	2	59	58	26	0	45	2	0	0	2	3	1
			X	63	100	0	0	81	65	30	5	0	98	5	21	8		2	3	84	41	0	98	2	0	63	62	27	0	56	3	2	0	5	5	3
	37	Widespread use in homes of 10 Gbits/sec. optical subscriber-type systems.	1	246	26	30	43	73	55	31	12	2	88	7	65	6		7	6	80	30	1	78	0	3	37	40	16	1	39	32	1	1	12	15	2
			2	229	24	31	45	79	64	26	8	2	92	4	67	2		5	4	83	25	0	82	0	4	39	45	11	0	45	32	1	0	7	15	0
			X	54	100	0	0	76	59	31	6	4	93	6	69	6		7	6	80	46	0	94	0	0	44	48	11	0	52	39	2	0	4	4	2
	38	Practical use of optical multiplexed communication equipment capable of multiplexing 200 channels of signals with 100 Gbits/sec. and transmitting them over a single optical fiber.	1	224	27	32	41	78	61	29	9	1	93	8	38	8		4	10	82	26	1	82	0	3	46	38	28	0	40	17	1	2	4	9	2
			2	217	23	31	46	83	69	23	6	1	95	5	38	2		4	8	82	19	0	86	0	4	54	41	21	0	49	16	1	0	3	7	1
			X	49	100	0	0	85	75	19	4	2	94	0	37	4		4	4	90	35	0	100	0	0	57	41	22	0	49	16	2	0	4	4	2
	39	Practical use of 1000 x 1000 surface emitting laser array, used in optical interconnections, for instance.	1	234	25	31	44	61	30	54	15	1	88	3	17	9		5	9	73	17	1	81	0	7	49	36	30	0	40	1	1	2	1	3	2
			2	215	25	28	47	61	29	60	11	1	92	1	15	6		5	5	75	13	0	85	0	5	60	39	27	0	47	0	1	0	0	2	1
			X	54	100	0	0	75	56	35	9	0	91	0	19	11		6	2	85	22	0	94	0	0	67	56	28	0	44	0	4	0	2	2	2
	40	Development of high-sensitivity sensing technology using technology to control the quantum condition of light.	1	188	20	26	54	56	24	55	21	1	64	9	13	53		2	16	76	31	2	52	0	15	61	35	28	2	39	1	0	1	2	5	3
			2	169	20	25	54	55	20	61	18	1	68	6	8	58		2	11	80	29	1	57	0	9	69	35	24	1	47	0	0	0	1	2	1
			X	34	100	0	0	68	38	56	6	0	71	9	26	53		0	9	88	38	0	74	0	6	76	56	21	0	62	0	0	0	3	0	3



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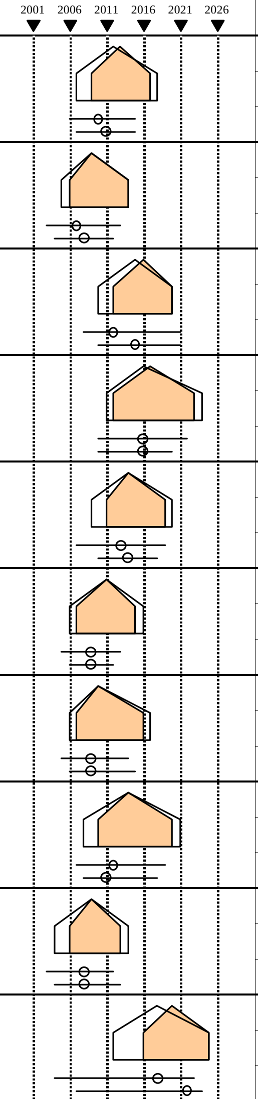
Optoelectronics	41	Practical use of semiconductor devices capable of emitting any wave-length of light by means of electric control signals.	1	241	26	32	43	66	38	51	11	1	88	3	12	29	10	12	66	24	1	72	0	11	57	41	26	1	40	1	0	1	1	3	2
			2	224	24	29	47	64	32	59	7	1	94	2	8	27	8	9	72	21	0	87	0	5	67	42	23	0	49	1	0	0	1	1	1
			X	53	100	0	0	74	49	47	4	0	96	4	9	32	4	4	60	25	0	92	0	0	74	43	17	0	47	4	0	0	4	0	0
	42	Practical use, in the field of optical communications and optical switching, of technology to convert the wavelength of a signal into another wavelength.	1	235	29	31	39	69	42	48	9	0	88	3	12	16	1	5	75	30	2	79	0	6	57	40	27	2	40	2	1	1	2	3	2
			2	215	27	33	40	70	42	52	6	0	96	2	8	14	0	4	87	27	1	90	0	2	67	44	22	0	51	2	0	0	1	2	1
			X	57	100	0	0	83	67	32	2	0	98	5	12	14	0	0	88	35	0	95	0	0	75	58	16	0	60	5	0	0	5	0	0
	43	Practical use of soft X-ray lasers oscillating at wavelengths in the order of 10/Å.	1	155	14	28	57	62	32	50	17	0	74	3	12	45	1	15	72	32	10	46	1	15	52	37	42	1	50	1	0	5	6	3	2
			2	146	13	23	64	58	23	63	13	0	75	2	7	51	1	16	84	31	8	53	1	10	66	30	37	1	55	0	0	2	4	1	1
			X	19	100	0	0	70	42	53	5	0	63	5	11	68	0	5	89	53	5	63	0	5	74	26	42	0	68	0	0	0	5	0	5
	44	Widespread use of semiconductor light sources for almost all types of lighting.	1	254	15	27	58	49	25	32	34	10	61	42	26	4	28	18	39	13	2	56	0	20	31	32	13	1	22	6	3	8	3	2	1
			2	229	15	28	58	49	20	42	32	7	69	41	27	3	27	14	43	11	0	70	0	14	43	39	9	0	28	4	2	7	2	1	0
			X	34	100	0	0	67	48	27	21	3	74	50	32	6	18	3	56	15	0	79	0	3	59	44	12	3	38	0	0	3	0	0	0
	45	Practical use of optical switches capable of connecting 10,000 video terminals.	1	193	20	28	52	67	43	44	12	2	85	5	42	5	3	9	74	23	1	74	0	7	38	35	17	2	30	17	0	1	6	11	2
			2	183	19	23	57	68	41	50	8	1	88	4	45	2	3	8	80	17	0	81	0	4	46	44	12	0	36	15	0	0	3	10	1
			X	35	100	0	0	87	77	17	6	0	89	6	46	3	0	0	83	40	0	100	0	0	46	43	11	0	46	11	0	0	9	3	0
	46	Practical use of optical communications between satellites.	1	201	19	23	57	52	22	46	31	1	73	21	9	7	3	9	83	25	9	45	0	6	40	33	22	0	45	6	1	2	4	3	1
			2	189	16	24	60	52	16	60	24	0	86	22	6	5	4	4	90	21	6	46	0	5	47	32	19	0	56	4	1	1	4	2	0
			X	31	100	0	0	71	48	39	13	0	87	26	16	3	3	0	94	29	0	77	0	0	68	35	26	0	58	6	0	0	6	0	0
	47	Practical use of optical soliton transmission for intercontinental undersea cables and other long-distance fiber communications.	1	201	25	31	44	65	37	52	9	2	88	13	14	10	6	11	76	20	2	83	0	4	44	34	25	1	44	7	1	2	3	3	1
			2	190	25	27	48	65	35	58	6	1	92	9	13	8	4	7	83	16	1	86	0	2	57	36	21	1	54	5	1	0	3	2	0
			X	47	100	0	0	72	49	43	9	0	94	9	17	4	4	9	83	30	0	89	0	0	62	45	23	0	57	2	2	0	4	0	0
	48	Practical use of devices capable of image recognition via optical operations.	1	222	17	32	50	59	30	51	17	3	78	3	32	16	6	12	73	22	2	60	0	13	51	36	25	1	35	1	1	0	5	3	1
			2	197	17	29	54	59	26	62	11	2	85	1	40	10	5	11	83	18	2	68	0	10	65	38	19	1	47	0	1	0	3	3	0
			X	33	100	0	0	75	52	45	3	0	88	3	42	9	3	6	91	30	3	79	0	0	82	48	24	0	45	0	0	0	3	0	0
	49	Production of household-use optical fiber signal tranceiver units at a cost of around 5,000 yen.	1	233	29	28	42	83	68	27	5	0	90	5	61	3	2	6	69	23	1	82	0	4	32	35	18	0	27	23	3	0	5	10	1
			2	211	27	30	43	88	78	19	3	0	95	3	60	1	1	3	72	17	0	88	0	2	42	43	9	0	31	25	3	0	3	10	0
			X	57	100	0	0	97	95	4	2	0	93	7	61	4	0	2	72	26	0	91	0	0	49	35	12	0	33	23	5	0	7	4	0
Molecular, sensor and bioelectronics	50	Elucidation of the interconnective mechanism in the cerebral nervous system, and development of artificially functioning bio-nerve circuits with about 10,000 cells.	1	127	9	18	73	67	39	51	10	0	65	2	39	62	13	11	80	35	6	46	0	16	66	40	24	11	47	2	1	2	6	24	2
			2	123	5	18	77	64	33	59	8	0	64	0	31	66	11	7	88	30	2	46	0	8	73	41	15	6	59	0	1	1	3	28	2
			X	6	100	0	0	92	83	17	0	0	100	0	17	50	17	0	83	33	0	100	0	0	100	33	17	0	67	0	0	0	0	17	0



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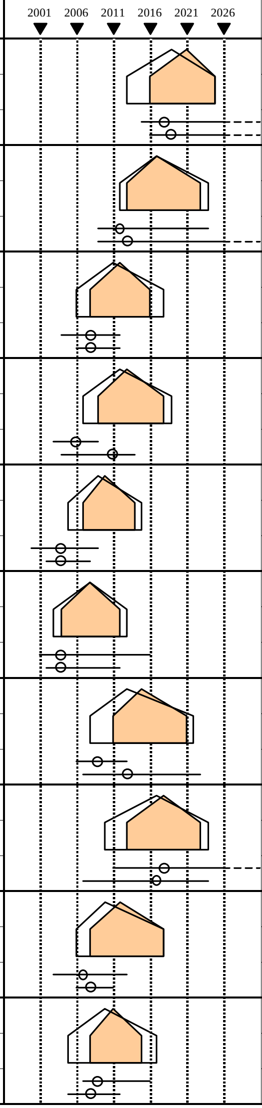
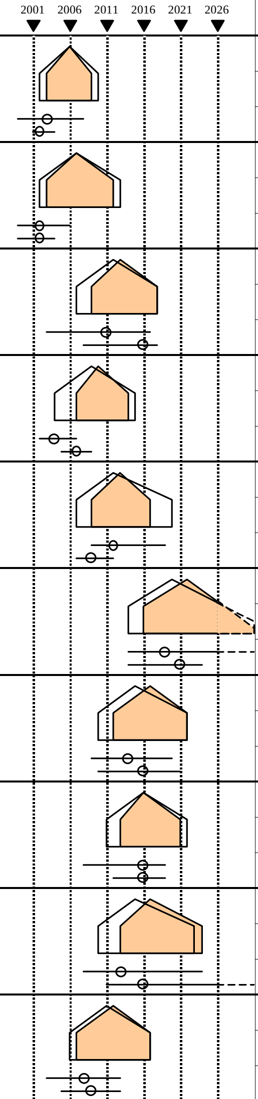
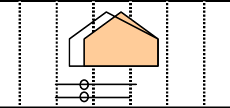
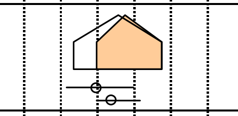
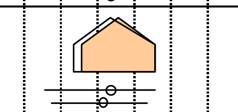
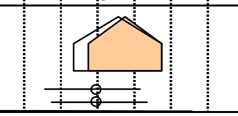
Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%) High	Degree of expertise (%) Medium	Degree of expertise (%) Low	Importance (index, %) Index	Importance High	Importance Medium	Importance Low	Importance Unnecessary	Expected effect (%) Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Forecasted realization time 	Will not be realized (%)	Do not know (%)	Leading countries (%) USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%) Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%) Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Molecular, sensor and bioelectronics	51	Development of logic LSIs and memory LSIs in which the basic switching element is a single molecule.	1	184	11	22	67	63	37	41	19	3	76	9	10	54		16	16	67	32	3	40	0	22	61	36	28	5	46	0	1	1	2	6	2
			2	166	11	16	72	61	31	51	18	0	80	4	7	49		13	13	75	27	2	46	0	16	68	37	17	2	54	0	1	0	1	4	1
			X	19	100	0	0	91	84	11	5	0	84	0	11	68		5	5	79	53	11	79	0	5	89	63	5	5	74	0	5	0	0	0	5
	52	Development of medical micromachine devices powered by the ATP etc. contained in blood.	1	85	7	18	75	69	47	37	14	2	51	5	85	31		14	15	61	22	0	36	0	21	53	40	19	7	44	6	1	4	9	20	2
			2	85	5	18	78	69	46	38	15	1	47	2	84	26		15	14	73	24	0	44	0	16	64	41	14	2	54	4	1	1	6	24	1
			X	4	100	0	0	63	50	0	50	0	75	0	75	0		25	0	50	25	0	100	0	0	100	50	0	0	75	0	0	0	0	50	0
	53	Practical use of devices which integrate sensors, controllers, and actuators, using micromachine technology.	1	208	9	27	64	68	42	47	10	0	78	10	62	10		2	5	78	31	2	70	0	8	49	58	33	2	46	2	0	1	5	7	1
			2	194	8	25	66	68	40	53	7	0	80	6	63	5		2	3	82	27	1	76	0	5	51	59	27	0	53	1	0	0	3	5	1
			X	16	100	0	0	91	81	19	0	0	94	13	75	0		0	0	88	56	0	88	0	0	44	63	25	0	63	0	0	0	0	6	0
	54	Practical use of micro medical devices for performing blood diagnosis and thrombus treatment.	1	118	8	25	68	72	47	47	6	0	44	0	92	6		1	8	80	30	2	58	0	13	58	53	19	8	51	6	0	1	11	16	3
			2	116	5	15	80	72	44	55	1	0	39	0	94	4		0	6	86	26	0	62	0	6	63	58	13	4	61	3	0	0	11	13	2
			X	6	100	0	0	83	67	33	0	0	83	0	67	17		0	0	83	33	0	100	0	0	100	50	0	0	50	0	0	0	33	33	0
	55	Practical use of ultra-small bio-sensors for use in medical and other applications, based on the utilization of biochemical reactions.	1	113	7	24	69	68	40	51	9	0	56	2	84	10		0	6	75	37	4	60	0	15	56	51	19	14	43	9	0	2	10	8	1
			2	105	9	16	75	68	38	60	3	0	52	2	89	4		0	2	87	31	2	73	0	6	67	55	8	10	50	5	0	0	12	6	1
			X	9	100	0	0	78	56	44	0	0	56	0	67	0		0	11	78	22	0	89	0	0	89	56	0	0	44	11	0	0	22	0	0
	56	Development of high-speed image recognition sensors capable of responding in real time to, for example, a baseball thrown by a pitcher.	1	174	14	24	62	54	23	45	32	0	71	4	51	14		0	6	65	17	2	61	0	17	47	42	26	1	32	0	1	1	5	5	2
			2	167	11	22	67	54	19	59	23	0	77	2	57	6		0	4	74	11	1	72	0	10	56	46	20	0	29	0	1	1	4	1	2
			X	19	100	0	0	69	44	44	11	0	89	5	58	0		0	0	84	21	0	79	0	0	68	37	21	0	42	0	0	0	5	0	5
	57	Practical use of various sensors (smell, taste, tactile) with levels of sensitivity comparable to those of humans.	1	158	10	20	70	62	34	48	18	0	61	10	78	13		4	10	61	33	3	53	0	20	52	47	16	13	39	1	1	1	5	12	1
			2	152	7	18	75	59	25	61	14	0	59	8	84	5		1	7	72	30	1	63	0	14	63	49	5	7	35	0	1	1	3	9	1
			X	10	100	0	0	75	50	50	0	0	50	10	80	0		0	0	80	10	0	100	0	0	70	40	0	10	20	0	0	0	10	0	0
	58	Practical use of biosensors capable of identifying single molecule.	1	96	9	19	72	58	28	49	23	0	60	8	50	32		7	16	65	33	3	34	0	20	57	36	22	9	41	1	0	2	1	2	2
			2	94	6	17	77	56	20	62	18	0	61	3	53	36		3	13	76	32	1	45	0	14	69	40	11	7	43	1	0	0	0	2	2
			X	6	100	0	0	75	50	50	0	0	83	0	33	17		0	17	50	0	0	50	0	17	83	17	0	0	50	0	0	0	0	0	0
	59	Development of non-invasive, CT-type devices capable of recognizing, in real time, excited cerebro-neural states with a resolution on the order of 1 mm.	1	96	13	21	67	74	53	37	10	0	42	1	78	45		0	8	78	34	5	52	0	14	51	39	29	3	54	3	0	1	18	18	1
			2	90	9	19	72	77	57	37	6	0	43	0	78	40		0	6	86	38	3	53	0	8	57	40	21	2	63	3	0	0	17	19	1
			X	8	100	0	0	100	100	0	0	0	88	0	88	25		0	0	88	63	0	75	0	0	88	50	25	0	63	0	0	0	25	13	0
	60	Practical use of multiplexed sensing methods which measure weight distribution from multiple points, for materials with self-diagnostic capabilities.	1	70	11	23	66	58	26	54	20	0	80	10	39	13		0	9	54	20	0	43	0	30	54	44	26	0	37	3	0	1	6	4	1
			2	64	11	17	72	57	21	62	16	0	83	6	31	6		2	3	67	14	0	58	0	20	63	50	19	0	33	2	2	0	3	2	2
			X	7	100	0	0	61	29	57	14	0	71	0	43	29		0	0	57	14	0	71	0	14	71	57	0	0	43	0	0	0	0	0	0

(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Medium	Low	Importance (index, %): Index	High	Medium	Low	Unnecessary	Expected effect (%): Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Forecasted realization time: Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Molecular, sensor and bioelectronics	61	Practical use of biometric sensors which utilize retinal patterns or fingerprint patterns for individual verification.	1	147	8	24	68	63	33	56	10	1	73	1	67	7	1	7	69	20	2	54	0	18	44	41	18	10	28	16	1	1	44	16	1
			2	143	6	22	73	64	31	64	6	0	77	0	75	1	1	5	79	16	0	62	0	11	54	43	10	8	24	16	1	0	43	20	1
			X	8	100	0	0	75	50	50	0	0	88	0	63	0	0	0	88	13	0	88	0	0	63	25	0	13	0	0	0	0	75	50	0
	62	Practical use of biosensors utilizing antibodies.	1	67	12	24	64	68	42	48	9	2	42	6	78	16	0	3	75	34	3	52	0	12	49	34	16	25	31	4	0	9	18	4	0
			2	63	8	24	68	65	33	60	6	0	43	6	92	3	0	0	81	35	2	63	0	8	60	43	8	22	33	2	0	8	27	3	0
			X	5	100	0	0	80	60	40	0	0	60	0	80	0	0	0	60	60	0	60	0	0	60	40	0	0	20	0	0	0	0	0	0
	63	Practical use of diagnostics and treatment of medical conditions using devices implanted inside the human body.	1	85	8	8	84	68	44	45	9	2	40	0	92	9	0	13	68	25	1	33	0	25	41	46	18	18	39	13	0	1	28	19	0
			2	80	4	6	90	69	41	53	5	1	39	0	95	3	0	10	76	26	1	35	0	16	48	56	16	10	49	5	0	0	40	24	0
			X	3	100	0	0	83	67	33	0	0	67	0	100	0	0	33	67	67	0	67	0	0	67	33	0	0	33	0	0	0	0	0	0
	64	Development of DNA analysis system capable of processing 10,000 bases in a single day.	1	42	7	19	74	65	36	54	8	3	48	12	55	57	0	10	88	55	2	48	0	5	50	29	31	29	43	0	0	7	14	26	0
			2	41	7	5	88	63	29	66	5	0	51	5	49	46	0	5	90	44	0	59	0	0	66	39	15	20	44	0	0	2	12	37	0
			X	3	100	0	0	83	67	33	0	0	100	0	0	33	0	0	67	67	0	67	0	0	100	33	0	0	33	0	0	0	0	33	0
	65	Development of sensors that could be substituted for human sensation, capable of directly stimulating nerves.	1	59	8	20	71	54	26	40	30	4	44	3	83	17	3	14	66	25	3	32	0	24	49	41	20	7	36	3	0	3	22	27	0
			2	61	5	13	82	55	23	52	25	0	39	3	82	10	3	10	75	21	3	39	0	16	62	48	11	3	43	5	0	2	33	43	0
			X	3	100	0	0	100	100	0	0	0	67	0	100	0	0	0	67	33	0	67	0	0	67	33	0	0	33	0	0	0	0	0	0
Storage and display electronics	66	Development of a strage system in which one atom or molecule corresponds to 1 bit.	1	235	17	26	57	72	51	35	12	2	83	7	12	46	12	15	69	26	3	50	0	17	57	36	31	1	50	0	1	1	3	4	2
			2	210	15	25	60	76	57	34	8	1	88	5	9	47	12	12	76	24	1	59	0	13	67	35	25	0	60	0	0	0	1	2	1
			X	32	100	0	0	86	72	28	0	0	97	0	16	59	6	3	94	19	3	69	0	0	78	47	31	0	59	0	0	0	6	6	3
	67	Development of a magnetic memory hard disk capable of recording 1,000 Gbits density per square inch.	1	199	17	22	61	78	58	38	3	1	91	4	18	13	7	15	76	12	1	71	0	7	49	48	26	1	37	1	1	1	4	6	2
			2	180	17	24	59	83	67	32	1	1	94	4	17	10	5	9	82	8	0	78	0	2	56	49	22	0	41	0	0	0	2	5	1
			X	30	100	0	0	92	83	17	0	0	100	3	27	10	0	0	90	7	0	83	0	0	70	50	33	0	60	0	0	0	7	10	0
	68	Practical use of optical memories with recording density of 10^{11} b/cm^2.	1	206	18	32	50	77	57	37	6	0	87	7	24	16	7	14	68	17	0	75	0	5	53	48	25	1	43	1	0	0	5	7	1
			2	184	16	33	51	82	66	32	2	0	92	4	26	10	4	13	71	13	0	83	0	3	59	48	21	0	47	0	0	0	2	4	1
			X	30	100	0	0	97	93	7	0	0	97	7	27	20	0	7	77	10	0	93	0	0	63	73	13	0	57	0	0	0	10	10	0
	69	Practical use of high-efficiency light energy converters utilizing organic materials.	1	159	13	21	66	65	36	53	11	1	65	54	19	13	11	13	62	30	2	45	0	23	53	39	18	5	42	2	1	6	1	3	1
			2	146	9	18	73	66	36	57	7	0	71	54	16	9	9	12	65	24	1	55	0	16	66	40	16	3	43	1	0	4	0	1	1
			X	13	100	0	0	79	62	31	8	0	77	38	15	8	8	0	77	46	0	62	0	0	92	54	15	0	46	8	0	8	0	0	8
	70	Practical use of small read/write optical filing systems with at least 1 tera bite capacity per system.	1	193	17	33	51	72	48	45	7	0	91	5	26	11	1	9	73	12	1	79	0	5	50	49	25	1	34	3	1	1	9	7	1
			2	177	15	33	53	78	58	38	4	0	93	3	28	5	1	6	72	8	0	85	0	3	57	55	17	0	34	2	2	0	7	6	1
			X	26	100	0	0	91	85	12	4	0	96	4	23	15	4	0	65	19	0	88	0	0	69	65	8	0	46	4	0	0	15	12	4



(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2026)			Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources		Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Storage and display electronics	71	<u>Development</u> of super-large-scale flat panel displays (covering an entire wall, for instance) utilizing organic materials.	1	226	16	19	65	61	33	48	14	4	81	6	40	4		10	12	50	17	0	69	1	13	49	49	18	1	34	2	0	5	3	10	1
			2	197	14	17	69	62	31	57	10	2	90	2	47	4		7	9	52	13	0	76	1	12	60	55	15	1	39	1	0	4	3	9	1
			X	27	100	0	0	80	59	41	0	0	89	0	41	0		4	0	56	30	0	100	4	0	78	74	15	0	63	0	0	0	0	22	4
	72	<u>Widespread use</u> in homes of large flat-screen televisions with diagonal screen size on the order of 3 m.	1	247	14	23	63	49	21	42	30	7	72	4	46	3		17	9	39	7	0	83	0	6	39	39	13	0	23	4	2	4	4	12	1
			2	226	13	21	66	51	20	47	29	4	76	3	59	2		16	6	37	6	0	88	1	4	50	47	10	0	29	3	3	4	5	12	1
			X	29	100	0	0	74	52	41	7	0	90	0	55	0		7	3	41	14	0	97	0	0	76	59	21	0	41	3	0	3	0	17	3
	73	<u>Development</u> of roll-up type displays.	1	207	17	18	64	53	26	39	29	5	75	6	39	5		7	14	40	8	0	64	0	19	45	43	16	0	28	1	1	3	3	8	1
			2	189	14	21	66	54	23	50	24	3	77	2	53	3		6	11	39	5	0	74	0	13	60	53	8	0	31	1	1	2	2	6	1
			X	26	100	0	0	69	38	62	0	0	96	8	54	4		0	0	50	12	0	96	0	4	85	69	8	0	42	0	0	0	8	15	4
	74	<u>Practical use</u> of miniature file devices that fit inside a pair of glasses and make it possible, for example, to watch a movie anywhere and at any time.	1	213	13	21	66	45	15	44	35	6	76	2	49	4		13	10	56	6	0	62	0	18	43	42	15	0	22	4	2	1	15	23	1
			2	193	10	22	68	46	12	52	31	5	82	2	55	2		12	6	62	4	0	73	0	13	54	53	11	0	22	2	1	1	18	27	1
			X	19	100	0	0	65	39	44	17	0	95	5	58	11		0	0	84	11	0	95	0	0	84	58	11	0	47	5	0	0	32	42	5

(Note) See page 7 for the interpretation of the graphs.

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3. Survey results in "Information"

3.1. Trends in noteworthy domains

In the fifth survey in 1992, the "information" field was combined with "electronics". But the progress of information technology over the past few years has been nothing short of remarkable, and today it has become a fundamental part of our information-hungry society. There is hardly an area where this technology has not had a substantial impact. So in this light, in this survey "information" has been handled as an independent field.

Broadly classifying the information field into 'basic technology' and 'applied technology', we drew up 79 topics. In the basic technology domain, we devised the topics from the viewpoints of (1) computers and related equipment, (2) networks, and (3) software and algorithm; while in the applied technology domain, we looked at (1) lifestyle, medical care, welfare and disaster prevention, (2) society, work, and the local community, and (3) education and entertainment. In each of these domains we arranged the topics according to the objectives of (a) search for new principles, (b) high integration and miniaturization, (c) large scale, wide area, (d) high reliability and safety, (e) intelligence and flexibility, (f) low environmental load, and (g) high productivity.

In this survey, we gave particular attention to forecasting the development of leading information technologies connected with (I) the internet, (II) multimedia, and (III) intelligent agents.

By domain topics, those in the "network technology" classification have the highest degree of importance index, and by topic objectives, "high reliability and safety," "low environmental load" and "high productivity" attracted the highest interest among the respondents. Of the top 20 topics in degree of importance to Japan among all1,072 topics, three are in the "information" field, indicating that the progress of information technology is a driving force for social change.

(Hideo Aiso)

3.1.1. Computers and related equipment

Advances in computers and peripheral equipment have been remarkable over recent years with systems becoming smaller, more powerful and cheaper as the functions of semiconductor devices improve. And along with this, how the systems are used has also undergone a substantial change. The relative importance of general-purpose computers has dropped dramatically, and before workstations had the chance to establish themselves at the top of the computer tree, personal computers forced their way in and now play the key role among the various computer types. Online business applications that were previously the domain of the large general-purpose computers are now set up through server client systems using PCs. Applications that were once only found on mainframe computers are often now able to be run on PCs.

We still need to further improve the functions of computers and related equipment and make them even more user-friendly. And we have to devise entirely new functions for computers. For example, applications that search traditional databases are quite common, but what users need are applications that search, store and process multimedia. This is tied in with the explosion of the internet, and demands for this are growing stronger. Topic "01: Practical use of biocomputers based on a new algorithm" is seen as a theme of the future, rather than something that can be tackled fairly soon; however topic "14: Practical use of face, voice, and other personal recognition technology in the area of security management" contains much that users would welcome in the short term.

There is no limit to user demands for cheaper and smaller computers, and we have to keep heading in this direction as far as technology allows. Topics "05: Practical use of systems which facilitate multimedia communication from anywhere in the world using pocket-size computers" and "15: Widespread use of low-energy personal computers capable of running for one full year on a single button-type battery" would be on every computer users' wish list, and these are areas where we should keep our attention focused.

Topic "13: Widespread use of portable electronic notebooks that offer the same level of flexibility as paper" is one theme that is viewed in the long term, and if a device that can rival paper and its thousands of years of history can be developed, its impact on society as a whole will be incalculable.

(Hiromu Hayashi)

3.1.2 Networks

All eight topics in the networks domain are forecast to be realized by 2010. The earliest is topic “19: Completion of networks enabling interconnection from anywhere through pocketbook-size telephones” at 2005, while the remaining seven topics are forecast between 2007 and 2009.

The topic with the highest percentage of respondents who indicated that it would not be realized with 19% is “23: Development of technology capable of automatically detecting harmful viruses and automatically producing vaccines.” Similarly, 7% of respondents indicated that topic “16: Practical use of administration systems that do not require network administrators” would be difficult to achieve. In all other topics the corresponding percentage is less than 5%. The topic with the highest importance index with 91 is “22: Widespread use of highly reliable network systems capable of protecting privacy and secrecy.” This topic is also rated the most important among the experts with an index of 94.

As for expected effect, in all topics “contribution to socioeconomic development” and “response to people’s needs” are ranked the highest. Expectations for “contribution to socioeconomic development” are especially high at 95–96% in topics 16 and “18: Realization of an environment in which the utilization of high-capacity networks for around 2,000 yen/month is possible.”

As for leading country, an overwhelming majority of respondents indicated that the United States is supreme in all eight topics, and the only topic in which Japan is ranked at anywhere near the level of the United States is topic 19.

As for measures the government should adopt, about 60% of respondents indicated “foster human resources” for topics 16, 22 and 23, and more than 60% of respondents indicated “adjust regulations (relax/toughen)” for the remaining, excluding topic “21: Widespread use of computer networks in which a virtual space can be shared in real time by a large number of unspecified persons.”

In all topics in the network domain, at least 30% of respondents indicated some concern about an “adverse effect on safety” or an “adverse effect on morals, culture or society.” In particular, concern about an adverse effect on safety exceeded 40% for topic 22, while more than 50% of respondents indicated concern that topic 21 could have an adverse effect on morals, culture or society.

General comments for the domain overall indicate that demand and other aspects of economic efficiency and laws and regulations have more of an impact on realization time than do technological difficulties. Some respondents stated that there is no such thing as completed technology, for every time we believe we have gone as far as we can with a technology, new technological themes emerge to force us to rethink our viewpoint and direction. In other words, technological progress is like a circle: it has no ending.

(Jun-ichi Mizusawa)

3.1.3. Software and algorithm

Similar to the cases in the two preceding domains, over the past five years the development of technology related to the internet and multimedia has been an important theme in the software and algorithm domain, and substantial progress has been made. On the other hand, while the themes of artificial intelligence and intellectual processing are just as important as ever, they no longer command center stage as much as they have in the past.

These trends can be seen in the high importance given to software standardization, re-utilization and security, and especially topics “44: Widespread use of software libraries which facilitate the re-utilization of software” and “45: Realization of software inspection and verification technology that enables quick development of error-free, large-scale software.”

In network-related software, respondents consider topics “25: Practical use of OS capable of operating as a single system in a dispersed system” and “26: Development of equipment for automatic preparation of summaries and abstracts of books and other documents” to be of high importance.

As for intellectual processing, topic “35: Elucidation of human creative mechanism to such an extent that it can be applied to computer science” is considered highly important, but its forecasted realization time is a somewhat pessimistic 25 years away.

A similar trend can be seen with topic “38: Realization of technology that enables computers to read through electromagnetic data information recorded in the human brain.”

An example of multimedia-related software is topic “39: Practical use of intelligent robots capable of judging their environment and making decisions autonomously,” and while its degree of importance is not considered to be low, it is not expected to be realized for at least another 15 years.

Software for super-parallel computers is one technology that should attract considerable interest in the future. Topic “43: Development of compilers that can efficiently execute the applications operated on super-parallel computer systems” is assessed as being fairly important, and its forecasted realization time is generally the same as that for the parallel computer topic 03 in the computers and related equipment domain.

Although agent technology is currently attracting considerable attention in the software field, this keyword was not directly included in any of the topics in this survey. But in the realization of topic 39 touched on before, highly intelligent agents will be essential.

(Makoto Arisawa)

3.1.4. Lifestyle, medical care, welfare and disaster prevention

The spread of IT into family life over the past five years has been remarkable. Respondents other than the experts have only moderately high expectation of topic “53: Widespread use of computer systems in the home,” but the personal computers that we have become accustomed to in our offices and schools are becoming central to the information environment in our homes as well. OA systems such as word processors and fax machines are being replaced by computer software packages, and these days with the proper hardware set-up, we can even watch TV through our computers.

Backing this up are the de facto standardization of CPU/OS, upgraded functions of the computer, peripheral equipment and memory components, and falling prices. As PC use increased, especially among business people and students, standardization of browser terminology and trial network services virtually guaranteed the explosive growth of the internet.

One change that is readily noticeable on our streets is the growing use of cellular phones and PHS. While the use of these telephones in trains is frowned upon, it is nonetheless quite a common sight, and more than a few vehicle accidents can be attributed to inattentive drivers engaged in a phone conversation.

The use of portable computers on the way to work, a growing trend among business people in the United States, is still quite uncommon in Japan, but it is probably only time before the trend is embraced with gusto by Japan’s white-collar workers.

With the tremendous growth of the internet, telephone calls and TV broadcasts can now be made through this medium. Unlike in the U.S. where cable TV started off with the sole aim of TV viewing, in Japan CATV is seen as creating a popular regional information environment that is faster and cheaper than existing networks. If the information environment continues to evolve in this way and if the data format becomes standardized, topic “58: Online provision of public procedures and services,” a forward step in administrative reform, will also gain momentum. In this survey, respondents forecast the topic will be realized relatively early at 2004.

As the value of the yen rose and the number of Japanese travelers heading overseas increased, the “borderless” concept steadily took hold in our general living environment; but the popularization of the internet has given an added boost to this trend. Like semiconductor and PC technology, technologies associated with the internet have been developed in a climate of fierce competition, resulting in an evolutionary pace that is astonishing, and the day when multimedia functions are fully incorporated into these technologies is thought to be just around the corner. In particular, expectations are high regarding the development of information filtering technology, which is expected to solve the information flood, and information agent technology, which is premised on the opening of public information, as core technologies that will further hasten the evolution of the internet culture.

It was against this backdrop that online shopping services through the internet began. But the public has not warmed to these services to the extent that initial predictions would have led us to believe, in part due to security concerns, and the bulk of online sales is through information providers backed up by advertising revenue.

In this survey many respondents viewed topic “52: Realization of virtual shopping systems” as important, so the high interest in topics “67: Enhancement of security functions that guarantee contracts over the network,” “64: Establishment of social rules regarding multimedia copyrights,” “16: Automatic network connection” and “18: Realization of an environment in which the unlimited utilization of high-capacity networks (150 Mbps) for around 2,000 yen/month is possible” will create an environment that can stimulate need and promote this kind of business.

In medical care and welfare, nursing and medical care for the elderly has become an imperative theme for the nation as Japanese society, which has been able to boast of the highest life expectancy in the world for more than the last ten years, continues to age at an increasing rate, advances in digital imaging equipment have qualitatively revolutionized surgical procedures, and an increasing amount of medical data is being transmitted and stored electronically.

Data format/protocol for network-based remote area medical information systems that facilitate quality regional medical care is becoming increasingly standardized, and microsurgery techniques that promote speedier recovery with less injury to the body are being put to practical use. Both have been made possible through the development of advanced camera and imaging technology.

In medicine, emphasis is being placed on quality of life, and the medical system is looking at the significance of home care in a new light. In line with this, advances are being made in the development of home care support structures, and in the use of portable multimedia terminal technology to assist in that care. The high expectations for topic “54: Robots which provide medical care support” is probably related to this situation.

In the disaster prevention domain, the inadequacies in Japan’s information gathering structure especially during a disaster has been a constant target of criticism, so local governments across Japan have worked to upgrade their regional information systems and disaster prevention facilities, making full use of multimedia equipment. Such a situation would explain in part why many respondents placed importance on topic “48: Widespread use of systems that provide emergency information at the time of a disaster.”

It is worth mentioning that during the Great Hanshin Earthquake, in addition to the normal information disseminated through public bodies, a substantial amount of important information was disseminated directly from the disaster site by the private sector through the internet, and this became an significant catalyst for action by volunteer groups.

What has stood out over the past few years during oil spills and the hostage crisis at the Japanese embassy in Peru is the extensive use of the internet to provide information. Such an evolution and enhancement of the information environment will also make it possible to share information on global level pollution and provide cooperation not constricted by national borders in such countermeasures as developing satellite communication functions, improving image monitoring systems, and developing damage forecast systems.

Although expectations of topic “49: Practical use of robots for rescuing humans involved in a disaster” are high, respondents are aware of the technological difficulties, and do not expect this technology to be realized before 2015.

Improvements in supercomputer functions and simulation technology have advanced weather forecasting, and weather consultation services as a part of the disaster prevention structure have taken root as a commercial business. Such developments could explain why, even considering the difficulties inherent in the theme, the forecasted realization time for topic “47: Capability to forecast weather up to one week in advance with at least 95% accuracy” is quite early at 2012.

This is also why respondents are looking forward to improvements in computer performance, as reflected in topics 02, 03 and 04, and advancements in parallel processing and super-parallel processing technology, such as topic “43: Development of high-performance compilers for super-parallel computer systems.”

(Masana Minami)

3.1.5. Society, work, and the local community

In this domain, it is forecasted that the internet will make an expanding world of information more available to more people, while the growing use of multimedia information and intelligent agents will generate a range of entirely new and readily accessible services. Services raised in this survey include information provision, information management, electronic transactions, and electronic verification, and many of these topics are forecasted to be realized in the next five to ten years.

Topics that are between 15 and 20 years away are “56: Widespread use of automobiles which drive automatically” and “62: The passage of bills (acts) through electronic voting by the citizenry.” But even though these topics may become technologically possible at an earlier stage, their actual application will require proper legislative foundations and a thorough social assessment of their merits, and this is expected to take considerable time.

As for the services that are five to ten years away, although some of these functions have already been realized and are being used to a degree, it will take 5–10 years before the functions are consolidated and used widely. In particular, topics “64: Establishment of social rules regarding multimedia copyrights,” “66: Widespread use of electronic money to settle monetary matters” and “68: Widespread use of systems to handle information management uniformly among related companies” are ranked high in both importance and expected effect, and are expected to be realized in the next ten years. Respondents also pointed out that the government should establish appropriate regulations for topics “61: Realization of in-home electronic voting in elections,” “58: Realization of applications, registrations, and other official public procedures and services over networks” and “57: Computerization of the foreign exchange, stock and other financial markets to enable the widespread use of fully automated rapid trading systems that do not require dealers or traders.”

(Satoshi Goto)

3.1.6. Education and entertainment

The education and entertainment domain is attracting considerable attention as an important application of the sophisticated information systems that make up our information-based society. The growth of this domain is one of the most important factors in the rapid expansion of information equipment and software in the home. Important in this domain are topics dealing with the development or widespread use of systems that facilitate the acquisition of high-level information or knowledge. In the two decades between 2000 and 2020, respondents forecast we will see network-based remote education support systems, advances in the development of educational and entertainment software as systems become more intelligent, and greater and easier access to these systems from the home or office.

One characteristic of this domain, and especially topics connected with education, is the special attention given to the “adverse effect on morals, culture or society” that could arise from realization. This is thought to indicate the respondents’ concern that because education is such a critical domain that will have a long-term impact on morals, culture and society, any developments in this domain have to take any potential effect fully into account.

Topic “71: Emergence of robots capable of acting as opponents to humans in sports activities” displays high-level functions, and is expected to be realized in 2014.

As large-scale technology over a wide area, network-based topics “72: Widespread use of two-directional, multi-point, remote education support systems in homes” and “73: Realization of an electronic school system that enables students who cannot commute to and from primary and middle school to graduate” are assessed as highly important, and are forecasted to be realized in 2008. Respondents also believe that the government should “adjust relevant regulations (relax/toughen)” as an effective means of facilitating the realization of these two topics.

In the aspects of high reliability, safety and ease of use, topics with a high degree of importance are “75: Widespread use of multimedia encyclopedias that enable the search and retrieval of text, sound, images and video,” “76: Widespread use of science museums capable of fostering scientific skills of children through play,” “78: Widespread use of advanced expert systems capable of utilizing teachers’ knowledge and experience etc.” and “79: Development of support systems to assist students in learning on their own via networks,” indicating the respondents hold great hopes and expectations about the acquisition of advanced specialist information or knowledge. All topics are expected to be realized between 2004 and 2010.

(Yasushi Kiyoki)

3.2. Forecast topic framework

In the course of compiling forecast topics, a framework representing the organization of technologies in tabulated matrix form was drawn up for each field, with objectives and technological domains defining the rows and columns of the table, respectively. The framework is designed to present an overall picture of technological development in each field in terms of future prospects, importance, etc. as seen from the present perspective, and is also used as a working framework for future reviews of forecast topics.

Table 3.2-1 Forecast Topic Framework for Information Field

Domain / Objective	Technology			Application		
	Computers and related equipment	Networks	Software and algorithms	Lifestyle, medical care, welfare and disaster prevention	Society, work, and local community	Education and entertainment
Pursuit of new principles	01	16	24			
High integration, miniaturization, high capacity, high speed, super-parallel processing, high performance, high output (including high performance) and low price	02 03 04 05 06 07 08 09 10 11 12 13	17 18	25 26 27 28 29 30 31		56 57	71
Large scale and wide area		19 20 21		46	58 59 60 61 62	72 73
High reliability and safety		22 23		47 48 49	63 64	
Intelligence and flexibility (including fuzzy technology) Ease of use (human interface)	14		32 33 34 35 36 37 38 39 40 41 42	50 51 52 53 54 55	65 66 67 68	74 75 76 77 78 79
Low environmental load (low pollution, resource conservation and energy conservation)	15				69	
High productivity			43 44 45		70	

* Figures appearing in the table represent topic numbers.

3.3. Topics with high degree of importance

Degree of importance index scores (Note 1) averaged at 62.4 for topics in the information field as a whole. Topics considered of particular importance to Japan (top 20 topics in terms of degree of importance index score) are listed in the table below. Only 22. Widespread use of highly reliable network systems capable of protecting the privacy and secrecy of individuals and groups, the topic rated most important, received a score greater than 90.

Table 3.3-1 Top 20 Topics in Terms of Degree of Importance Index

Topic	Degree of importance index	Forecasted realization time (year)
22 Widespread use of highly reliable network systems capable of protecting the privacyand secrecy of individuals and groups from the intrusion of ill-intentioned hackers.	91	2007
18 Realization of an environment in which the unlimited utilization of high-capacity networks (150 Mbps) for around 2,000 yen/month is possible.	90	2008
64 Establishment of social rules regarding multimedia copyrights, and expanded production and distribution of multimedia information.	89	2005
48 Widespread use in all areas of security systems capable of providing emergency information to the general public in the case of a disaster.	87	2007
05 Practical use of systems which facilitate multimedia communication from anywhere in the world using pocket-size computers.	85	2003
45 Advances in software inspection and verification technology, enabling quick development of error-free, large-scale software.	83	2012
68 Widespread use of systems to unitarily handle information management (orders, design, manufacturing, maintenance) among related companies.	82	2005
66 Widespread use of electronic money to settle monetary matters.	81	2006
44 Separation of developed software into components, and widespread use of software libraries which facilitate the re-utilization of those components.	81	2006
54 Practical use of robots which provide medical care support in homes, hospitals, etc.	81	2010
67 Become possible to verify the counterparty to a contract concluded over a network with the use of database systems.	78	2004
19 Completion of networks enabling interconnection from anywhere in Japan through pocketbook-size telephones.	78	2005
69 Creation of a global multimedia network to disseminate global environmental information on-line, and utilization of global environmental information on a worldwide basis.	77	2007
46 Widespread use of systems facilitating on-demand acquisition of multimedia information dispersed on networks around the globe.	77	2005
15 Widespread use of low-energy personal computers capable of running for one full year on a single button-type battery	75	2012
49 Widespread use of systems facilitating on-demand acquisition of multimedia information dispersed on networks around the globe.	74	2015
06 Widespread use of hand-held, motor-less (all silicone) multimedia devices capable of operating for about 3 hours.	73	2005
16 Practical use of administration systems which conduct network connection and operation automatically and without a network administrator.	73	2007
23 Development of technology capable of automatically detecting viruses and automatically producing corresponding vaccines.	72	2009
35 Elucidation of human creative mechanism to such an extent that allows to apply to computer science.	71	2023

Note 1: Degree of importance index = (number of “high” responses × 100 + number of “medium” responses × 50 + number of “low” responses × 25 + number of “unnecessary” responses × 0) ÷ total number of degree of importance responses

3.4. Forecasted realization times

Forecasted realization times were distributed as shown in the diagram below.

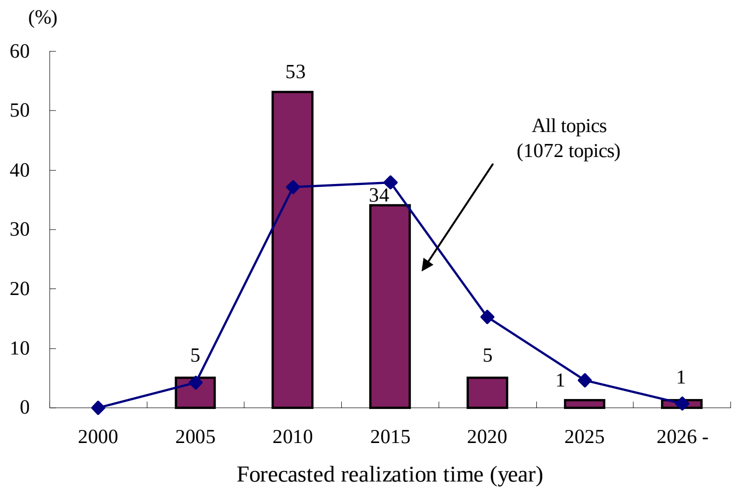


Fig. 3.4-1 Trends in Forecasted Realization Times

With more than half the topics in the information field forecasted to be realized between 2006 and 2010, the distribution of forecasted realization times peaked earlier than the general trend covering all topics.

3.5. Current leading countries etc.

Responses to the question concerning current leading countries etc. were as shown in the diagram below. Named by 77.6% of the respondents, the U.S. is dominant in the information field as a whole, with Japan trailing at 50.9%. The score of the third-ranking EU was less than half of Japans.

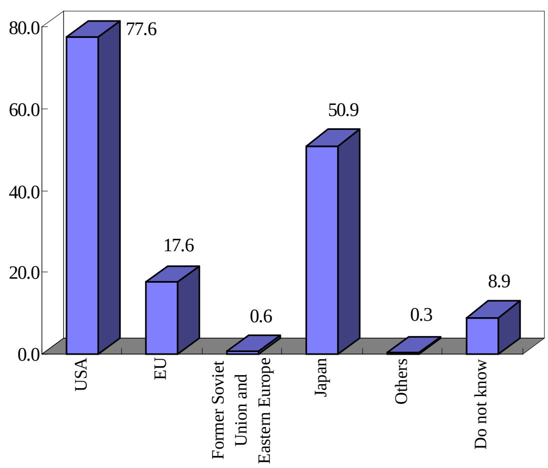


Fig. 3.5-1 Current Leading Countries etc. (%)

3.6. Comparison with the 5th Survey (previous survey)

Of the 79 topics included in the latest survey, 14 (18%) were identical to the previous survey, 15 (19%) were modified, and 50 (63%) were newly introduced. For identical topics, the results of the latest survey were compared with those of the previous survey in terms of degree of importance index scores and forecasted realization times, as shown in the table below.

Degree of importance index scores rose for 6 topics, fell for 6 topics and remained the same for 2 topics. 53. Widespread use of integrated home computer systems saw the greatest jump in the degree of importance index score, up 13 points, while 04. Practical use of computers with computational speed exceeding 10 TFlops saw the greatest drop, down 9 points.

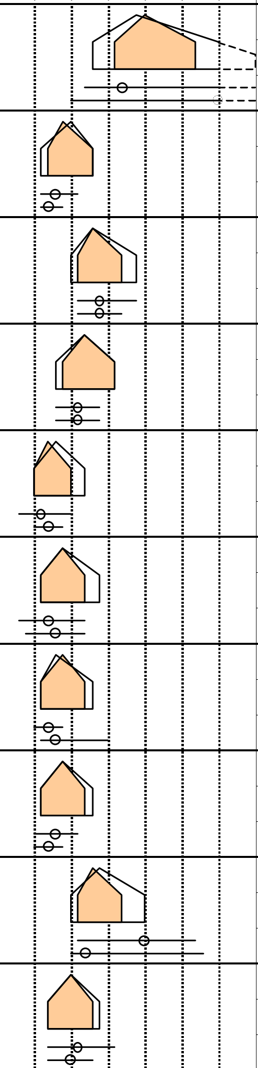
From the 4th to the 5th Survey, forecasted realization times were pushed back for all but one topic. Likewise, from the 5th to the 6th Survey, forecasted realization times were pushed further into the future for 13 of the 14 topics.

Table 3.6-1 Comparison with 5th Survey for Identical Topics

Topic	Degree of importance index/forecasted realization time (year)	
	6th survey	5th survey
03 Practical use of parallel computers with one million or more processors.	64/2009	71/2007
04 Practical use of computers with computational speed exceeding 10 TFlops	70/2008	79/2005
14 Practical use of face, voice, and other personal recognition technology in the area of security management.	67/2005	59/2002
19 Completion of networks enabling interconnection from anywhere in Japan through pocketbook-size telephones.	78/2005	75/2002
26 Development of equipment for automatic preparation of summaries and abstracts of books and other documents (degree of condensation can be adjusted as necessary).	60/2009	60/2010
27 Widespread use of voice word processors in which Japanese text can be input by voice (continuous speaking by unspecified speakers).	56/2011	61/2008
33 Widespread use of three-dimensional image processing technology capable of detecting moving objects and recognizing moving patterns and changes in shapes.	61/2010	63/2003
34 Development of robots capable of identifying and repairing their own faults by themselves.	58/2016	58/2011
35 Elucidation of human creative mechanism to such an extent that allows to apply to computer science.	71/2023	78/2020
39 Practical use of intelligent robots with visual, auditory, and other types of sensors, capable of judging their environment and making decisions autonomously.	68/2014	65/2012
40 Development of technology for quantitatively measuring comfort sensations such as wearing, riding, and coziness.	46/2010	45/2004
45 Advances in software inspection and verification technology, enabling quick development of error-free, large-scale software.	83/2012	86/2009
53 Widespread use of home computer systems which can be used to control equipment in the home, manage household finances and health, and provide interactive learning.	64/2007	51/2004
76 Spread of science museums capable of fostering scientific skills of children through play based on the applied use of natural history and science education techniques.	57/2006	53/2001

Note: Up until the 5th Survey, realization meant realization in Japan unless otherwise specified. However, this was changed to mean realization somewhere in the world in the 6th Survey, so realization now means realization somewhere in the world. Therefore, care should be taken when comparing forecasted realization times from the two surveys.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time			Leading countries (%)						Measures the government should adopt (%)							Information Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001 2006 2011 2016 2021 2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Computers and related equipment	1	Practical use of bio-computers based on a new algorithm which takes into account the organic information processing system.	1	171	6	30	63	62	36	43	19	2	54	13	22	69		8	8	77	12	2	25	0	19	61	49	20	21	42	2	1	5	4	27	2
			2	141	4	27	69	60	29	57	12	2	54	9	16	76		7	9	75	8	1	21	0	22	65	45	18	16	47	2	1	4	6	34	1
			X	6	100	0	0	83	67	33	0	0	100	33	33	67		0	17	100	0	0	67	0	0	100	67	17	0	67	0	0	0	0	17	0
	2	Practical use of high-performance supercomputers for vector calculations, priced at one million yen or less.	1	189	17	43	40	64	35	50	14	1	78	18	15	28		3	4	89	2	1	73	0	1	40	38	17	1	36	4	4	2	7	6	2
			2	153	10	49	41	63	31	59	10	1	88	13	11	23		1	3	88	1	1	73	1	1	47	40	9	0	39	3	3	1	6	5	1
			X	16	100	0	0	77	56	38	6	0	88	13	6	19		0	13	69	0	0	88	0	0	31	50	13	0	38	0	6	0	6	6	0
	3	Practical use of parallel computers with one million or more processors.	1	197	18	45	37	63	35	47	16	1	68	33	11	50		7	6	93	10	1	53	1	3	53	46	20	2	43	4	3	2	6	7	2
			2	160	14	49	37	64	34	54	12	0	79	27	6	42		7	3	96	7	0	55	0	1	63	44	18	0	45	2	2	1	4	6	1
			X	22	100	0	0	68	45	36	18	0	77	36	0	27		5	5	91	5	0	73	0	0	59	59	18	0	36	0	0	0	5	5	0
	4	Practical use of computers with computational speed exceeding 10 TFlops.	1	186	18	38	44	71	47	45	8	0	74	34	13	39		0	5	90	6	0	64	0	2	53	37	21	2	45	5	2	1	9	6	2
			2	151	13	45	42	70	43	51	6	0	82	31	9	34		0	1	91	5	0	64	0	0	66	33	17	0	48	2	1	0	8	5	1
			X	20	100	0	0	80	65	25	10	0	80	50	5	25		0	0	80	0	0	70	0	0	70	35	15	0	40	5	0	0	5	5	0
	5	Practical use of systems which facilitate multimedia communication from anywhere in the world using pocket-size computers.	1	228	27	42	31	80	63	32	5	0	88	11	76	12		0	0	87	15	0	75	1	0	35	36	8	1	21	47	7	0	43	38	1
			2	183	25	48	27	85	71	25	3	0	89	6	78	10		1	0	88	12	0	83	2	1	38	41	5	0	20	60	5	0	46	44	0
			X	45	100	0	0	93	87	13	0	0	84	11	89	16		0	0	91	18	0	89	4	0	49	38	7	0	24	64	4	0	53	47	0
	6	Widespread use of hand-held, motor-less (all silicone) multimedia devices capable of operating for about 3 hours.	1	174	18	44	37	68	45	39	15	1	77	10	67	10		2	3	69	8	1	73	1	4	35	32	9	2	23	18	3	1	17	21	1
			2	148	16	45	39	73	52	37	11	0	81	3	69	9		1	1	70	5	0	86	2	1	45	41	4	1	24	18	1	1	16	24	0
			X	24	100	0	0	90	79	21	0	0	92	4	79	13		0	0	71	4	0	96	0	0	58	29	8	0	21	25	0	0	25	21	0
	7	Development of 5,000 dpi high-quality color printers.	1	145	8	27	65	55	26	44	29	1	71	1	36	6		0	8	50	7	0	88	0	3	32	28	7	1	15	5	3	6	4	10	1
			2	121	4	25	71	53	20	54	25	1	77	0	40	4		0	7	52	2	0	94	0	1	46	32	4	0	15	3	1	3	2	13	0
			X	5	100	0	0	60	40	20	40	0	60	0	60	20		0	20	40	0	0	100	0	0	40	40	0	0	40	0	0	0	40	0	0
	8	Widespread use of multipurpose ID card system with wireless communication capability.	1	189	13	35	52	66	38	49	12	1	83	8	75	6		1	2	79	29	1	65	1	6	31	26	8	2	22	48	4	2	59	30	2
			2	159	9	35	57	66	36	59	5	1	84	6	83	4		0	1	84	30	0	78	2	3	35	26	3	1	18	62	2	2	55	29	1
			X	14	100	0	0	91	86	7	7	0	100	29	86	14		0	0	100	57	0	93	7	0	50	36	0	0	29	64	7	0	79	29	0
	9	Widespread use of sound field shielding technology capable of isolating a specific spatial area from the surrounding noise.	1	83	7	20	72	52	23	43	33	3	39	13	64	14		7	10	42	12	0	42	0	30	37	20	20	1	27	8	2	6	16	16	2
			2	69	7	16	77	52	21	49	29	1	38	9	72	7		7	9	51	4	0	54	0	23	43	16	17	0	35	9	1	6	13	16	0
			X	5	100	0	0	100	100	0	0	0	80	20	40	0		0	0	60	20	0	100	0	0	40	20	40	0	60	20	0	20	20	40	0
	10	Practical use of portable computers powered primarily by solar cells.	1	162	6	27	67	67	41	45	14	0	69	59	49	5		2	4	50	9	1	72	1	13	37	35	15	2	38	4	2	13	7	5	2
			2	130	5	21	74	66	38	50	13	0	67	57	50	2		2	2	55	3	1	81	1	8	45	37	10	1	49	2	1	11	6	4	0
			X	7	100	0	0	79	57	43	0	0	71	43	29	0		0	14	43	0	0	86	0	14	57	57	0	0	71	0	0	29	29	0	0



(Note) See page 7 for the interpretation of the graphs.

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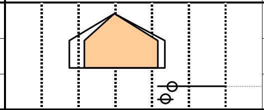
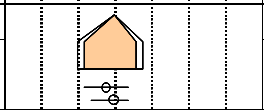
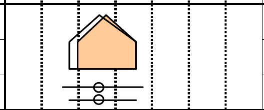
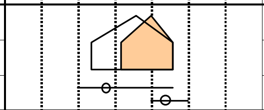
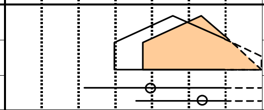
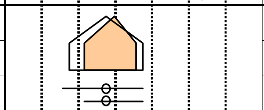
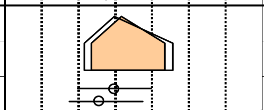
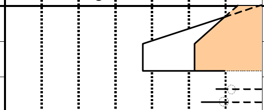
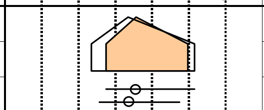
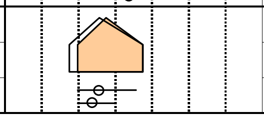
Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic development	Expected effect: Resolution of global problems	Expected effect: People's needs	Expected effect: Expansion of intellectual resources	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Computers and related equipment	11	Development of complete solid angle 4π dome-shaped three-dimensional display (for space exploration simulation, etc.).	1	89	12	17	71	42	11	40	43	6	55	11	44	25	1	9	71	7	1	47	0	11	30	26	18	1	29	3	6	1	3	10	3
			2	75	8	9	83	40	8	41	47	4	53	5	49	19	1	4	76	3	1	57	0	8	44	25	20	1	37	3	5	0	5	17	1
			X	6	100	0	0	75	50	50	0	0	67	17	67	17	0	0	83	0	0	83	0	0	33	17	17	0	50	17	17	0	0	17	0
	12	Widespread use of three-dimensional television sets that can be viewed without special glasses.	1	143	14	15	71	49	17	47	34	2	57	1	55	11	5	10	59	8	1	62	0	13	36	33	10	1	27	3	2	1	6	21	2
			2	117	9	16	74	46	12	50	35	3	51	0	64	9	4	5	62	5	1	79	0	9	44	28	9	1	25	1	2	0	9	21	1
			X	11	100	0	0	73	45	55	0	0	82	0	55	9	0	9	82	0	0	91	0	0	45	45	18	0	45	9	0	0	9	36	0
	13	Widespread use of portable electronic notebooks that offer the same level of flexibility as paper (thin and pliable).	1	150	15	23	61	68	44	40	16	0	73	21	56	9	6	11	51	8	0	55	0	22	44	36	9	3	35	6	2	5	9	13	2
			2	129	9	21	71	67	41	48	12	0	74	12	65	6	5	7	54	5	0	63	0	17	51	31	5	1	39	4	2	4	5	13	0
			X	11	100	0	0	82	64	36	0	0	91	27	64	9	9	9	64	0	0	82	0	0	55	45	0	0	45	18	0	18	0	36	0
	14	Practical use of face, voice, and other personal recognition technology in the area of security management.	1	202	17	35	48	68	41	47	11	1	75	2	67	9	2	2	82	22	1	67	0	8	53	35	15	2	35	17	2	0	54	31	1
			2	163	15	33	52	67	38	57	6	0	78	2	70	6	2	1	88	17	1	69	1	6	57	30	13	2	36	17	2	1	53	32	0
			X	24	100	0	0	87	74	26	0	0	79	4	79	17	4	4	92	29	8	79	0	4	50	33	13	8	33	25	4	0	67	38	0
	15	Widespread use of low-energy personal computers capable of running for one full year on a single button-type battery.	1	135	7	28	64	70	46	41	12	1	64	47	49	3	10	9	58	4	1	70	0	15	42	33	11	4	32	3	1	10	4	7	1
			2	114	5	24	71	75	55	36	9	0	71	42	50	4	9	4	61	1	1	79	0	10	53	32	9	1	32	3	1	13	6	7	1
			X	6	100	0	0	92	83	17	0	0	67	17	33	0	17	0	67	0	0	83	0	0	33	17	33	17	17	17	0	33	17	17	0
Networks	16	Practical use of administration systems which conduct network connection and operation automatically and without a network administrator.	1	206	26	37	36	70	45	45	11	0	89	5	40	9	8	5	92	20	0	36	0	2	49	32	14	2	27	18	1	0	30	16	1
			2	172	24	31	45	73	49	45	7	0	95	2	40	4	7	3	92	15	0	37	0	2	60	29	8	1	23	15	1	0	37	16	0
			X	42	100	0	0	83	66	34	0	0	95	5	52	5	5	2	98	19	0	48	0	0	62	36	12	0	38	19	2	0	33	14	0
	17	Widespread use in Japanese households of next-generation cable TV capable of transmitting programs on over 300 channels by means of data compression technology.	1	174	18	29	53	61	34	46	19	2	74	4	69	8	2	5	92	21	1	34	0	2	25	31	11	1	24	50	2	2	10	35	1
			2	145	14	29	57	60	27	57	15	1	74	2	74	5	3	3	94	14	0	32	0	1	22	25	7	1	19	63	0	0	7	40	1
			X	21	100	0	0	73	48	48	5	0	86	10	76	10	5	5	95	33	0	52	0	0	24	19	0	5	24	71	0	0	10	43	5
	18	Realization of an environment in which the unlimited utilization of high-capacity networks (150 Mbps) for around 2,000 yen/month is possible.	1	199	24	37	39	87	75	22	3	0	94	14	70	15	4	3	93	28	1	48	1	3	22	23	16	2	33	61	9	0	23	28	1
			2	164	23	37	41	90	80	17	2	0	96	9	73	11	2	1	93	23	0	52	1	3	20	21	7	1	34	73	2	0	22	38	1
			X	37	100	0	0	93	86	11	3	0	97	22	81	16	0	0	95	30	0	70	0	3	22	14	11	3	46	73	0	0	27	46	0
	19	Completion of networks enabling interconnection from anywhere in Japan through pocketbook-size telephones.	1	198	18	31	52	76	54	39	7	0	79	8	84	3	3	3	79	29	1	70	0	5	21	18	14	2	26	49	8	2	21	21	1
			2	159	18	35	47	78	58	38	4	0	80	4	88	4	1	0	86	26	0	79	0	3	19	14	5	1	23	72	3	1	24	25	0
			X	28	100	0	0	79	57	43	0	0	79	7	89	7	0	0	86	36	0	96	0	0	18	7	4	4	29	79	4	0	25	25	0
	20	Widespread use of mobile terminals capable of transmitting and receiving data at 10 Mbps, even from a moving train.	1	184	18	30	52	66	39	46	15	0	82	5	61	7	1	4	83	25	1	64	1	4	34	24	11	1	29	53	3	2	30	18	1
			2	159	16	30	54	66	36	56	8	0	87	3	65	5	1	2	89	26	0	69	0	3	35	18	4	0	27	67	1	0	38	19	0
			X	25	100	0	0	67	36	60	4	0	96	8	60	12	0	4	88	40	0	72	0	0	32	12	8	0	36	64	0	0	40	16	0

(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time			Leading countries (%)						Measures the government should adopt (%)							Information Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001 2006 2011 2016 2021 2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Networks	21	Widespread use of computer networks in which a virtual space can be shared in real time by a large number of unspecified, geographically dispersed persons.	1	205	29	34	37	60	31	49	20	0	77	12	63	21		1	4	94	17	0	47	0	2	44	44	22	3	32	26	0	1	36	46	1
			2	166	29	33	39	60	26	60	13	0	82	10	61	19		1	1	96	13	0	53	0	1	50	41	17	1	33	28	1	0	33	53	1
			X	48	100	0	0	69	42	50	8	0	81	13	69	17		0	0	100	17	0	58	0	0	46	42	21	0	48	27	2	0	40	52	0
	22	Widespread use of highly reliable network systems capable of protecting the privacy and secrecy of individuals and groups from the intrusion of ill-intentioned hackers.	1	209	21	35	44	85	71	28	1	0	78	4	60	11		7	5	91	19	1	33	0	5	53	34	15	1	37	27	1	0	41	25	1
			2	168	20	34	46	91	81	19	0	0	87	4	67	7		5	2	95	15	0	35	0	2	60	31	10	0	38	31	2	0	43	26	0
			X	34	100	0	0	94	88	12	0	0	79	12	71	3		9	0	97	6	0	32	0	0	71	29	9	0	53	26	3	0	32	26	0
	23	Development of technology capable of automatically detecting viruses and automatically producing corresponding vaccines.	1	157	11	31	58	69	45	44	9	2	69	6	53	10		24	19	85	17	3	20	0	8	55	31	9	3	31	7	2	0	31	13	0
			2	125	10	25	65	72	47	48	5	1	78	5	54	7		19	15	91	17	2	22	0	4	63	24	2	2	30	4	2	0	36	12	0
			X	13	100	0	0	73	58	25	8	8	54	8	62	15		23	8	85	15	15	15	0	0	54	15	8	15	31	15	0	0	46	31	0
Software and algorithms	24	Development of software capable of using sensory and learning functions to rewrite itself into an even more advanced program.	1	187	23	43	34	64	35	51	14	0	65	5	21	53		13	11	81	24	1	30	0	10	72	27	17	5	39	4	1	0	13	22	2
			2	151	21	41	38	64	34	52	13	0	74	3	17	58		11	7	87	17	1	28	0	7	76	21	9	1	42	4	2	0	17	25	3
			X	31	100	0	0	67	39	52	10	0	77	0	19	58		10	3	84	26	3	35	0	3	81	23	6	0	45	6	3	0	16	29	0
	25	Practical use of OS capable of operating, in distributed environment on an area network, without cognizance of position as if the systems were a single system.	1	192	27	39	34	69	42	48	9	0	88	8	39	20		2	3	95	14	0	28	0	2	58	36	18	1	40	8	2	0	20	12	1
			2	159	25	38	38	67	36	60	4	0	91	6	38	14		2	1	94	11	0	26	0	1	67	30	13	2	43	6	1	0	20	12	0
			X	39	100	0	0	76	54	41	5	0	87	10	44	26		5	3	92	21	0	41	0	0	74	31	15	3	51	3	3	0	18	15	0
	26	Development of equipment for automatic preparation of summaries and abstracts of books and other documents (degree of condensation can be adjusted as necessary).	1	191	20	41	39	63	34	49	17	0	70	6	53	37		8	4	76	19	1	47	2	14	56	32	16	15	37	7	2	0	11	19	2
			2	155	15	43	43	60	27	57	16	0	67	2	56	31		7	1	82	14	0	45	1	10	63	28	12	9	37	5	3	0	6	19	2
			X	23	100	0	0	76	52	48	0	0	65	9	61	35		0	9	100	13	0	65	0	0	87	30	9	13	43	13	13	0	4	22	4
	27	Widespread use of voice word processors in which Japanese text can be input by voice (continuous speaking by unspecified speakers).	1	194	14	39	47	59	31	43	26	1	58	1	86	13		10	4	53	14	1	82	1	6	54	37	10	10	41	3	1	0	8	16	0
			2	157	13	36	51	56	25	49	25	0	55	1	87	11		10	3	47	9	0	92	1	3	62	32	7	7	45	2	3	0	4	17	1
			X	21	100	0	0	64	33	57	10	0	43	5	95	10		14	5	67	0	0	100	0	0	52	19	5	10	48	5	10	0	0	19	5
	28	Practical use of portable translation devices (translates simple, common phrases in both directions) using voice input.	1	182	16	35	49	65	36	52	10	1	64	6	80	18		5	4	60	25	0	77	1	9	57	40	11	9	38	2	2	0	5	15	1
			2	148	15	32	53	63	31	61	9	0	57	4	86	14		7	1	64	18	0	82	0	7	65	41	7	6	39	1	3	0	3	18	1
			X	22	100	0	0	64	32	59	9	0	59	5	91	18		9	0	73	14	0	100	0	0	82	32	5	14	41	5	9	0	5	14	0
	29	Development of systems capable of recognizing and understanding expressions which use metaphors to express information.	1	168	18	33	49	46	15	43	39	4	40	1	44	38		15	11	59	23	1	48	1	21	63	27	10	10	27	1	0	0	2	14	1
			2	133	17	29	54	40	7	45	45	4	41	0	55	38		16	6	71	21	0	54	0	17	67	28	8	4	26	2	2	0	2	14	1
			X	23	100	0	0	40	4	48	48	0	39	0	30	70		17	9	91	13	0	65	0	4	74	30	4	4	26	4	4	0	4	22	0
	30	Practical use of knowledge bases which consolidate their knowledge in a consistent manner through automatic learning.	1	182	20	40	40	61	31	53	15	1	65	3	42	48		18	11	79	28	1	40	1	11	67	33	13	10	39	3	0	0	8	18	1
			2	145	18	34	48	58	23	62	14	1	70	1	36	48		13	7	85	26	1	48	0	10	73	30	8	4	43	2	1	0	3	21	0
			X	26	100	0	0	67	40	48	12	0	65	8	27	58		8	4	85	31	4	50	0	4	77	27	8	15	58	8	4	0	0	31	0

(Note) See page 7 for the interpretation of the graphs.

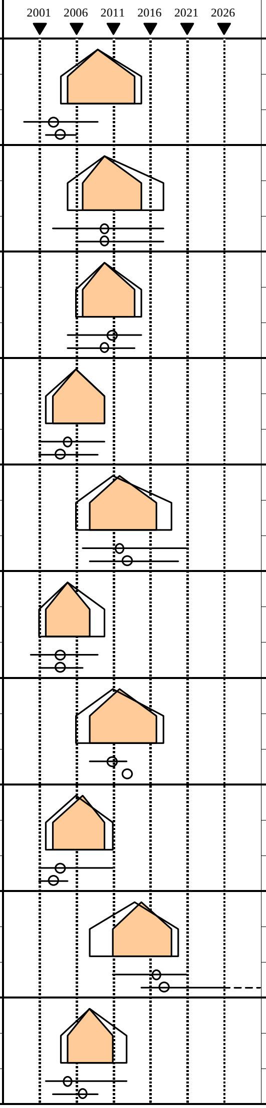
Information

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Medium	Low	Importance (index, %): Index	High	Medium	Low	Unnecessary	Expected effect (%): Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Software and algorithms	31	Development of multipurpose assessment methods for taste, smell, etc., which do not depend upon the physical senses of humans.	1	84	4	23	74	48	15	50	34	1	48	6	56	27		7	15	31	19	2	29	0	43	42	31	10	15	29	6	2	4	1	20	2
			2	73	3	16	81	45	11	46	41	1	42	4	64	19		8	7	32	15	1	37	0	36	45	33	3	10	22	3	3	1	5	29	3
			X	2	100	0	0	75	50	50	0	0	50	0	50	50		0	0	50	50	0	50	0	50	50	50	0	0	100	0	0	50	0	50	50
	32	Widespread use of portable conversation devices which convert the volition of disabled individuals into speech.	1	133	6	24	70	63	37	41	22	0	25	1	95	8		1	10	66	32	0	34	0	20	47	40	14	8	65	5	2	0	11	18	2
			2	113	4	18	78	60	31	48	22	0	22	0	94	7		0	6	73	32	0	43	0	17	57	35	8	4	73	4	3	0	10	18	0
			X	5	100	0	0	75	50	50	0	0	20	0	60	40		0	20	100	40	0	60	0	0	40	20	0	0	60	40	0	0	0	60	0
	33	Widespread use of three-dimensional image processing technology capable of detecting moving objects and recognizing moving patterns and changes in shapes.	1	165	16	32	52	63	30	60	9	0	85	2	57	19		1	4	89	24	2	55	0	4	63	40	18	2	40	1	1	0	5	9	1
			2	130	15	28	57	61	25	71	5	0	87	0	54	15		1	2	89	15	1	59	0	4	68	36	10	1	52	1	2	0	8	9	0
			X	19	100	0	0	67	37	58	5	0	84	0	58	32		0	0	89	11	0	79	0	0	58	32	16	0	58	0	5	0	16	11	0
	34	Development of robots capable of identifying and repairing their own faults by themselves.	1	138	10	33	57	63	34	54	11	1	79	15	44	20		9	9	74	17	5	56	0	14	62	41	14	3	42	3	1	4	9	12	1
			2	111	5	25	69	58	21	70	8	1	86	13	41	13		6	5	80	12	2	63	0	9	68	37	8	2	50	2	1	0	12	14	1
			X	6	100	0	0	54	33	33	17	17	67	33	0	33		17	17	67	0	0	67	0	17	67	33	0	0	83	17	0	0	17	33	0
	35	Elucidation of human creative mechanism to such an extent that allows to apply to computer science.	1	144	14	35	51	69	47	37	15	1	43	3	17	84		19	14	69	33	5	31	1	20	65	42	16	10	46	1	1	1	6	33	1
			2	123	8	29	63	71	50	35	15	0	47	1	9	89		21	9	72	28	3	30	0	18	72	37	9	5	60	2	2	1	4	40	0
			X	10	100	0	0	90	80	20	0	0	60	0	10	100		10	0	90	40	10	90	0	0	100	50	0	0	80	0	0	10	0	70	0
	36	Development of visualized systems which facilitate the easy comprehension of very complex cause-effect relationships such as juridical cases.	1	154	13	33	54	53	20	55	22	3	62	5	40	41		1	5	62	23	0	36	0	24	58	36	12	10	35	4	1	0	10	21	0
			2	132	11	28	61	51	15	64	19	2	67	2	39	35		1	5	70	18	0	42	0	19	64	39	9	6	44	2	2	0	9	29	0
			X	14	100	0	0	59	21	71	7	0	86	0	43	57		0	7	93	21	0	79	0	7	71	43	0	7	64	7	7	0	14	36	0
	37	Development of technology capable of distinguishing over 10,000 different human beings from images recorded with a video camera.	1	156	16	24	60	54	22	51	25	1	69	8	55	13		7	10	73	21	2	54	1	12	57	31	15	9	37	4	1	0	39	19	1
			2	127	13	24	62	53	17	60	23	0	77	6	60	8		6	3	84	16	1	67	0	8	69	28	12	5	43	1	2	0	45	22	0
			X	17	100	0	0	61	31	50	19	0	71	12	76	18		6	0	88	12	0	76	0	0	76	12	6	6	53	6	0	0	47	18	0
	38	Become possible for computers, using electromagnetic data, to read the information recorded inside the human brain.	1	113	7	21	72	55	31	36	24	9	37	3	42	67		35	14	50	20	4	25	0	29	44	22	13	14	33	8	1	1	42	58	0
			2	92	5	15	79	55	26	46	21	7	33	1	39	75		39	5	60	17	2	22	0	23	59	22	9	11	37	7	2	0	41	67	0
			X	5	100	0	0	70	40	60	0	0	60	0	60	80		40	20	100	40	0	60	0	0	80	40	40	0	60	20	0	0	80	80	0
	39	Practical use of intelligent robots with visual, auditory, and other types of sensors, capable of judging their environment and making decisions autonomously.	1	161	17	25	58	68	41	47	11	0	76	17	66	27		6	8	78	20	5	57	1	10	59	44	22	2	45	5	1	1	21	28	1
			2	128	16	21	63	68	41	49	10	0	80	13	71	21		6	6	84	12	2	59	0	5	66	41	16	2	54	2	2	0	24	31	0
			X	20	100	0	0	68	42	47	11	0	80	20	80	25		5	5	95	10	0	95	0	5	85	30	20	5	75	5	5	0	20	30	0
	40	Development of technology for quantitatively measuring comfort sensations such as wearing, riding, and coziness.	1	109	11	17	72	50	18	48	33	1	50	1	77	13		4	14	40	21	0	39	0	33	44	42	14	6	28	3	1	0	6	18	0
			2	86	9	14	77	46	10	55	35	0	41	0	85	8		2	8	52	12	0	51	0	26	49	42	8	5	31	2	2	0	8	22	0
			X	8	100	0	0	50	13	63	25	0	63	0	88	0		0	0	75	25	0	75	0	0	63	38	0	25	75	0	0	0	13	38	0

(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic development	Expected effect: Resolution of global problems	Expected effect: People's needs	Expected effect: Expansion of intellectual resources	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Software and algorithms	41	Development of sensation information systems capable of selecting music which corresponds to the perception of a given image.	1	132	11	32	58	35	5	32	54	9	39	2	57	26	8	12	52	16	1	45	0	20	47	32	9	6	33	2	2	0	2	19	1
			2	111	8	27	65	34	5	26	61	7	36	1	64	23	6	7	65	17	1	56	0	16	52	34	5	4	39	1	3	0	2	20	2
			X	9	100	0	0	69	44	44	11	0	78	0	78	33	11	0	56	0	0	67	0	0	67	78	11	0	33	0	0	0	0	33	0
	42	Practical use of systems capable of understanding the content of image data, in order to filter out information traveling on a network which may, for example, be unsuitable for children.	1	171	16	32	53	53	22	49	27	2	47	4	65	11	12	7	70	14	0	30	1	20	44	30	9	6	29	13	1	0	39	47	0
			2	140	13	31	56	51	17	56	24	3	46	3	72	9	9	3	84	9	0	39	2	9	52	28	4	2	38	7	1	0	36	52	1
			X	18	100	0	0	72	50	39	11	0	67	0	61	6	0	0	94	22	0	61	11	0	56	33	6	6	61	6	0	0	33	61	0
	43	Development of super-parallelizing compilers which efficiently execute the applications operated on super-parallel computer systems.	1	163	16	38	46	62	32	54	13	1	75	17	12	37	5	7	90	20	1	43	1	5	64	33	27	2	47	2	1	0	1	8	1
			2	141	14	40	46	61	28	59	12	1	80	11	7	33	5	3	94	16	0	46	0	1	72	28	18	1	52	1	1	1	1	7	0
			X	20	100	0	0	63	37	47	11	5	65	10	5	45	0	0	90	0	0	55	0	0	65	15	20	0	40	10	0	0	0	10	0
	44	Separation of developed software into components, and widespread use of software libraries which facilitate the re-utilization of those components.	1	195	27	39	34	79	61	32	6	1	90	7	19	23	2	4	90	26	1	43	1	4	57	40	14	12	34	10	3	0	8	11	2
			2	157	27	38	34	81	63	34	3	0	92	4	17	22	1	1	93	20	1	46	0	1	62	45	6	10	34	7	3	0	5	10	1
			X	43	100	0	0	86	74	24	2	0	88	5	16	23	0	2	86	23	0	53	0	2	65	44	7	5	44	7	2	0	5	9	2
	45	Advances in software inspection and verification technology, enabling quick development of error-free, large-scale software.	1	187	26	41	33	78	61	31	9	0	83	9	17	24	21	8	80	26	2	34	0	9	63	29	14	5	39	2	2	0	6	7	2
			2	148	22	43	35	83	68	28	3	0	90	5	12	18	22	3	89	21	1	34	0	5	67	26	9	3	41	3	1	0	5	6	1
			X	33	100	0	0	86	75	19	6	0	79	9	6	21	24	3	88	36	3	48	0	3	67	30	9	0	36	3	3	0	3	9	3
Lifestyle, medical care, welfare and disaster prevention	46	Widespread use of systems facilitating on-demand acquisition of multimedia information dispersed on networks around the globe.	1	213	29	38	34	74	52	43	6	0	82	13	69	23	1	1	93	25	0	39	0	2	37	35	13	9	29	38	4	0	28	32	2
			2	169	29	37	34	77	56	41	3	0	83	9	69	20	1	1	94	20	1	40	0	2	43	37	7	5	31	44	2	0	29	36	1
			X	49	100	0	0	88	78	20	2	0	82	18	71	27	0	0	98	29	2	63	0	0	47	37	6	2	39	39	6	0	37	39	2
	47	Weather for up to one week in advance will be able to be forecasted with at least 95% accuracy.	1	90	4	14	81	69	43	48	8	1	50	49	64	13	17	14	57	23	3	49	1	20	47	18	26	14	42	3	2	7	4	10	0
			2	71	1	13	86	67	39	51	10	0	54	39	65	7	18	4	62	15	4	59	0	10	54	13	18	11	52	4	1	6	3	11	0
			X	1	100	0	0	100	100	0	0	0	0	0	0	100	0	0	100	0	0	100	0	0	100	0	0	0	100	100	0	0	0	100	0
	48	Widespread use in all areas of security systems capable of providing emergency information to the general public in the case of a disaster.	1	149	13	21	66	85	71	27	2	0	36	19	91	3	0	3	59	16	1	47	1	20	27	36	21	4	54	29	6	1	29	15	1
			2	120	12	19	69	87	75	23	3	0	36	13	88	3	0	2	70	11	2	56	0	15	27	33	13	3	72	31	3	1	36	13	0
			X	14	100	0	0	100	100	0	0	0	29	14	79	7	0	7	86	7	0	64	0	0	29	29	14	14	86	36	0	0	36	14	0
	49	Practical use of robots capable of recognizing, finding, and rescuing humans involved in a disaster.	1	119	8	26	66	72	48	42	10	0	36	11	86	7	8	7	68	22	3	50	1	16	48	39	18	3	53	9	0	1	25	13	1
			2	94	9	20	71	74	53	38	10	0	31	4	90	3	4	6	79	18	3	59	0	12	55	35	11	0	68	4	1	1	29	11	0
			X	8	100	0	0	81	63	38	0	0	63	0	88	13	0	13	88	0	0	75	0	13	63	25	38	0	88	13	0	0	63	25	0
	50	Widespread use of portable terminals from which electronic newspapers can be purchased at information kiosks (information sales outlets established at train stations) through radio connection.	1	179	16	29	55	50	19	45	34	2	70	11	61	7	6	6	72	21	1	59	1	11	31	30	8	3	23	32	3	1	9	30	1
			2	151	17	30	53	49	15	53	30	1	68	5	66	4	4	3	78	17	0	67	0	7	32	30	3	1	25	42	2	0	5	38	0
			X	26	100	0	0	63	35	50	15	0	73	4	85	4	0	4	81	27	0	88	0	0	38	35	4	0	35	42	0	0	8	50	0

Forecasted realization time



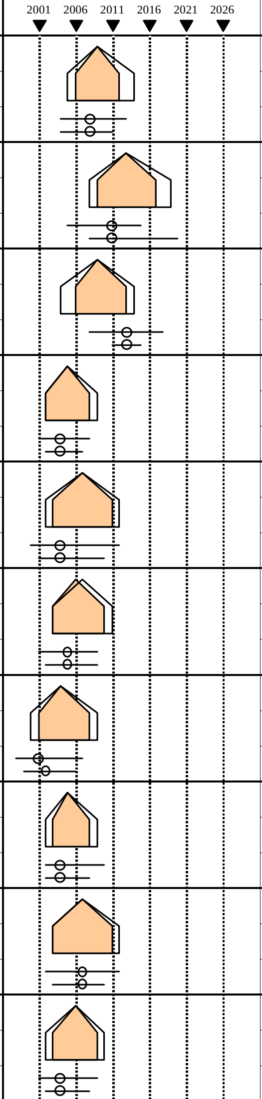
(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Medium	Low	Importance (index, %): Index	High	Medium	Low	Unnecessary	Expected effect (%): Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Lifestyle, medical care, welfare and disaster prevention	51	Widespread use of electronic newspapers or electronic museums which can be compiled to match the specific interests of each individual.	1	207	20	37	43	56	22	56	22	0	67	6	78	14		0	2	88	22	0	44	0	6	33	32	14	15	25	33	3	0	20	31	1
			2	164	21	34	45	55	19	65	16	0	65	7	85	9		1	1	94	19	0	53	1	2	38	30	11	13	24	41	2	0	18	36	1
			X	35	100	0	0	67	37	57	6	0	71	11	91	9		0	0	100	14	0	77	3	0	43	31	17	14	40	43	0	0	23	46	3
	52	Widespread use of in-home shopping via networks, by means of virtual shopping systems.	1	215	26	33	40	63	33	53	14	0	78	7	88	3		1	0	93	29	0	46	0	1	19	33	11	3	13	58	4	0	44	36	1
			2	174	26	33	41	61	27	65	9	0	79	5	91	2		1	0	96	24	1	49	1	0	11	31	5	3	9	72	2	0	53	41	2
			X	45	100	0	0	70	43	52	5	0	82	7	96	4		0	0	98	24	0	62	0	0	7	27	11	2	18	69	2	0	47	38	2
	53	Widespread use of home computer systems which can be used to control equipment in the home, manage household finances and health, and provide interactive learning.	1	202	18	36	46	64	36	51	14	0	67	4	88	6		1	2	84	22	0	46	0	7	27	31	8	2	21	28	4	0	33	25	0
			2	165	18	30	52	64	31	61	7	1	66	2	88	4		1	1	90	16	0	51	0	4	23	35	2	2	22	36	3	0	45	27	1
			X	30	100	0	0	80	61	39	0	0	70	7	93	3		0	0	97	10	0	57	0	0	27	37	7	0	33	37	7	0	43	20	0
	54	Practical use of robots which provide medical care support in homes, hospitals, etc.	1	131	10	27	63	75	54	40	5	1	40	2	95	4		4	4	67	26	2	56	0	14	46	46	14	2	60	16	2	0	21	27	2
			2	111	7	21	72	81	64	30	5	1	42	0	95	3		2	5	76	20	3	66	0	8	46	48	5	0	70	14	0	0	25	29	1
			X	8	100	0	0	82	71	14	14	0	38	0	75	13		0	13	88	13	0	75	0	0	50	13	0	0	75	25	0	0	13	38	0
	55	Become possible for virtual operators with dialogue comprehension capabilities to converse with humans and operate information equipment.	1	177	18	33	50	54	20	54	25	0	58	3	81	8		5	5	79	17	0	50	1	8	52	34	9	3	36	8	3	0	15	16	1
			2	145	18	26	56	52	15	63	23	0	61	1	86	4		6	2	83	13	0	57	0	8	61	34	4	1	48	3	1	0	19	19	0
			X	26	100	0	0	61	27	62	12	0	73	0	85	4		8	0	85	8	0	58	0	4	69	42	0	4	54	8	0	0	27	23	0
Society, work, and local community	56	Widespread use of automobiles which drive automatically.	1	115	6	17	77	62	35	43	21	1	74	14	83	3		10	8	71	36	1	50	0	10	33	41	10	2	43	40	3	4	42	16	0
			2	94	4	16	80	61	33	47	21	0	81	7	86	2		6	4	78	36	1	59	0	6	28	45	6	0	54	56	1	2	62	12	0
			X	4	100	0	0	83	67	33	0	0	100	0	50	0		0	25	100	50	0	25	0	0	25	50	0	0	75	100	0	0	50	50	0
	57	Full computerization of the foreign exchange, stock and other financial markets, and widespread use of fully automated rapid trading systems that do not require dealers or traders.	1	150	12	23	65	69	46	40	13	1	88	4	33	2		0	7	88	37	0	39	1	5	19	27	9	1	21	68	3	0	52	35	0
			2	121	9	18	73	68	40	52	7	1	89	3	33	1		2	2	90	36	0	40	1	3	12	17	7	0	17	83	2	0	64	37	1
			X	11	100	0	0	91	82	18	0	0	82	9	45	0		0	0	91	55	0	64	0	0	27	9	18	0	9	82	9	0	73	36	0
	58	Realization of applications, registrations, and other official public procedures and services over networks.	1	201	12	29	58	70	44	47	9	1	45	2	92	2		0	6	66	25	0	31	1	19	13	19	8	4	30	72	3	0	58	24	0
			2	161	12	26	61	69	42	52	6	0	43	2	93	2		0	2	79	22	0	34	1	14	8	14	6	2	30	83	2	0	62	26	0
			X	20	100	0	0	86	75	20	5	0	65	10	90	5		0	0	95	35	0	60	0	0	20	15	20	0	35	80	5	0	45	25	0
	59	Formation and widespread use of a dynamic information market (including auctions) based on information provided by individuals.	1	187	20	38	42	63	34	48	17	1	71	4	75	11		1	4	89	32	0	34	0	3	17	23	12	4	14	55	3	0	52	39	0
			2	150	20	36	44	58	22	65	13	0	75	3	80	5		0	1	95	30	0	41	0	1	12	21	8	2	11	70	2	0	58	41	1
			X	30	100	0	0	69	45	41	14	0	73	10	87	3		0	0	93	33	0	53	0	0	27	27	20	7	20	57	10	0	47	40	0
	60	Formation of virtual communities, and realization of cultural interchange over wide areas.	1	183	20	38	42	62	32	51	16	1	61	15	80	22		2	4	86	33	1	44	0	6	19	30	17	4	23	42	3	0	34	50	1
			2	150	21	32	47	58	24	63	13	1	60	10	83	18		1	1	90	30	0	50	1	3	17	27	10	3	25	57	2	0	35	58	0
			X	32	100	0	0	67	41	47	13	0	63	13	91	19		0	0	94	25	0	59	0	0	28	25	19	6	41	44	6	0	28	56	0

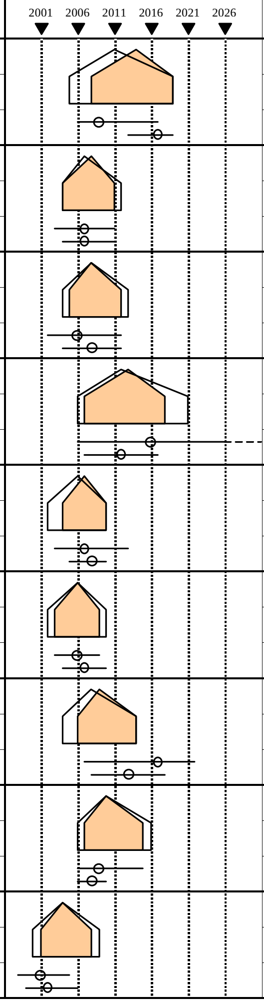
(Note) See page 7 for the interpretation of the graphs.

Information

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Medium	Low	Importance (index, %): Index	High	Medium	Low	Unnecessary	Expected effect (%): Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Forecasted realization time: Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Society, work, and local community	61	Realization of in-home electronic voting . (elections)	1	180	13	27	60	53	25	38	33	3	32	5	74	5	8	18	52	18	0	23	0	34	11	13	7	2	22	71	3	0	53	47	1
			2	148	12	24	64	51	22	44	30	4	28	4	82	3	7	9	61	13	0	24	0	28	9	10	3	0	21	84	3	0	53	55	1
			X	18	100	0	0	81	67	22	11	0	44	6	89	6	6	6	78	22	0	56	0	11	28	28	0	0	33	78	11	0	33	33	0
	62	The holding of electronic parliamentary sessions (electronic prefectural council meetings) in conjunction with television broadcasts of parliament, and the passage of bills (acts) through electronic voting by the citizenry.	1	155	10	28	61	54	30	34	31	5	36	6	64	6	20	22	43	14	0	17	1	38	9	12	7	2	17	68	4	0	42	58	1
			2	127	9	25	65	52	24	40	30	6	35	2	74	3	21	13	44	11	0	14	0	39	6	7	4	0	14	79	2	0	44	64	3
			X	12	100	0	0	80	64	27	9	0	42	8	92	8	17	0	67	17	0	42	0	17	25	17	0	0	25	75	8	0	8	33	0
	63	Practical use of automatic security surveillance systems using robots equipped with crime prevention functions and information.	1	149	9	30	62	58	25	55	19	1	58	5	84	3	1	5	74	13	2	48	0	13	36	40	10	2	26	22	2	0	47	24	1
			2	121	7	25	68	58	23	64	13	0	60	3	81	2	0	2	82	8	0	46	0	7	40	40	7	1	22	25	2	0	54	27	0
			X	9	100	0	0	75	56	33	11	0	78	11	78	11	0	0	67	0	0	67	0	0	22	56	22	0	44	44	11	0	22	22	0
	64	Establishment of social rules regarding multimedia copyrights, and expanded production and distribution of multimedia information.	1	193	17	36	47	85	71	26	3	0	86	4	46	27	1	8	85	32	1	35	1	8	22	34	4	8	18	73	3	0	35	48	2
			2	160	16	33	51	89	79	19	1	0	91	3	44	26	0	4	91	28	1	32	0	4	17	31	3	6	11	83	3	1	38	54	0
			X	26	100	0	0	90	81	19	0	0	92	8	65	35	0	4	96	46	0	50	0	0	27	19	4	4	19	92	12	4	27	50	0
	65	Widespread use of paper-less processing for the majority of office work.	1	210	20	42	38	67	40	51	10	1	69	58	32	6	14	9	74	26	0	38	0	16	19	21	8	2	16	45	3	7	19	27	0
			2	170	20	41	39	67	38	54	8	0	76	64	30	5	11	6	86	24	1	45	0	8	14	19	6	2	14	66	1	5	20	34	0
			X	34	100	0	0	82	65	35	0	0	82	47	44	9	6	6	88	29	0	47	0	12	21	15	3	6	15	65	0	3	24	21	0
	66	Widespread use of electronic money to settle monetary matters.	1	206	17	34	49	76	55	40	4	0	91	9	67	5	1	4	88	64	1	32	1	3	23	34	6	2	24	78	1	0	63	44	1
			2	166	15	31	54	81	63	35	2	0	95	4	67	4	1	3	90	65	1	35	1	1	19	33	2	1	23	84	1	0	67	46	1
			X	25	100	0	0	90	80	20	0	0	92	16	80	8	0	4	80	84	0	52	0	0	32	44	4	0	52	80	0	0	64	52	0
	67	Become possible to verify the counterparty to a contract concluded over a network with the use of database systems.	1	198	22	33	45	73	51	39	9	1	88	3	57	6	0	4	89	38	1	40	1	5	32	26	9	8	26	62	2	0	61	31	0
			2	163	18	31	50	78	60	33	7	0	93	2	58	2	0	2	92	36	1	43	1	3	30	20	6	1	25	77	1	0	66	34	0
			X	30	100	0	0	92	83	17	0	0	93	10	73	7	0	0	93	57	0	63	3	0	27	20	3	0	47	70	3	0	63	23	0
	68	Widespread use of systems to unitarily handle information management (orders, design, manufacturing, maintenance) among related companies.	1	191	24	34	43	76	56	37	7	0	96	12	20	3	3	3	83	27	0	37	0	7	26	40	9	7	21	49	3	0	36	22	1
			2	158	20	35	46	82	66	31	4	0	98	8	19	1	2	4	88	22	0	41	1	5	20	42	3	2	20	68	1	0	46	22	0
			X	31	100	0	0	92	84	16	0	0	94	19	39	0	0	3	94	23	0	45	0	0	35	39	3	0	35	68	3	0	35	29	0
	69	Creation of a global multimedia network to disseminate global environmental information on-line, and utilization of global environmental information on a worldwide basis.	1	185	16	29	55	73	52	37	10	1	49	81	37	15	1	3	80	37	2	35	1	12	26	30	24	23	39	24	3	16	19	21	1
			2	152	13	28	59	77	61	29	9	1	48	80	32	9	1	3	86	35	1	38	0	9	21	33	15	18	49	25	1	13	17	18	0
			X	19	100	0	0	94	88	12	0	0	53	58	53	16	0	5	100	42	0	63	0	0	32	37	26	11	58	26	5	5	5	32	0
	70	Formation of open communities via area networks, and performance of multimedia creative activity through collaboration within them.	1	191	27	32	41	63	33	51	16	0	72	13	54	43	1	5	87	29	1	38	0	7	31	40	19	6	26	30	3	0	23	43	1
			2	155	23	32	45	61	28	60	12	0	75	8	55	43	1	3	90	30	1	45	1	3	30	44	10	4	26	34	4	0	20	50	0
			X	36	100	0	0	69	44	44	11	0	72	14	61	44	0	3	94	39	0	64	0	0	31	39	19	8	42	25	3	0	22	50	0



(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time			Leading countries (%)						Measures the government should adopt (%)							Information Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001 2006 2011 2016 2021 2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Education and entertainment	71	Emergence of robots capable of acting as opponents to humans in sports activities (such as Sumo Wrestling, etc.).	1	101	8	20	72	33	6	24	61	9	26	0	69	8		7	11	45	15	1	35	0	24	29	32	14	4	22	3	3	0	13	19	4
			2	83	8	16	76	32	6	16	73	5	18	0	72	8		7	8	52	13	0	36	0	22	27	33	8	2	22	4	2	0	13	28	1
			X	7	100	0	0	46	29	0	71	0	29	0	86	14		14	0	100	14	0	71	0	0	57	29	14	14	57	14	14	0	0	29	0
	72	Widespread use of two-directional, multi-point, remote education support systems in homes.	1	203	21	32	48	64	36	51	13	1	62	7	82	17		2	5	76	21	1	47	1	12	26	36	19	7	35	38	2	0	16	49	1
			2	162	22	27	52	64	33	57	9	1	57	5	83	16		2	3	81	17	0	52	1	7	19	34	12	3	40	54	2	0	15	52	1
			X	35	100	0	0	84	69	29	3	0	71	6	94	20		0	3	89	20	0	54	0	0	23	34	14	3	60	57	3	0	9	46	0
	73	Establishment of electronic primary and middle schools, making it possible for students who cannot travel to and from schools to take courses and obtain graduation diplomas.	1	171	12	26	62	57	30	44	23	4	26	4	84	9		5	8	52	17	1	23	1	28	12	22	16	5	26	63	2	0	15	46	1
			2	139	13	21	66	55	24	53	22	2	21	3	86	6		4	4	65	17	1	31	1	20	9	17	9	4	24	75	1	0	12	56	0
			X	18	100	0	0	76	56	39	6	0	28	6	83	11		0	6	78	17	6	50	0	11	11	17	17	0	39	67	6	0	0	56	0
	74	Development of computer program which beats professional Shogi (Japanese Chess) champions.	1	162	7	27	65	28	3	16	68	13	10	0	14	64		9	13	35	12	2	66	1	7	31	14	4	1	16	2	3	0	0	14	1
			2	131	8	23	69	28	5	12	69	15	7	1	10	69		13	9	28	8	2	78	0	3	34	9	2	1	11	1	3	0	0	16	0
			X	10	100	0	0	47	33	0	56	11	10	10	10	70		10	10	30	10	0	80	0	0	20	0	0	0	0	10	0	0	0	10	0
	75	Widespread use of multimedia encyclopedias that enable the search and retrieval of text, sound, images and video (e.g. search using the sound of a bird singing or a sketch).	1	210	21	39	40	54	20	58	22	0	57	3	74	25		0	2	89	27	1	48	0	4	33	27	15	18	23	19	2	0	9	25	1
			2	161	22	35	43	53	15	65	20	0	58	2	77	19		1	2	92	24	1	50	0	2	35	24	11	19	26	14	3	0	6	26	1
			X	35	100	0	0	62	29	63	9	0	71	6	83	14		0	0	97	26	0	51	0	0	49	17	9	29	29	11	9	0	3	37	3
	76	Spread of science museums capable of fostering scientific skills of children through play based on the applied use of natural history and science education techniques.	1	167	11	33	56	58	28	50	22	0	37	4	66	37		2	3	78	34	1	34	1	13	25	28	28	13	40	11	2	0	2	22	1
			2	137	10	28	62	57	25	53	22	0	34	2	77	33		1	2	85	32	1	34	0	7	21	25	26	10	56	10	1	0	1	25	0
			X	14	100	0	0	70	43	50	7	0	43	7	71	29		0	7	93	43	0	57	0	0	29	14	14	7	57	7	14	0	7	43	0
	77	Development of an entrance exam system in which comprehensive skill assessment is conducted using networks.	1	131	11	21	67	41	13	37	36	14	31	2	44	12		27	21	31	9	2	22	1	38	18	16	5	2	18	31	6	0	28	38	2
			2	112	10	15	75	39	10	38	41	11	29	3	59	11		23	15	30	5	2	25	1	41	16	11	4	1	18	46	2	0	29	47	0
			X	11	100	0	0	68	50	20	30	0	45	18	55	36		9	9	55	18	0	55	9	18	36	27	18	0	36	45	9	0	55	64	0
	78	Widespread use of advanced expert systems capable of utilizing tutorial examples etc. where the knowledge experience and performance of teachers has increased.	1	176	14	29	57	51	19	51	26	4	44	3	59	28		6	15	65	20	1	32	1	18	41	32	13	14	32	11	3	0	7	34	2
			2	139	13	24	63	48	13	57	25	5	45	2	67	27		9	9	74	19	1	33	0	14	47	31	4	13	37	9	2	0	6	42	0
			X	18	100	0	0	68	44	44	6	6	67	11	67	33		6	6	100	17	0	56	0	0	61	33	6	11	50	22	11	0	11	39	0
	79	Development of support systems to assist students in learning on their own via networks.	1	195	16	34	50	60	28	54	18	0	46	4	78	24		1	4	77	25	1	48	1	13	31	33	18	9	37	19	1	0	11	31	2
			2	156	15	29	56	57	22	64	14	0	43	6	81	20		1	1	85	27	1	60	0	6	35	38	10	8	52	18	1	0	8	36	1
			X	24	100	0	0	82	67	29	4	0	54	13	75	25		0	0	92	29	0	79	0	0	42	38	13	4	58	17	4	0	17	42	4

(Note) See page 7 for the interpretation of the graphs.

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4. Survey results in “Life science”

4.1. Trends in noteworthy domains

4.1.1. Progress in cancer research

Since 1981 cancer has been Japan’s biggest killer, and the importance of this disease in reflected in the results of this survey, with six of the top 20 topics in degree of importance cancer-related. We can put this down to the fact that interest in cancer is not limited to researchers who are cancer experts, but is also found in researchers from a cell biology and molecular biology background. Improvements in the treatment of cancer using surgery, radiotherapy and chemotherapy have been achieved for individual cases, and the five-year survival rate is steadily rising, albeit very slowly. But unfortunately, despite the tremendous efforts of researchers and the massive injection of funds, we are still waiting for a breakthrough in the development of a cancer drug that can promise a dramatic improvement in the survival rate.

Over the past ten years, Japan has promoted research that sought to elucidate the essence of cancer, based on the comprehensive anti-cancer strategy formulated at a special cancer-related cabinet meeting in 1983. This work has led to an understanding that cancer is cell mutation caused by the progress of genetic mutation at multiple levels due to a range of factors, including oncogenes and unexpressed oncogenes, and different cancer treatments can be used according to individual cancer characteristics. Of late, wide-ranging attention has been drawn to cancer characteristics, genetic instability, and the relationship between gene polymorphism and carcinogenic susceptibility. On the other hand, unfortunately we have not seen the desired progress in the important areas of cancers caused by the environment, development of new chemotherapeutic agents, and cancer immunotherapy. A reason for this is a lack of basic research data in the more complex aspects, such as avoiding side-effects and tumor heterogeneity, and because of this research had come to a standstill. It also a fact, though, that experts have begun searching in a new direction, namely gene therapy, based on bioscience technology and basic cell biology research results. For example, the fact that analysis of carcinogenesis centering on oncogenes and the signal transmission system in cancer cell growth, and research into cancer cell growth, infiltration and metastasis control mechanisms through extracellular substrate molecules and various growth factors is being promoted vigorously has signaled a new phase in the biological approach to cancer treatment. The identification of a gene causing breast cancer (BRCA1) through genetic analysis of families with a history of breast cancer, centering on genome research, will contribute significantly to the establishment of gene therapy for the prevention of cancer. A great deal of effort is also going into the development of gene therapy techniques that aim at selectively destroying cancer cells through the framework of apoptosis.

Surgery can be an extremely effective means of treating some cancers if they are detected and treated early enough, excluding cancers located in areas that cannot be operated on, such as brain tumors. Cancers are indeed diverse, and it is this very diversity that has made the treatment of cancer so difficult. It is, however, pleasing to see that research based on current gene analysis is slowly shedding light on the complex biological phenomenon that is the cancer cell, and this should increase our understanding about cancer diversity. The advance of modern civilization is taking a heavy toll on the global environment, so it is crucial for our future that we search for and identify external environment or other lifestyle factors that can turn a healthy cell cancerous, and clarify the connection between those external factors and carcinogenesis. Though it will be possible to use genetic screening to identify and treat groups at risk of cancer, the fact that not all people with potential cancer-causing genes develop the disease in any of its forms means that researchers have to proceed very carefully along this line of research, ensuring it does not lead to any possibility of discrimination against the human rights of affected individuals whatsoever.

In this survey we selected important themes in the four domains of 1) basic biological elucidation of cancer, 2) widespread use of methods for the early diagnosis of cancer, 3) development and widespread use of effective cancer treatments, and 4) epidemiological surveys of cancer risk factors (cancer characteristics). The forecasted realization time for topic “01: Identification of most genes related to cancer, and elucidation of the relationships between those genes and carcinogenesis” is 2014; “02: Development of anti-cancer agents which target the manifestation functions of cancer genes” is 2010; “28: Widespread use of treatment methods for dysdifferentiating carcinogenic cells” is 2020; “48: Development of drugs capable of preventing the occurrence of certain types of cancer” is 2010; “49: Practical use of effective means to prevent metastasis of cancer” is 2013; and “72: Elucidation of the factors within daily life which influence the process of carcinogenesis” is 2012.

It is hoped that in addition to the extensive research into the suppression of cancer carried out thus far and the tremendous effort of researchers, the results of this Delphi survey will not only be of use in future cancer research, but also help to further improve the level of individual basic research, facilitate the prevention, diagnosis and treatment of cancers whose progress is not readily discernible due to a range of complex factors, and expand the basic cytobiological knowledge of cancer.

(Moriaki Kusakabe)

4.1.2. High-speed genome analysis technology and application of genome information

All living organisms produce proteins based on their inherent genetic information. The process by which genetic information is translated into “form” and “function” such as protein, in short the manifestation process, is represented by the flow DNA Æ RNA Æ protein. This information flow is referred to as “central dogma,” and occurs continually in humans and most other living organisms. This is a fundamental action that is at the core of life.

The genome structure is described by the sequence of bases (A (adenine), T (thymine), C (cytosine), and G (guanine)) of a chromasome DNA, and the whole base sequence over the full length of the genome amounts to about five million in a coliform bacillus, and a massive three billion or so in humans. Genes are read by messenger RNA made up of on average 2,000 base pairs (from several hundred up to almost 20,000). These are for coding proteins, and within the whole genome of humans and mice, there are about 100,000 genes, accounting for about 5% of the whole genome. Elucidating the genome of an organism and the whole genetic structure will provide information about the structure of proteins coded by genes, and will contribute significantly to the life science field.

In the previous survey, respondents forecasted that determining the entire DNA base sequences in human chromosomes would be realized in 2010, but in this survey, respondents revised their forecast to about 2003. The main reasons for this reassessment to an earlier year are the advancements in genome technology and the rapid development of new technologies, discussed later, that have taken place over the past few years.

The effects that the genome project will bring are:

i) Capability of analyzing the sequence information that encodes all proteins (nucleotides over the entire length of mRNA), which is the genetic product, and the entire primary structure of a genome; and

ii) Development of new generation genome technologies that can determine this.

In life science in the 21st century, the process of linking genes and their functions is expected to be accelerated by base sequence information and high-speed DNA analysis technology. This information and technology will become a decisive intellectual resource not only in medical science and biology, but in environment issues, improvement of agricultural species and livestock breeds, and biological manufacturing technology as well.

In the medical science and biology fields, analysis has shifted from hereditary diseases caused by single genes to multiple-factor hereditary diseases. The mutant genes causing the ten major hereditary diseases in humans (e.g. muscular dystrophy) have already been isolated, but even though adult diseases (e.g. diabetes, hypertension, and arteriosclerosis), mental diseases and cancer, which affect all humankind, are all hereditary disease, few attempts have been made to elucidate the causes because of the large numbers of genes involved in each of the diseases (topic 74). Research into these human diseases require pure-breed and crossbreed experiments, and this reinforces the value of genome analysis of mice and other laboratory animals for the following reasons.

1. High homology between human and mouse genes;
2. Commonality of many human and mouse diseases;
3. Genes can be obtained from the mice in all stages of their life cycle, but this is not the case for humans; and
4. Crossbreed experiments are possible, and results can be obtain quickly.

In this sense, topic “21: Practical use of technology to analyze whole genome sequence in livestock breeding, and fisheries, agriculture and forestry” is important.

The gene identification approach will probably shift from the positional cloning method to the positional candidate method once the position of each cDNA (cDNA is DNA created from the removal and copying of mRNA, which carries DNA messages in the process of protein synthesis; this corresponds to the information on the protein blueprint extracted from the genome) on the chromosome is clarified through cDNA and genome base sequence information built up from the genome project. And through the clarification of the whole gene sequence, a new approach to drug preparation is possible. Coupled with advancement in research in new molecular biology fields (aging, cell death, differentiation, morphogenesis, etc.), these cDNA will also form the basis of gene therapy.

Information about the whole gene will provide valuable data for analysis of the higher-order structures of proteins and the basic cell motive. In this sense, topic “25: Establishment of technologies enabling prediction of the functions of proteins from their higher-order structures” is important. This will also be a source of basic information for next generation brain sciences and issues such as aging.

Analysis of human genome will teach us much about the process of human development, because locked within the genome is the history of human evolution. This analysis should also provide us with knowledge about human differences and genealogy.

If we can build up our knowledge base about not just human genome, but that of various other organisms as well, we will have a better understanding of the relationships between organisms, and also of the ecosystem in which we all live.

It is pleasing to see that Japan has developed its own techniques for several new methods (PCR-SSCP, RLGS (RLCS), molecular indexing, full-length cDNA synthesizing) in a field where there is a constant pursuit for the development of new techniques for genome technology. On the other hand, while techniques such as DNA chip technology are expected to speed up DNA analysis (DNA diagnosis) dramatically in the future, Japan is lagging well behind in R&D, so urgent action in this field is essential. In the previous survey, the development of methods for collecting and storing data on and identification of higher-order animals, as reflected by the “completion of a comprehensive human protein data library,” is forecasted to be realized in 2014.

What is most important from now on is the development of high-speed and low-cost technologies for determining base sequences. We want to be able to extract data in volumes of three billion base pairs for higher organisms at a rate 10-100 times faster than current levels. From the mid 1990s, advances have been made in bringing together analysis resources involving numerous fluorescent sequencers and the work of many people as a large-scale system for determining bases sequences, and this is now functioning as a genome center.

Centers that can determine base sequences of 20–80Mbp a year have been established in Europe and the U.S., and these are the first moves toward a shift to “big science” in medicine and biology. However, new techniques have been appearing in quick succession in the development of basic methods and cost cutting, and DNA analysis centers that use small but high-performance systems are expected to appear in the very near future. Most technologies in this field have been developed in Europe or the U.S., so acquiring the intellectual property rights to these technologies is a crucial task for Japan. In fact it is not an exaggeration to say that the future of Japan’s DNA analysis industry (gene analysis, diagnosis, treatment and drug development) in the 21st century rests on the outcome of this intellectual property rights issue.

Regarding the intellectual property rights covering genome analysis data, in response to an application by research institutions in the U.S. and U.K. for patents for base sequence data on genome fragments, the courts ruled that patents cannot be approved unless the data are connected with functions in the genome structure. Therefore considerably more effort will be made in linking genes and their functions using dictionaries produced from genome analysis.

Thus in promoting genome technology, it is extremely important for us to strike a balance between development and organization aimed at making it more systematic on the one hand, and international competition and cooperation on the other.

The following are some of the issues facing this technology in the future.

First, with expectations that the human genome will be completely mapped out around 2003, we have to fully discuss Japan's contribution to this and Japan's national interest (cost versus effect), and formulate policies that set the foundations for life science into the 21st century. Determination of the entire primary structure of genome and the full cDNA chain is the principal goal of genome technology, but following this we must move quickly to establish a new life science base with our sights on how we can utilize a single dictionary (generally, the beginning of the second phase of genome science; this is referred to as the post-genome era, but I do not believe this is an appropriate term).

Next, rapid progress is expected in the connection of each gene with its manifestation character (identification of the genes causing mutation), elucidation of the cascade among all genes that takes into account the entire genome (topic 23), analysis of genome and full cDNA chain in new drug development technology and all organisms, and elucidation of the mutual operation between genetic products. Progress will also be seen in the analysis of gene functions other than those fragments transcribed from the genome structure, and also in the description of the diversity of the human genome.

As was often pointed out, in the case where topic "03: Utilization of information about the gene structure of each individual patient in diagnosis and treatment" is realized, we must ensure that elucidation of an individual's genetic information does not disadvantage that individual. And this will probably require considerable debate.

Clearly, genome research is about to enter a new phase. It is also clear that the effective use of the mass of information assembled from genome research will greatly expedite life science research. We will need to develop the next-generation computer science that will enable us to process and analyze this rapidly expanding information base. It is important to examine and establish without delay a research structure and human resources development system that respond to the new era in medical science, biology and other natural sciences through the emergence of new research styles using the volumes of base sequence information.

(Yoshihide Hayashizaki)

4.1.3. Molecular mechanisms of development, differentiation and morphogenesis

Life on our planet started 3.8 billion years ago, and we humans, currently the most advanced life-form, have much in common with other eukaryotes; the life process from a single fertilized egg, through development, differentiation, and morphogenesis to the adult form in humans is in principle no different from that in all other animals. That so, it is entirely natural that being so curious about our own existence, humans have for ages craved an answer to the simple scientific question of to what extent are we similar to and different from other animals, and how is that process predetermined and how is it differentiated. To what extent can our current level of life science answer this question, when will we have a complete answer, and how do researchers with an interest in this field feel about this are all questions that raise considerable interest. It is also natural that there is considerable interest in the mechanism by which genetic defects trigger disease, and the aging mechanism that brings on change in the living body with the passage of time, and also whether it is possible to prevent or treat this.

At the time of the previous survey in 1991, the best techniques for analyzing development, differentiation and the molecular mechanism of morphogenesis were gene cloning using the gene recombination and polymerase chain reaction (PCR) methods, base sequence determination, and functional analysis based on these results and homology at the protein level. These are still important techniques, but these days the techniques of specification of the gene manifestation segment through in situ hybridization, gene knock-out, preparation of transgenic individuals, and effect analysis of artificial manipulation at the development stages of the individual, which can be referred to as developmental engineering are more widely used. These techniques reveal the genes connected with development, differentiation and formation of tissue and the individual, and analyze the links between these genes and hereditary diseases. Furthermore, in relation to aging, advances have been seen in the elucidation of the mechanism and actual state of aging at the molecular level, as typified by telomerase.

As is the case in science, in some aspects developments at times exceed expectations. The formation of an individual based on information in the nucleus originating from tissue cells of the adult form, which had been thought to be exclusive to plants, was done with a sheep, which essentially differs little from humans. The paper* announced to the world that a cloned individual had been born. In this survey, the forecasted realization time of topic "15: Development of technology to regenerate organs or individuals from separated animal cells" is 2023, and of topic "78: Practical use of technology for producing cloned individuals from the cells of livestock" is 2015; but these two topics suddenly became reality shortly after the round two questionnaire. Of course, if the premise "using cells grown *in vitro*" is attached, realization will be quite some time in the future, if at all.

Topic "24: Development of technology to analyze the genes manifested in a single cell in higher animals with an accuracy in the order of 1 mRNA molecule" will be a powerful tool in tracing the progress leading to the elucidation of the molecular mechanisms from development to formation of the individual, but it is unlikely to be realized before 2014, while the forecasted realization time for topic "23: Elucidation of the mechanism by which differentiation and functions from fertilized egg to individual are manifest in mice etc." is 2023, and for topic "84: Complete elucidation of the molecular mechanisms of development and differentiation" it is 2022. The knowledge derived from this process will probably be used in the realization of other topics, and most researchers believe topic "29: Widespread use of methods of multiplying stem cells in test tubes and using them for treatment purposes" will be realized in 2015, and topic "28: Widespread use of treatment methods for dysdifferentiating carcinogenic cells" in 2020. Organ donation and the use of artificial organs in organ transplants is currently the subject of much debate in Japan, and in this regard, topic "47: Elucidation and artificial control of the molecular mechanisms of the morphogenesis of human organs" is expected to be realized in 2022, but it is interesting to note that the realization times for topics "15: Development of technology to regenerate organs or individuals from separated animal cells" and "54: Clinical application of technology enabling organs to regenerate through the multiplication of their own cells" are 2023 and 2021, respectively.

Naturally, elucidation of the molecular mechanisms of development, differentiation and morphogenesis, in itself, generates high expectations of "expansion of intellectual resources," but when it is linked with topics dealing with actual diseases and their treatment, and such issues as artificial organ formation, expectations tend to be higher regarding "response to people's needs." These themes contain various difficult ethical questions and their progress will have to be subject to public acceptance, and how these are dealt with will have a significant influence on realization times.

(Kazuo Nagai)

4.1.4. Brain functions

The 21st century is said to the "century of the brain," and expectations about brain research are currently extremely high. First, it appears possible that we will find answers about human mental functions, and based on this, new concepts about what it is to be human are expected to be established in the next century. Second, hopes are high regarding research into the causes of mental and nervous diseases, such as dementia, and the development of treatments for those diseases. Third, with the elucidation of brain functions, there will also be

* The paper announcing the world's first successful creation of a cloned sheep by a team headed by Dr. Ian Wilmut at the Roslin Institute near Edinburgh, Scotland, was published in the journal *Nature* (27 February 1997).

high expectations for the application of that knowledge in engineering fields such as artificial intelligence and more advanced computers, an especially important theme for countries like Japan that need to build industries that can generate high added value.

Rapid advances are being made in molecular-level research into the mechanisms being applied when neurons encode information as electric signals, and transmit those signals to adjacent neurons — ion channels, neurotransmitter receptors, and their modification — through the introduction of molecular biological methods and advances in physiological methods. Against this backdrop, the mechanism of learning and memory, one of the higher functions of the brain, is being actively researched at the synapse level. Typical examples are “long-term potentiation” and “long-term depression” of synaptic transmission discovered in the hippocampus, regarded as an essential structure in certain memory functions, and molecular mechanisms here are gradually being elucidated. We can perhaps look forward to its overall elucidation and development of drugs that will improve memory and learning functions in the relatively near future. But we do not know how changes in synaptic plasticity are actually linked to memory, and this perhaps illustrates that while tremendous progress is being achieved in the elemental aspects of brain research, research into the functions of the brain as an integrated organ is falling further behind. What has the potential to cut away this disparity is the technology to produce mice lacking in unique genes (knock-out mice) using homologous recombination, and with this technology, when a certain gene is lacking (coded protein) we can examine abnormalities shown by the mouse from the molecule and cell level to the behavior level. The function of genes (protein) lacking from the start of development are readily compensated by other genes (protein), so in some aspects it is difficult to interpret the results. Nonetheless, scientists are in the process of developing techniques to limit the manifestation or non-manifestation of certain genes to specific cell groups, or change the genes at will after development of the individual, and if these techniques prove successful, they will do much to lessen the disparity mentioned above.

At present, research into the cerebral cortex, the foundation of high-level brain functions, is most advanced in the vision area, and what this research has revealed is that subjectively unified visual experiences are processed in parallel by way of information processing in the cerebral cortex; for example, when we see a red apple fall from a tree, we experience this as a uniform consciousness, but in the brain the information — form (apple), color (red) and action (falling) — is processed separately in different spheres. How these parallel and dispersed processes are combined in the brain to form a uniform conscious experience is one of the great mysteries of the brain that we have yet to unravel, and the fact that in the past few years brain scientists have begun to look seriously at issues such as this is a sign that “consciousness,” which to date has been the realm of philosophers, is now being approached from a scientific angle. Research into brain functions that form the foundations of language and thought is methodologically difficult because these skills are regarded as peculiar to humans, and it is far from easy to devise a specific strategy for this. To date mainstream research into brain functions has focused on recording the activity of single neurons using microelectrodes, but microelectrodes alone have their limitations in measuring mental functions formed by the cooperation among and functioning of massive numbers of neurons. What is needed is a method that can record the activity of large numbers of neurons simultaneously over an extended period and analyze the data obtained effectively. We can also look forward to advances in recent non-invasive research methods, such as positron emission tomography (PET) and functional MRI. To date researchers have been examining functional maps of associated areas in the human brain drawn up psychologically using patients with brain damage, but new non-invasive methods are already making a major contribution to the preparation of functional maps of healthy brains. And we can look forward to these methods making similar contributions to research into speech and thought. But these methods do not observe nerve activity directly, rather they observe changes in blood flow or glucose metabolism resulting from nerve activity, so there are some limitations. It is hoped that PET will be able to show how and in what area of the brain functional molecules change following brain activity by labeling functional molecules such as neurotransmitters or their messengers within the cells, and similar substances and injecting them into the human subject.

It is crucial that research into brain functions does not focus entirely on the “hardware,” such as neurons, synapse, on the linkage between neurons, and intuitive understanding and hypotheses based on this, but proceeds parallel to and in cooperation with theoretical research using mathematical models. For this, interdisciplinary research that includes engineers is essential, and I have no doubts that such research will bear fruit also when knowledge of brain functions is applied in the field of engineering.

(Masaki Sakurai)

4.1.5. Elucidation of plant functions and its use

Research aimed at elucidating plant functions has advanced remarkably over the last ten years, and one of the main reasons for this is that researchers across the world have focused on the shepherd's purse as a model plant. Various genetic maps are steadily being completed thanks to the smooth progress of the genome project using the shepherd's purse coupled with the accumulation and analysis of numerous mutants, and this is indeed a milestone in plant research to date. On the other hand, plants are a vital source of food for humanity, and like the shepherd's purse project, genome projects with rice, maize, tomatoes and other important agricultural products are also proceeding smoothly, and it should be noted that with various genetic maps being prepared using numerous mutants accumulated over many years of research, scientists are beginning to isolate the myriad of genes that control the agriculturally important properties.

Efficient gene introduction methods were developed earlier for plants than for animals, and from the early 1990s, many practical recombinant plants, such as pest- and herbicide-resistant farm products, have been raised. In 1996, food from recombinant farm products was first consumed on a wide scale not just in the U.S. and Canada, but in Europe and Japan as well, and this is an extremely important development for the future of humankind. In the previous survey, the topic "Widespread use of new plants produced using gene manipulation technology for food" was forecasted to be realized in 2003, but it was actually realized seven years earlier, illustrating the rapid pace of research in this field. Behind this is an understanding among researchers throughout the world that solving the food shortage that is likely to accompany the population explosion predicted in the first half of the next century is absolutely crucial for the survival of humankind.

The biggest issues directly confronting humankind on a global scale are food, environmental degradation and energy problems, and in this survey we set many topics connected with the elucidation and use of various plant functions thought to be vital to the resolution of these problems, but excluding topics "35: Widespread use of bioplastic production so it accounts for 10% of total worldwide plastic production" and "91: Development of technologies which dramatically improve photosynthetic ability in order to increase food production," the perceived degree of importance to Japan is generally lower than that of medical topics, and especially those dealing with cancer. Certainly, aging and its related medical care are important issues that cannot be ignored in any developed nation, but if we think at the global level, surely feeding the world's expanding population is more important than medical care in the long-term survival of the human race, and without food, medical care has little significance. We in Japan depend on imports for most of our food, and in our daily lives there is no hint of any food crisis. We are living in an era of plenty as far as food is concerned, yet in other parts of the world people are still dying of starvation in huge numbers. A future world food crisis will impact on Japan just as much as it will on many other countries, so we need to do much more to try to resolve the food problem before it becomes critical.

The most important measures we can take to put and end to food shortages and environmental destruction that some have said will reach crisis proportions in the early part of the next century will be to elucidate the various plant functions, improve plant species, and utilize those plant functions at a high level. If we look at the survey topics from this perspective, there is a concern that the forecasted realization times may be on the late side; for example, the forecasted realization time of topic "92: Practical application of breeding techniques for plants resistant to dry and saline conditions aimed at desertification prevention" was 2009 in the previous survey but 2014 in this survey, and that of topic "91: Development of technologies which dramatically improve photosynthetic ability in order to increase food production" was 2011 before but 2017 this time. Elucidation of plant functions and research into the utilization of those functions are the foundations upon which humankind will survive, so it is crucial that research into this moves ahead so that topics such as these can be realized earlier than forecasted.

(Hiroshi Kamada)

4.1.6. Structural biology

Research aimed at trying to understand life phenomena based on the three-dimensional structure of biopolymer is said to have started with the elucidation of the three-dimensional structure of protein using X-ray crystal analysis in the 1960s. Because of advances over the past five years in protein engineering technology that allows us to produce recombinant protein or new protein efficiently, mass supply of protein that previously had been difficult or impossible to produce naturally is now possible, and with this, elucidation of the three-dimensional structure of protein progressed rapidly, and a new academic field of "structural biology" was born. Structural biology seeks to elucidate biofunction mechanisms based on the three-dimensional structures of biopolymers such as proteins and nucleic acid and their changes, and through this, to understand life phenomena, and it is expected to generate new basic concepts and research guidelines not just for the basic sciences, such as biophysics and molecular biology, but also for life science and biotechnology over a broad range of applied fields, including medicine, pharmacy, and engineering.

As of October 15, 1996 the Protein Data Bank (PDB) contained 4,873 registered structures, 1,051 more than in October 1995. This highlights the tremendous advances made in three-dimension structure analysis technology during these twelve months. Researchers can now analyze hundreds of thousands of protein structures that they could not before, and papers detailing analyses of conjugated proteins that interact with nucleic acids such as DNA binding protein were published one after the other. Large-scale production of recombinant protein using genetic engineering techniques and advances in new analysis technologies such as synchrotron radiation are expected to generate a further rapid increase in the number of registered structures.

The structural biology topic "04: Development of methods for surmising new functions of proteins from human genome information" is forecasted to be realized in 2011. Advances in gene analysis technology and its growing use and the progress of the genome analysis project are pushing up dramatically the number of genes whose base sequences are being determined. There is thought to be considerable demand for methods of predicting the kind of functions genes and gene products perform within an organism, including prediction of three-dimensional structures. The realization of this is linked to the realization of topic "25: Establishment of technologies enabling prediction of the functions of proteins from their higher-order structures," which is forecasted to take place in 2014, but work in the development of methods of predicting higher-order structures from primary order structures of proteins is expected to become more dynamic as the number of three-dimensional structures of proteins registered in the PDB soars. Topic "17: Practical use of continuous, industrial-scale production of protein by means of a non-cellular protein synthesizing technique" is an encouraging theme for examining the structures and functions of proteins coded by new genes, and though industrial-scale production is not expected before 2015, the technique does show promise for manufacturing gene products from unknown genes, and analyzing their structures and functions. As for improving the catalytic functions of enzymes through structural biology, topic "13: Development of biomimetic elements with better functional characteristics than enzymes" is expected to be realized in 2014. Scientists are looking to the development of new catalysts that compensate for the weaknesses in enzymes through the elucidation of the 3-D structure of the active part of enzymes and the molecular design and synthesis of biomimetic elements based on this. Along with this, topic "16: Practical use of technology to design/synthesize thermostable protein" is forecasted to be realized in 2009, and in the future the elucidation of the 3-D structures of thermostable enzymes from thermophilic bacteria and super-thermophilic bacteria will make the molecular design of thermostable enzymes possible, and catalytic reactions using thermostable enzymes on an industrial scale will be put to practical use.

In conclusion, we expect progress in the analysis of biopolymer at the molecular level, and while the forecasted realization time of topic "19: Elucidation of the molecular mechanism of life creation" is well into the future, we can look forward to interesting results from research that steadily moves toward the origin of life through advances in structural biology.

(Izumi Kumagai)

4.1.7. Substance and energy conversion

Humankind has created industries that produce substances necessary for survival and general life through the skillful use of the capability to convert substances and energy inherent in living creatures. Good examples of this include the fermentation and microorganism industries, which utilize the substance and energy conversion capabilities of microorganisms, and the oil and fat manufacturing industry and agriculture, which utilize the substance and energy conversion capabilities of plants.

In recent years attempts to use these substance and energy conversion capabilities of organisms to resolve various global environmental problems have attracted world attention. These attempts include biomass fuel using recyclable biomass resources, production of bioplastics, fixing biological CO_2 using microscopic algae, and application of bioprocesses to the chemical industry, which is imposing an increasingly serious burden on the global environment because of its numerous production processes that use various kinds of organic solvents. Biomimetic research aimed at copying the substance and energy conversion capabilities of organisms, such as carbon or nitrogen fixing, and research aimed at developing artificial systems that exceed organic functions are expanding on a world scale in the research area of supermolecular chemistry.

In this survey, we prepared 11 topics connected with substance and energy conversion, of which six deal with global environmental problems — "35: Widespread use of bioplastic production so it accounts for 10% of total worldwide plastic production," "36: Widespread use of fuel oil production technology using microorganisms etc. so it accounts for 10% of total worldwide fuel oil production," "37: Widespread use in chemical industry processes of biological catalysts which are resistant to organic solvents, heat, etc.," "38: Establishment of a system for biologically reducing and fixating CO_2 using energy other than light," "39: Practical use of technology for the biological fixation of highly concentrated carbon dioxide at thermal power plants" and "81: Practical use of plants accumulating high amounts of hydro-carbon as fuel sources" — and five deal with the construction of biomimetic artificial systems — "17: Practical use of continuous, industrial-scale production of protein by means of a non-cellular protein synthesizing technique," "18: Development of light energy elements patterned after photosynthetic response," "31: Development of engineering technologies that apply biological energy conversion mechanisms," "32: Development of technology for synthesizing artificial cells that replace such functions as cell membrane transport and substance conversion" and "33: Development of artificial membranes with functions similar to biological membranes."

The six topics dealing with the global environment have an average degree of importance of 71.2, just over five higher than the overall average of the life science field (66.1). Topic "35: Widespread use of bioplastic production so it accounts for 10% of total worldwide plastic production" is the highest with 87, and ranks fifth among all life science topics. This result reflects the belief that the widespread use of biodegradable bioplastics produced from recycled material can alleviate the problem of waste plastic disposal, which is a major burden on the global environment, and resolve the various problems that arise from the fact that the majority of fossil fuels, which are not recyclable, are consumed in plastic production. Most of the six topics also exceeded 90% in the expected effect "resolution of global problems," and are ranked high among the top topics with this expected effect. Topic 37 was slightly higher in "contribution to socioeconomic development" with 82%.

As for the five topics dealing with construction of biomimetic artificial systems, topic "18: Development of light energy elements patterned after photosynthetic response" is rated the highest in degree of importance with an index of 77, but with degree of importance indices between 58 and 63, the other four topics are below the overall life science average. All five topics have "contribution to socioeconomic development" as the main expected effect, ranging from 65% to 77%, and all are ranked high among the top topics with this expected effect.

The forecast realization times of all 11 topics connected with substance and energy conversion range between 2013 and 2021, slightly earlier than the overall average forecasted realization time for life science. The earliest is topic "35: Widespread use of bioplastic production so it accounts for 10% of total worldwide plastic production" at 2013, but in the past few years, a joint team comprising members from three universities including the University of Durham in the U.K. and the Mon Santo company successfully extracted bioplastic from matured seeds and leaves of rape plants into which they had implanted genes from microorganisms that produce copolymerized polyester. This lowered production costs substantially, which in turn has given impetus to its practical use, so the realization time of this topic could actually be realized several years earlier than forecasted.

For four of the six topics dealing with the global environment, the response rate for Japan as the leading country is a high 50-70% (excluding topics 38 and 81), and this is roughly the same as that for U.S.A. Considering the overall life science rates are 82% for the U.S.A. and 36% for Japan, we can say that the level of research in Japan into technology to apply substance and energy conversion capabilities of organisms to the global environment is on a par with that in the United States, and that this is one area where much is expected from the contribution Japan can make. Of the measures the government should adopt to help realize these topics, “promote exchanges among industrial, academic and government sectors and different fields” and “increase government research funding” are rated quite high, showing an awareness among respondents that more effort has to be made to promote such exchanges through NEDO and RITE projects etc., and that more money has to be allocated for research.

(Teruyuki Nagamune)

4.1.8. Immune system

(1) Trends in immunology research over the past five years

i) Background and major research trends to date

In the latter half of the 19th century various pathogenic bacteria were identified as a part of programs to prevent infectious diseases, and research proved that immunity can be built up against an infectious microorganisms by introducing a weakened version of that microorganism into the body, and with this the concept of vaccination was put forward. Later it was shown that the immune response is classified into humoral immunity, which utilizes circulating antibodies, and cellular immunity, which utilizes lymphocytes, and that each kind of immunity requires the interaction of lymphocytes. Both old and new research themes in immunology are (1) how are antigen-specific lymphocytes chosen, and growth and differentiation induced; (2) how is the diversity and multiformity of the immune response formed; (3) what are the mechanisms by which immune tolerance appears; and (4) what is the substance of immune memory. In the 1970s it was discovered that the reconstitution of antibody genes, which are B-cell antigen receptors, is evoked following the B-cell differentiation stage, and the antigen specificity of antibodies and molecular mechanisms of diversity manifestation were elucidated. In the 1980s, the structure of T-cell antigen receptors (TCR) and major histocompatibility complex (MHC) genes were isolated, and it was found that T-cells recognize antigen peptides and self MHC molecules by means of TCR complex on the cell surface and are then activated. It was also shown that T-cells that respond actively to their own antigens are eliminated at the maturation/differentiation stage within the thymus. The latter half of the 1980s was marked by the search for cytokines and their receptor genes, which are essential for the activation, growth and differentiation of immune response cells. Numerous immunologically functional molecules and binding molecules were newly identified, and their importance in immunoregulation was established. There is no doubt that the explosive progress of research in this field can be put down to technological innovation and progress in gene manipulation and cell engineering, and the active introduction of transgenic mouse production techniques.

Major research themes have been (1) antigen analysis of foreign pathogenic microorganisms that activate the immune system, and classification of the host responses to these microorganisms; (2) identification of molecules responsible for the immune response (humoral and cellular) to pathogenic microorganisms, and the groups of cells that are involved in this response (T and B lymphocytes and macrophages); (3) isolation of TCR and elucidation of antigen peptides recognized by TCR complex and self MHC; (4) isolation and functional analysis of the immunologically functional molecules (cytokines, binding molecules, secondary stimulant molecules, etc.); and (5) elucidation of the cellular characteristic and molecular mechanisms of immune tolerance, i.e. the elimination of self-reactive cells during the maturation process. Thus the main interest during this period was focused on when the immunological “self” and “not-self” recognition mechanism would be elucidated, and at that time the forecasted realization time was about 2006.

ii) Major research projects over the past five years

1) Fas and FasL genes were isolated and their structures determined. Functional analysis of recombinant Fas/FasL and analysis using Fas antibodies revealed that the Fas/FasL system causes apoptosis, and as a result of gene mutation, the Fas/FasL system struggles to eliminate self-reactive cells, leading to autoimmune disease. This analysis also revealed that apoptosis, including the Fas/FasL system, has a significant part in the elimination of self-reactive cells, and clarified the molecular mechanisms behind this. Research regarding general cell death also advanced in great strides. These days, the elucidation of the molecular mechanism of cell apoptosis is one of the hottest research domains in biology.
2) Research into whether a humoral or cellular immune response is triggered by an antigen stimulus (immunodominance) moved forward in leaps and bounds. It showed that newly discovered cytokine IL-12 triggers a cellular immune response, while IL-4 is closely linked to a humoral immune

response.

3) Progress was made in elucidating the molecular mechanisms of cell signaling through immunologically functional molecules (antigen receptor complex, cytokine receptors, binding molecules, CD40, etc.). A new tyrosine kinase (JAK, Tec, etc.) family gene was isolated, and it was revealed that the gene's activation is important for signal transmission through immunologically functional genes. Furthermore, a new transcription activating molecule (STAT family) gene was isolated, and its role in signal transmission is being clarified.

4) Gene homologous recombination technology was widely incorporated into immunological research, producing gene knock-out mice lacking specific immunologically functional molecules. To date, knock-out mice lacking more than 50 kinds of immune-related molecules have been produced. This has helped to clarify the role of antigen receptors, transcription factors and tyrosine kinase in the early development of lymphocytes within the body, the function of cytokines and receptors connected with growth and differentiation and the molecular mechanisms of cytokine signal transmission, the role of molecules connected with lymphocyte cell death, the role of binding molecules and various enzymes connected with the effector phase of immunity, and the role of previously unknown molecules in the control of the immune response.

5) The causative genes of X-linked immunodeficiency syndrome were determined, and analysis of the form of the disease progressed. From this it was clarified that X-linked serious complex immunodeficiency (XSCID) is caused by growth abnormality in T and B lymphocytes due to mutation of IL-2 receptor γ chain, that in X-linked hyperIgM syndrome the isotype conversion of immunoglobulin is not possible because of mutation of CD40 RIGANDO, and that X-linked agammaglobulin syndrome (XLA) is an abnormal differentiation of B cells caused by mutation of BURUTON tyrosine kinase (Btk).

(2) Current topics in immunity

Genetic isolation of the functioning molecules involved in immunoregulation and determination of their overall structure, the structure of T and B lymphocyte antigen receptors and the molecular mechanism of diversity manifestation, and the molecular mechanism of lymphocyte activation, growth and differentiation have been clarified. However, there still remains much to uncover, including the molecular mechanism of immune tolerance and its failure; the mechanism by which self-reactive cells are eliminated (apoptosis); the mechanism by which a dominant immune response (humoral or cellular, Th1 or Th2) to an antigen is determined; the cellular nature and molecular mechanism of an immune response through the mucosa; the mechanism of intractable inflammation, which can be seen in autoimmune disease and allergic disorders, and its control; immunoregulation for viral infections; molecular mechanisms of immune diseases and repair of the immune system. Examples of this include: 1) elucidation of the mechanism by which differentiation from multifunctional stem cells to lymph stem cells is predetermined, and the micro-environment under which this occurs; 2) analysis of the detailed mechanism by which T (thymus-derived) cells that have a strong recognition of self peptide and self histocompatibility molecules are eliminated in the thymus, and its failure; 3) molecular mechanism by which foreign protein antigens are resolved to as far as peptides within antigen cells and join with MHC; 4) the molecular mechanism of lymphocyte activation, non-response, tolerance and cell death; 5) cell signaling mechanism from immunologically functional molecules on the cell membrane; 6) analysis of infectious parasites and the host's immune response; 7) elucidation and repair of the mechanism of intractable inflammation and its control; 8) the induction mechanism of mucosa immunity and of immune tolerance by means of oral antigens; and 9) molecular mechanism by which immune memory is maintained.

(3) Importance and future prospects

As more cell groups, molecules and genes connected with the immune system are identified, and the secrets behind the molecular mechanism of immune cell growth and differentiation and the induction mechanism of immune tolerance are steadily revealed, researchers are beginning to question how the immune system at the individual level is regulated by these molecules and cells. And an urgent task researchers have is to elucidate the molecular mechanism of diseases caused by an immune response (autoimmune disease, allergies, transplant rejection, and intractable inflammation) and develop methods of repairing the immune system. In this survey we prepared four topics (05, 06, 07 and 70), and the importance index is quite high in all four (average 74.6), indicating a high level of interest in this domain among the respondents. However, forecasted realization times are all after 2010, which is slightly later than the times forecasted by the experts, and this made us realize the difficulty faced in resolving the topics and the need for more effort by researchers. Considering the importance of the topics and the high level of public interest, it is vital that everyone concerned gives even more support to the research effort.

Virtually nothing is known about how the immune system as a high-level function regulatory system functions while interfering with the nervous and endocrine systems. The results for the topic dealing with this (topic 71) in this survey showed that there is considerable interest in this theme (importance index of 78), but its realization is expected to be quite some time away (2017). Considering the importance of and high level of interest in this theme, I firmly believe much more support has to be given to the research effort. It is interesting to note that the importance index of topic “27: Elucidation of the immune mechanisms which distinguish between ‘self’ and ‘not self’” is, at 70, lower than we expected, and the forecasted realization time is later than that of the previous survey. The importance index of topic 08, which deals with apoptosis, at 65 is also lower than expected. The fact that this is a relatively new theme (it suddenly attracted world attention from the 1990s with a succession of discoveries) probably had some bearing on its survey results.

As mentioned above, research in immunity is indeed multi-faceted and diverse. The importance and future prospects of research themes in immunology as biology, and applied science in clinical medicine, and as a high-level function regulatory system are extremely high, and the results of this survey support this. The research contribution and expectations of Japan in the immunology domain are high, also as reflected in the survey results. The future of research in this domain promises to be exciting.

(Kiyoshi Takatsu)

4.1.9. Medical engineering

(1) Technological change

This is a domain in which various technologies are applied, and areas that have achieved remarkable progress over the past several years have all been backed by advances in basic technology. Contributing the most has been the progress in biotechnology in recent years, but advances in micromachine technology, virtual reality technology and superconductivity technology (generation of strong magnetic fields, and micro-magnetic field measuring technology), and the development of medical polymers and multimedia technology in home medical care have also played a key role. Many of the topics realized over past surveys are based on biotechnology, and in medical engineering, the mainstream seems to be shifting from a situation where only artificial products are used, to one now where cells and tissues are altered using biotechnology, and this is used in conjunction with artificial products. The same can be said about micromachine technology. Although there are still many hurdles that have to be surmounted before realization, the production of artificial micro-organs and tissues using micromachine technology is beginning to show signs of possibility, and this is an important force driving research in this domain. The same applies to the following technologies as well.

(2) Current topics

i) Artificial organs

Trial production and research is aimed at fully implantable artificial hearts and various other artificial organs. Although there are still many problems that have to be resolved, even with today's technology the development of compact, high-performance systems or batteries for energy transmission into the body, development of material that does not cause thrombus formation, development of microsensors that can be used within the body (within blood vessels), and the development of control algorithms are possible.

The forecasted realization time of topic "52: Development of an entirely implantable artificial kidney" is 2013. Work on the development of hybrid artificial organs (especially metabolic artificial organs) using cultured cells of organisms has been progressing, and an artificial liver of this kind has reached the clinical trial stage in the treatment of severe hepatitis (in Europe and the U.S.). And while the results are still not perfect, the number of papers presented at international academic societies and the like has been increasing rapidly, and there seems no doubt that research in this area will become a growing trend in the future (however, there is still much to be resolved regarding cultured cell reconstruction technology and the improvement and reduction in size of systems that can be used over the long term). The forecasted realization time of topic "51: Practical use of artificial organs incorporating human cells and tissues" is 2015. One direction this kind of artificial organ research is heading is the regeneration of organs using biotechnology. This is still very much at the embryonic stage, and research is at the point where various kinds of growth factors are extracted from the organism for examination, and although a degree of liver cell regeneration has been realized, the multiplication and regeneration of any organs to the desired size is still a long way off. Reflecting the current state of research, the forecasted realization time of topic "54: Clinical application of technology enabling organs to regenerate through the multiplication of their own cells" is 2021, the latest time of any topic covered thus far. But from a non-expert's point of view, considering the progress in biotechnology over the past few years, the realization of this theme could well be earlier than expected.

Another theme in this field relates to micromachines and virtual reality, and research here is aimed at producing micro-interface arrays that enable direct multi-channel input and output through the body's nervous system, and through this system, create artificial sense, such as vision. Artificial inner ears are already available, and artificial retinas have reached the stage where some animal experimentation is being conducted, but as yet the number of channels is limited, and many technical breakthroughs and considerable time will be required before this technology can be put to practical use. The forecasted realization of topics related to this — "53: Development of an artificial retina, allowing the visually impaired to regain their sight" and "56: Establishment of interface technology between neural information and artificial organism structures” — are quite close at, respectively, 2019 and 2020.

Problems that have to be overcome when leaving an artificial object in the body for an extended period are the biocompatibility, resistance to thrombus formation and the selective permeability (parts that come into direct contact with blood) of the material used, and although not spectacular, steady progress is being made.

ii) Medical micromachines

Medicine is said to be the most promising domain for the application of micromachine technology, and hopes have been high since development of this technology first began. Although there is some question as to exactly what constitutes a micromachine, the generally accepted perception is a microscopic device that can be inserted into the body (in blood vessels, the spinal column, and the bronchiole) and has some form of treatment or diagnostic function within the body. In the early stages of micromachine technology, the general public had the idea that these machines were just around the corner, but even though it may be possible to produce extremely tiny devices (running gears), numerous technologies essential for the development of fully functional micromachines, such as energy transmission, microsensors that correspond to vision and other senses, and the transmission of such sensory information, biocompatible material, material that does not cause thrombus formation, and the means to direct the micromachine into the target location, are as yet out of our reach. Thus the reality is that considerable time and massive development effort will be needed before an overall system is developed and functioning. In this survey the forecasted realization time of topic “62: Development of diagnostic and medical treatment micromachines capable of traveling on their own inside organisms” is relatively early at 2015, but in the experts eyes, this is too early, so it would be interesting to know upon what the general respondents based their forecasts. Research is currently focused on minimum invasive surgery, in which surgery is performed in the stomach cavity and chest cavity using tiny precision endoscope systems and micromanipulators operated from outside the body through the TORAKAARU (narrow tube through which the instrument is passed), and is expected to lead to even smaller instruments with combined functions (endoscope and manipulator) that can be applied to surgery in blood vessels, the spinal column, and the bronchiole.

iii) Medical application of virtual reality

Considerable research is being directed to the medical application of virtual reality. The remote surgical system is one in which a surgeon performs surgery on a patient at a different location using a slave manipulator (surgical instrument), but through VR technology the surgeon has the sensation that he or she is actually operating directly on the patient. Research in this area has been quite extensive in Europe and the U.S. (especially in the U.S.), particularly in view of the potential military application of this technology. The same can be said about the application of VR to microsurgery. It creates the virtual space of a much expanded surgical area. But how real does this artificial sense of reality have to be? Perfect VR requires the development of microsensors and systems that can give feedback on the detected sensation to the body (an interface that exchanges information directly with the nervous system), and a system that cuts down the time lag in information transmission to acceptable levels. This could be possible to a degree even with current technologies, provided sufficient money, effort and time is spent on the research. The forecasted realization times of topics “75: Widespread use of remote surgery systems utilizing virtual reality technology” and “76: Widespread use of vicarious experience devices which allow bed-ridden patients to take vacations, etc.” are also quite early (this of course depends on the level of the virtual reality) at, respectively, 2011 and 2008.

As mentioned above, work is being done on the development of interface systems that facilitate direct multi-channel input and output through the body’s nervous system, and also research into the control of artificial prostheses using information from the nervous system and, in the other direction, the generation of artificial sensations through stimulation of the nervous system.

iv) High-speed biofunction measuring devices

The development of computerized tomography (CT) and the subsequent development of MRI have made it possible to obtain clear structural images of internal organs using non-invasive techniques, and this has contributed enormously to disease diagnosis. The focus of research is now on using similar methods to obtain tomographic images that show bodily functions, such as metabolism, and not just organ structures, and on maximizing image speed to determine local time-series change of metabolism etc. At this stage, functional MRI is being put to practical use in estimating the active parts of the brain using the magnetic difference between oxyhemoglobin and deoxyhemoglobin, and the high-speed measurement of MRI connected with P or S, which is currently only applied to spectroscopy, will be realized in the near future.

As for non-invasive methods, magnetic maps of the brain and heart obtained by micro-magnetic measurement are already being used widely, and similarly, functional measurement methods using light (optical CT, etc.) are also now used extensively. Both methods still have problems in identifying the local parts of dipoles and space resolution, but further developments are expected in the future.

(3) Future prospects

I discussed the future prospects of individual items in the preceding sections, so here I will touch on general problem areas.

Need is naturally the main driving force of developments in medical engineering, but it is impossible to discuss future prospects in terms of the extent of need in isolation. One reason for this is that since medical engineering is an applied science, its progress largely depends on the progress of basic technology; a breakthrough in basic technology will bring about progress in medical engineering where that breakthrough can be applied, and quite often this can come from completely unexpected directions. Research in this field generally requires expensive equipment and facilities, so when the money goes, so too does the research, so research funding has an enormous influence on the progress of the research (there are many examples in the U.S. where projects (laboratories) simply vanished because of cuts to research grants from NIH and other organizations). Because of this, it is not always easy to judge how topics that have currently attracted attention will progress in the future. But the fact that a topic is attracting attention in itself shows that some kind of breakthrough in basic technology has taken place and progress is expected, or that the country is trying to appropriate a research budget on a priority basis because of a need. Progress in the topics mentioned above will therefore be commensurate with the amount of funds invested in research. Regarding my area of expertise, the forecasted realization times in this survey are somewhat more optimistic than what I forecast (perhaps because the survey results include the hopes of people outside this field). From a specialist's viewpoint, many technological breakthroughs will be necessary before these topics can be realized, and my feeling is that this will be difficult to achieve by the forecasted realization times. To realize these topics earlier, effective management of budgetary measures (especially the massive research budget that at present seems to be scattered around at random), and a stronger cooperative structure among researchers in related fields (especially the basic fields of chemistry and applied physics) are essential.

(Kunihiko Masubuchi)

4.1.10. Sensors and computers

The sensor and computer field is a combination of life science, electronics, optics and micromachines, and technological advances in areas that become the basis of individual devices are largely reflected in the advancement of this field.

The field itself can be looked at in terms of progress of materials based on biosubstances and electronic devices, and in terms of the receipt and processing of information through the application in electronics of new knowledge obtained from advances in life science.

Recent achievements in this field have been the creation of biomaterial useful in sensors and biocomputers through genetic engineering and protein alteration technologies. Research is being conducted into sensors that utilize the functions of various protein molecules, such as enzymes and antibodies, but some have not been suitable for practical use as the molecules themselves were unstable, or deactivation into elements was too great because of fixation. However, efforts are being made to resolve these problems by altering protein molecules or modification through genetic engineering. The practical use of technology to design/synthesize thermostable protein is expected to be realized in 2009, and this will facilitate the use of many biosensors. And it is forecasted that through the use of thermostable proteins, biodevices that can be used in electronics will be developed in 2015.

On the other hand, transducers, typified by terminals made up of sensors, are also undergoing major changes. On the surface, this does not seem to be connected with life science technology itself, but currently one of the important directions of research in this field is miniaturization, and besides terminals, new conceptual sensors, such as SAW and optometric methods are being developed. Application of microdevices is not limited to the monitoring of individual organisms or tissues, which has already been tried in clinical tests; the monitoring of individual cells will become possible. And research is already heading in this direction.

As a future technology, nano-devices will become possible through advances in electronics. These devices will allow real-time measurement of cell functions, and this in turn will expand our knowledge in life science. They can also be applied in systems without suitable probe pigment, and the *in vivo* monitoring of various organisms will reveal previously unknown phenomena within cells.

It is forecasted that the design/synthesis of thermostable protein (2009) and development of biomimetic elements with better functional characteristics than enzymes (2014) will lead to the development of biodevices that can be used in electronics (2015) and the development of basic concepts of biocomputers based on this (2016). At present, biocomputers and neural-computers are viewed as different concepts, but there is a possibility that they may be merged over time.

This is because the following forecasts were made about neural-computers. It is forecast that experimental techniques for recording and analyzing the activities of a large numbers of neurons simultaneously and over a long period of time will be developed in 2011, and this will dramatically expand our knowledge about information processing in the nervous system, and advance our analysis of brain functions. It is also forecasted that the relationship between learning/memory and synaptic plasticity will be elucidated in 2017. This will build up the knowledge necessary for computer development, leading to the development of neural-computers with new logic structures modeled on brain functions in 2018. It is also forecasted that electric circuits with similar self-organization and self-restoration functions as neural networks will be developed in 2018, and at this stage, biocomputers and neural-computers will probably begin to merge. This neural-computer will be a first-generation device, and the elucidation of the neurobiological basis for emotion in 2021 and the elucidation of brain mechanisms for logical reasoning in 2023 will probably lead to the development of second- and third-generation neural-computers.

In 2025 interfaces that enable a direct linkage between computer and brain will be developed, and this will probably mark the beginning of a new century for the brain and computer. Brains could be helped by computers, and conversely, computers may seek the opinion of brains. Forecasting this far ahead has a touch of science fiction about it, but by that time, there will probably be a need for clear ethical standards in relation to this.

(Izumi Kubo)

4.2. Forecast topic framework

In the course of compiling forecast topics, a framework representing the organization of technologies in tabulated matrix form was drawn up for each field, with objectives and technological domains defining the rows and columns of the table, respectively. The framework is designed to present an overall picture of technological development in each field in terms of future prospects, importance, etc. as seen from the present perspective, and is also used as a working framework for future reviews of forecast topics.

Table 4.2-1 Forecast Topic Framework for Life Science Field

Domain / Objective	Molecules	Cells	Tissues and organs	Individuals	Groups
Medical care	01 02 03 04 05 06 07 08	27 28 29	47 48 49 50 51 52 53 54 55 56	67 68 69 70 71 72 73 74 75 76	
Information	09 10		57 58		
Food	11	30		77 78	91 92
Industry	12 13 14 15 16 17 18	31 32 33 34 35 36 37	59 60 61 62		
Environment and energy		38 39 40		79 80 81	
Elucidation of biological phenomena that form the basis of various technologies	19 20 21 22 23 24 25 26	41 42 43 44 45 46	63 64 65 66	82 83 84 85 86	93
Other				87 88 89 90	94

* Figures appearing in the table represent topic numbers.

4.3. Topics with high degree of importance

Degree of importance index scores (Note 1) averaged at 66.1 for topics in the life science field as a whole. Topics considered of particular importance to Japan (top 20 topics in terms of degree of importance index score) are listed in the table below. The importance attached to cancer-related topics stood out, with up to six of them featuring in the top 20. Environment-related topics also ranked high, with six included in the top 20.

Table 4.3-1 Top 20 Topics in Terms of Degree of Importance Index

Topic	Degree of importance index	Forecasted realization time (year)
49 Practical use of effective means to prevent metastasis of cancer.	91	2013
74 Identification and classification by the molecular etiology of the genes related to diabetes, hypertension, and arteriosclerosis, typical geriatric diseases which exhibit multiple-factor hereditary traits.	88	2012
48 Development of drugs capable of preventing the occurrence of certain types of cancer.	87	2010
02 Development of anti-cancer agents which target the manifestation functions of cancer genes.	87	2010
35 Widespread production of bioplastics using microorganisms and plants, accounting for10% of the total volume of worldwide plasticproduction.	87	2013
01 Identification of multiple genes related to cancer, and elucidation of the relationships between those genes and carcinogenesis.	86	2014
67 Become possible to cure senile dementia of Alzheimer type.	86	2016
91 Development of technologies which dramatically improve photosynthetic ability in order to increase food production.	86	2017

Topic	Degree of importance index	Forecasted realization time (year)
72 Scientific elucidation of the factors within daily life (eating habits, air quality, etc.) which influence the process of carcinogenesis.	83	2012
52 Development of an entirely implantable artificial kidney.	83	2013
28 Control of signal transduction in the carcinogenesis of cells, and widespread use of treatment methods for dysdifferentiating carcinogenic cells.	82	2020
07 Elucidation of the environmental factors and control mechanisms of the immune response which triggers allergies such as hay fever and atopy, facilitating the complete control over immediate type hyper-sensitivity.	82	2014
36 Widespread production of alcohol and other fuel oils utilizing microorganisms, seaweed, etc., accounting for 10% of total worldwide fuel oil production.	81	2015
29 Complete understanding of the factors contributing to stem cell multiplication, and widespread use of the practice of multiplying stem cells, as necessary, in test tubes and using them for treatment purposes.	81	2015
54 Establishment and clinical application of technology enabling organs to regenerate through the multiplication of their own cells.	80	2021
71 Elucidation of the mutual regulatory mechanisms of the immune system, nervous system, and endocrine system, and utilization of such knowledge in the treatment of disease and promotion of health.	78	2017
51 Practical use of artificial organs (pancreases, kidneys, livers, etc.) incorporating human cells and tissues.	78	2015
39 Practical use of technology for biologically fixation of highly-concentrated carbon dioxide emitted from steam power plants.	78	2017
80 Production of genetically engineered plants with high CO_2 fixing ability, as a means of preserving the environment.	77	2012
18 Development of light energy elements patterned after photosynthetic response.	77	2017

Note 1: Degree of importance index = (number of “high” responses × 100 + number of “medium” responses × 50 + number of “low” responses × 25 + number of “unnecessary” responses × 0) ÷ total number of degree of importance responses

4.4. Forecasted realization times

Forecasted realization times were distributed as shown in the diagram below.

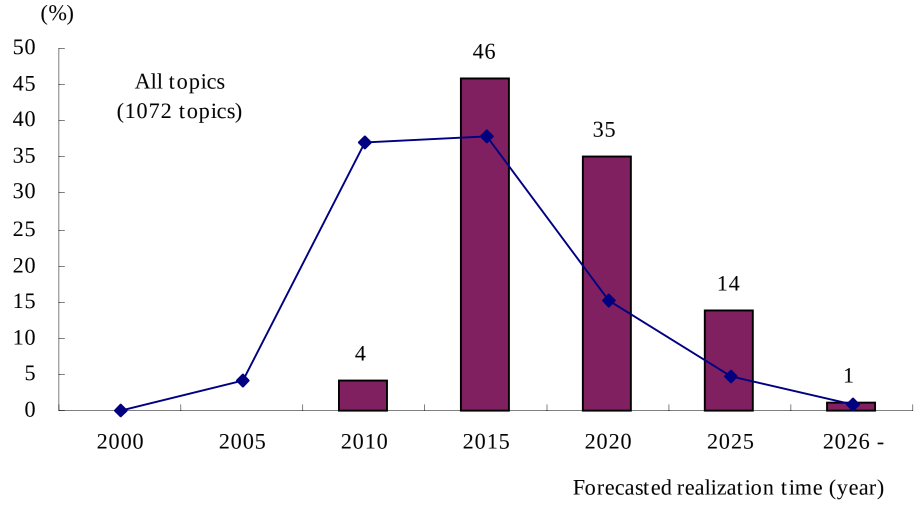


Fig. 4.4-1 Trends in Forecasted Realization Times

Nearly half of the forecasted realization times in the life science field fell between 2011 and 2015. Compared to the general trend covering all topics, forecasted realization times were somewhat on the remote side. This seems to be due to the fact that, because of the nature of this field, many forecast topics were related to basic research, which tends to involve numerous difficulties and uncertainties that must be overcome in the process of their realization.

4.5. Current leading countries etc.

Responses to the question concerning current leading countries etc. were as shown in the diagram below. Named by an overwhelming number of respondents, the U.S. ranked No. 1, with Japan and the EU trailing with similar scores.

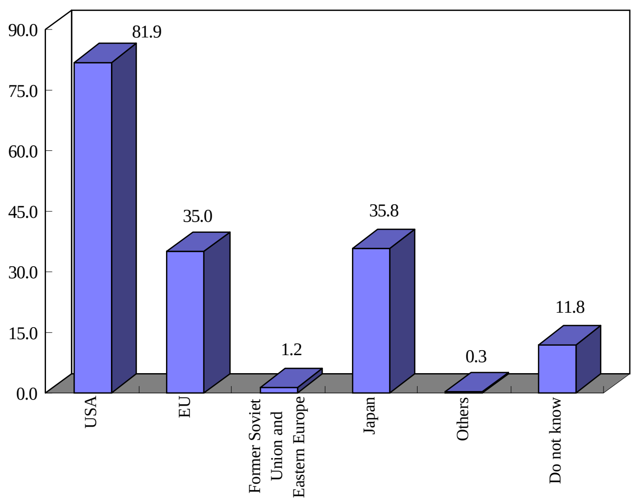


Fig. 4.5-1 Current Leading Countries etc. (%)

4.6. Comparison with the 5th Survey (previous survey)

Of the 94 topics included in the latest survey, 23 (24%) were identical to the previous survey, 18 (19%) were modified, and 53 (56%) were newly introduced. For identical topics, the results of the latest survey were compared with those of the previous survey in terms of degree of importance index scores and forecasted realization times, as shown in the table below.

Degree of importance index scores rose for 3 topics, with “09: Development of biodevices that can be used in electronics” experiencing the greatest jump. Scores remained the same for 1 topic and fell for 19 topics. The following topics saw the greatest drop: “25 : Establishment of technologies enabling prediction of the functions of proteins from their higher-order structures”, “41: Elucidation of relationships between higher-order structures and functions of the nuclei in eukaryotic cells”, and “92: Practical application of breeding techniques for plants resistant to dry and saline conditions aimed at desertification prevention”, down 23, 25 and 31 points, respectively.

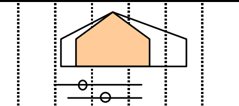
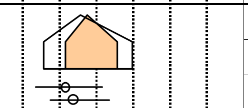
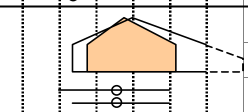
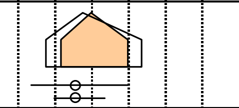
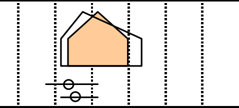
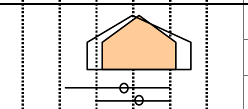
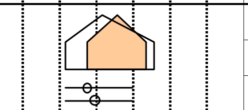
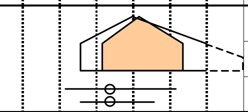
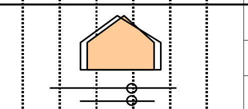
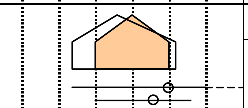
From the 4th to the 5th Survey, forecasted realization times for all topics were pushed back. Likewise, from the 5th to the 6th Survey, no topic was brought forward.

Table 4.6-1 Comparison with 5th Survey for Identical Topics

Topic	Degree of importance index / forecasted realization time	
	6th survey	5th survey
09 Development of biodevices (protein transistors, for example) that can be used in electronics.	64/2015	59/2010
10 Systematization of the basic concepts of bio-computer architecture.	64/2016	68/2008
25 Establishment of technologies enabling prediction of the functions of proteins from their higher-order structures.	66/2014	89/2006
27 Elucidation of the immune mechanisms which distinguish between “self” and “not self”.	70/2013	86/2004
31 Development of technologies, such as biomotors, using the biological energy conversion mechanisms.	59/2016	64/2011
32 Development of technology for synthesizing artificial cells that replace cellular functions such as cell membrane transport, substance conversion, energy conversion, etc.	58/2021	63/2019
41 Elucidation of relationships between higher-order structures and functions of the nuclei in eukaryotic cells.	54/2015	79/2008
49 Practical use of effective means to prevent metastasis of cancer.	91/2013	97/2007
51 Practical use of artificial organs (pancreases, kidneys, livers, etc.) incorporating human cells and tissues.	78/2015	81/2009
57 Development of neural-computers with new logic structures modeled on brain functions.	74/2018	81/2010
58 Development of interfaces enabling direct linkage between the computer and the brain.	65/2025	63/2020
59 Development of devices with self-assembling, self-organizing, and self-recovering capabilities.	61/2022	64/2018
61 Development of materials similar to organisms, which have self-recognizing and judging functions.	55/2019	59/2016
65 Elucidation of brain mechanisms for logical reasoning.	67/2023	81/2020
67 Become possible to cure senile dementia of Alzheimer type.	86/2016	93/2015
68 Elucidation of the cause of manic-depressive psychosis at the molecular level.	74/2016	81/2009
69 Elucidation of the cause of schizophrenia at the molecular level.	74/2016	82/2010
73 Development of a complete in vitro embryo cultivation technique based on artificial placentas for small mammals.	54/2017	58/2009
81 Practical use of plants accumulating high amount of hydro-carbon as fuel sources.	68/2015	69/2012

Topic	Degree of importance index / forecasted realization time	
	6th survey	5th survey
86 Elucidation of the neurobiological basis for emotion.	57/2021	58/2017
87 Elucidation of physiological effects of gravity-free state and development of measures for preventing deterioration in biological functions caused by the weightless state.	45/2016	43/2012
88 Development of technologies for breeding and cultivating organisms in (cosmo) space.	43/2015	43/2007
92 Practical application of breeding techniques for plants resistant to dry and saline conditions aimed at desertification prevention.	61/2014	92/2009

Note: Up until the 5th Survey, realization meant realization in Japan unless otherwise specified. However, this was changed to mean realization somewhere in the world in the 6th Survey. Therefore, care should be taken when comparing forecasted realization times from the two surveys.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time			Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001 2006 2011 2016 2021 2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Molecules	1	Identification of multiple genes related to cancer, and elucidation of the relationships between those genes and carcinogenesis.	1	290	22	37	41	82	65	31	4	0	19	2	87	51		8	7	96	41	0	38	0	2	66	24	28	55	53	3	0	1	27	37	1
			2	233	23	35	42	86	73	26	1	0	15	1	93	45		2	3	98	42	0	39	0	1	75	18	21	62	57	3	0	0	25	49	0
			X	53	100	0	0	94	89	9	2	0	15	0	89	66		0	0	100	53	0	49	0	0	87	32	17	58	55	0	2	0	23	47	0
	2	Development of anti-cancer agents which target the manifestation functions of cancer genes.	1	283	16	39	45	82	67	28	4	1	37	1	93	18		3	6	93	34	0	28	0	5	55	52	28	31	47	10	0	4	12	27	3
			2	228	16	37	47	87	75	22	3	0	35	0	96	13		2	4	95	33	0	32	0	2	64	58	19	25	48	7	0	2	16	33	2
			X	37	100	0	0	91	86	8	3	3	38	0	92	19		0	0	97	49	0	46	0	0	76	73	16	27	54	5	0	5	16	27	3
	3	Utilization of information about the gene structure of each individual patient in diagnosis and treatment.	1	289	17	37	45	65	40	42	15	3	19	1	90	27		13	7	88	39	1	24	0	6	42	25	17	66	33	18	1	1	67	70	0
			2	231	15	36	49	67	39	54	7	1	15	0	97	19		9	3	94	44	0	25	0	3	47	21	13	77	34	17	0	0	57	75	1
			X	34	100	0	0	81	62	38	0	0	21	0	100	26		3	0	100	56	0	24	3	0	44	21	9	74	38	26	0	0	56	88	0
	4	Development of methods for surmising new functions of proteins from human genome information.	1	281	22	42	36	71	47	45	8	0	34	5	59	63		2	6	90	44	1	28	0	6	60	32	27	57	45	3	0	1	17	26	1
			2	230	19	43	38	71	45	50	4	0	31	3	62	64		2	2	95	48	1	28	0	2	69	20	19	66	50	2	0	0	12	30	1
			X	44	100	0	0	87	75	23	2	0	45	2	66	77		2	0	100	61	2	34	0	0	70	23	20	73	59	2	0	0	11	18	0
	5	Elucidation of the molecular structure of the manifestation and adhesion control of binding molecules, and control over cancer, autoimmune disease, and chronic inflammation by controlling these binding molecules.	1	244	19	41	40	68	42	47	11	0	23	1	90	34		10	10	88	35	1	47	0	5	64	39	21	16	55	3	0	2	9	16	3
			2	202	15	39	47	68	39	55	7	0	17	0	94	26		4	7	93	31	0	51	0	4	72	41	15	9	62	2	0	0	8	18	1
			X	30	100	0	0	87	76	21	3	0	20	0	97	40		0	7	100	50	0	73	0	0	83	60	13	7	70	0	0	0	3	17	0
	6	Elucidation of various immunologically functional molecules responsible for organ transplant rejection, thereby making it possible to completely control organ transplants.	1	249	15	34	51	72	48	42	8	1	23	0	94	29		10	10	94	39	0	28	0	2	63	39	21	15	50	19	1	2	17	49	2
			2	201	10	33	56	73	48	48	4	1	17	0	96	17		9	7	95	39	0	26	0	1	73	35	15	10	58	17	0	0	13	55	2
			X	21	100	0	0	90	80	20	0	0	29	0	95	19		10	0	100	67	0	33	0	0	71	52	14	10	71	33	0	0	0	52	5
	7	Elucidation of the environmental factors and control mechanisms of the immune response which triggers allergies such as hay fever and atopy, facilitating the complete control over immediate type hyper-sensitivity.	1	263	15	27	58	77	59	34	7	1	21	4	95	20		6	8	82	34	0	45	0	10	64	42	22	15	54	2	0	5	11	11	4
			2	212	14	24	62	82	65	31	3	0	17	3	97	16		4	5	90	32	0	48	0	6	75	43	17	6	62	0	0	4	9	13	2
			X	29	100	0	0	87	75	21	4	0	28	3	97	14		3	7	100	34	0	66	0	0	86	66	7	7	79	0	0	0	7	7	0
	8	Elucidation of the molecular structure of apotosys, making it possible to create and remove cells at will.	1	265	23	32	45	64	38	44	17	1	15	3	72	57		11	12	88	35	0	40	1	6	66	32	22	17	56	3	0	6	9	30	2
			2	209	22	32	46	65	35	52	12	0	10	2	78	56		9	8	91	37	0	47	0	5	75	30	14	10	63	3	0	4	7	33	1
			X	46	100	0	0	78	57	41	2	0	17	4	80	65		9	4	100	52	0	67	0	0	89	35	17	11	74	4	0	4	4	26	0
	9	Development of biodevices (protein transistors, for example) that can be used in electronics.	1	172	13	22	65	62	36	43	19	2	74	17	23	31		8	9	72	25	0	37	1	16	52	52	22	5	44	1	1	9	6	12	4
			2	132	11	22	67	64	35	50	14	1	80	11	27	26		6	4	86	22	1	46	0	8	62	61	14	2	55	0	2	5	5	14	2
			X	14	100	0	0	75	50	50	0	0	64	29	21	43		14	0	79	7	0	50	0	0	57	79	7	0	43	0	7	7	0	14	0
	10	Systematization of the basic concepts of bio-computer architecture.	1	148	11	27	62	65	41	42	12	4	71	11	17	53		7	9	77	22	1	28	0	14	57	55	24	7	41	1	1	4	4	14	2
			2	124	10	20	70	64	36	51	11	2	78	6	15	44		5	6	85	23	2	29	0	11	64	62	20	3	48	1	2	2	4	20	1
			X	12	100	0	0	67	42	50	0	8	75	8	0	58		0	0	92	0	0	33	0	0	67	58	25	0	42	0	8	0	0	0	0

(Note) See page 7 for the interpretation of the graphs.

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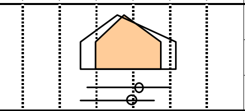
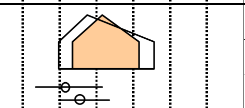
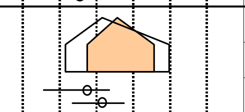
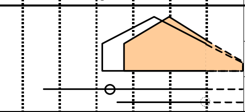
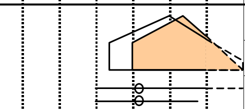
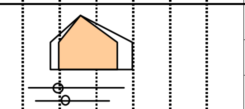
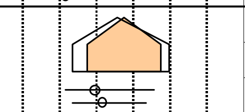
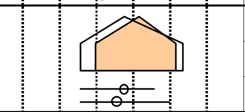
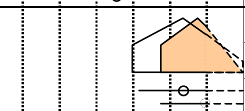
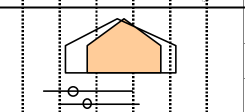
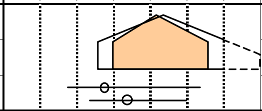
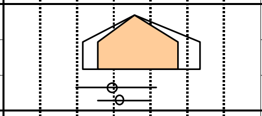
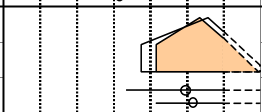
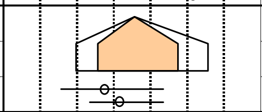
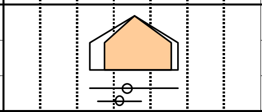
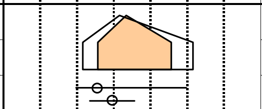
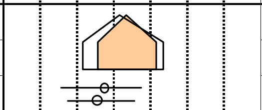
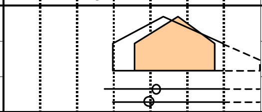
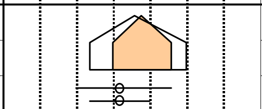
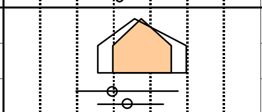
Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time			Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001 2006 2011 2016 2021 2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Molecules	11	Establishment of a nitrogen fixation mechanism mimicking the biological processes.	1	182	10	34	56	64	37	46	15	2	39	91	6	17		4	12	60	38	3	20	1	26	54	38	24	11	52	3	1	51	1	4	2
			2	145	10	32	59	65	36	52	10	1	42	91	5	12		5	6	68	37	3	19	0	25	66	40	21	6	58	2	2	57	1	3	1
			X	14	100	0	0	71	50	36	14	0	36	100	14	0		7	0	86	36	7	14	0	7	64	29	29	7	64	0	0	64	0	0	0
	12	Practical use of technology to alter the functions of biological molecules and cells by means of molecular evalutional engineering techniques.	1	226	22	37	41	63	33	52	15	0	59	47	38	37		5	7	77	31	0	37	0	15	57	38	24	23	49	9	0	30	8	21	1
			2	187	21	33	46	61	29	59	12	0	66	42	35	30		3	3	88	34	0	43	0	7	70	35	18	18	54	6	1	36	7	20	1
			X	39	100	0	0	74	49	49	3	0	74	36	38	36		0	0	97	44	0	56	0	3	79	44	18	18	62	8	0	26	5	13	3
	13	Development of biomimetic elements (stable molecules which have the same functions as those of biological molecules and which are made up of components other than peptides) with better functional characteristics than enzymes.	1	186	15	35	50	64	38	44	17	2	69	42	25	27		8	8	68	27	1	37	0	22	59	48	25	11	45	2	1	18	7	7	2
			2	154	14	29	57	62	33	52	14	1	78	33	21	19		6	3	79	24	1	40	0	16	66	49	20	7	47	1	2	23	8	5	1
			X	21	100	0	0	67	38	52	10	0	71	29	33	38		10	5	95	43	5	57	0	0	67	48	14	5	57	5	0	14	5	5	0
	14	Development of biomimetic elements which duplicate themselves according to information.	1	146	8	34	59	54	24	48	22	5	58	25	21	43		14	12	63	16	1	20	0	26	55	45	20	10	38	3	0	18	5	14	1
			2	119	8	27	65	51	17	54	26	3	65	18	17	37		13	10	70	13	1	18	0	24	64	42	18	8	40	3	0	20	5	15	0
			X	10	100	0	0	78	60	30	10	0	60	30	20	80		10	0	100	30	10	50	0	0	60	30	30	10	70	0	0	20	0	10	0
	15	Development of technology to regenerate organs or individuals from separated animal cells.	1	247	14	30	56	65	39	44	14	3	32	13	79	41		17	16	70	35	1	21	0	20	60	28	26	11	51	10	0	11	11	55	1
			2	201	12	26	62	67	40	48	11	1	31	9	84	31		18	9	80	32	0	19	0	15	73	23	22	5	58	8	0	8	9	63	0
			X	24	100	0	0	79	58	42	0	0	42	13	88	38		4	0	100	58	0	50	0	0	75	38	29	4	71	13	0	8	21	50	0
	16	Practical use of technology to design/synthesize thermostable protein.	1	240	22	35	43	62	33	51	16	0	71	43	24	23		0	4	77	31	1	60	0	13	58	46	20	21	40	2	0	19	3	5	3
			2	187	22	34	44	62	30	60	10	0	80	33	19	12		1	2	84	26	1	74	0	5	67	55	17	13	46	1	1	25	2	5	1
			X	41	100	0	0	71	46	46	7	0	80	37	15	22		2	0	88	29	0	80	0	2	63	56	15	17	49	2	0	15	0	7	0
	17	Practical use of continuous, industrial-scale production of protein by means of non-cellular protein synthesizing techniques.	1	203	11	42	47	61	34	46	19	2	67	49	29	19		3	8	60	21	11	33	0	26	51	49	19	10	44	2	0	17	6	7	2
			2	166	10	36	54	60	29	56	14	2	77	42	19	9		2	6	67	17	8	39	0	21	56	60	14	4	48	2	0	20	4	5	1
			X	17	100	0	0	81	71	18	6	6	76	53	6	24		6	0	88	24	41	53	0	0	53	71	6	6	59	0	0	12	0	0	0
	18	Development of light energy elements patterned after photosynthetic response.	1	170	11	34	55	72	51	38	10	1	60	79	6	26		4	11	71	38	1	31	0	18	57	48	30	8	49	1	1	22	4	4	2
			2	136	10	30	60	77	57	35	7	1	68	76	5	17		1	4	79	38	0	31	0	14	64	51	25	1	58	0	0	27	3	1	2
			X	14	100	0	0	86	71	29	0	0	71	79	0	7		0	0	86	50	0	50	0	7	64	36	21	0	43	0	0	21	0	0	0
	19	Elucidation of the molecular mechanism of life creation.	1	234	9	31	60	52	27	35	29	8	7	11	16	89		21	18	71	36	6	21	0	19	59	14	21	14	49	3	1	7	4	35	2
			2	194	7	27	66	50	21	42	32	5	4	4	9	93		21	17	80	40	6	19	0	14	70	9	19	7	56	3	1	2	3	45	1
			X	13	100	0	0	65	46	31	15	8	8	8	23	100		23	0	85	54	23	31	0	0	69	15	23	8	46	8	8	8	0	46	0
	20	Complete elucidation of the molecular mechanism explaining the cell cycle in higher order mammals (humans, mice).	1	248	18	39	44	62	35	44	20	2	13	6	53	76		4	6	93	54	1	42	0	5	73	19	23	21	63	1	0	4	4	17	2
			2	205	16	34	50	61	31	52	16	1	8	3	49	83		4	6	95	57	0	46	0	2	80	10	22	14	67	0	0	2	2	19	0
			X	33	100	0	0	88	75	25	0	0	6	9	61	88		0	0	100	73	0	58	0	0	88	6	42	9	82	0	0	0	6	18	0

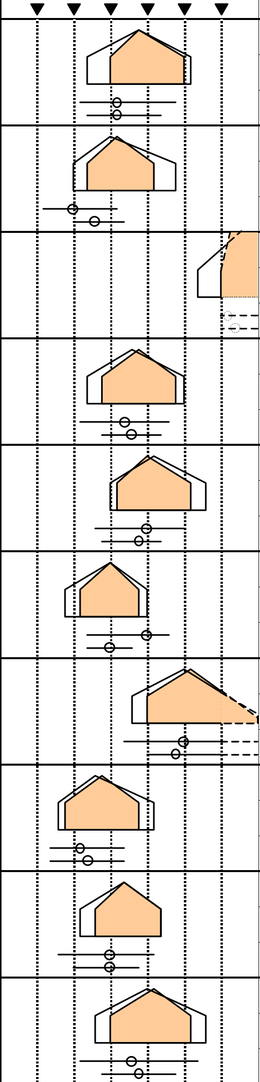
(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic development	Expected effect: Resolution of global problems	Expected effect: People's needs	Expected effect: Expansion of intellectual resources	Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	Leading countries: EU	Leading countries: Former Soviet Union and Eastern Europe	Leading countries: Japan	Leading countries: Other countries	Leading countries: Do not know	Measures the government should adopt (%): Foster human resources	Measures: Promote exchanges among industrial, academic and government sectors and different fields	Measures: Upgrade advanced facilities and equipment	Measures: Develop a research base	Measures: Increase government research funding	Measures: Adjust regulations (relax/toughen)	Measures: Others	Potential problems (%): Adverse effect on the natural environment	Potential problems: Adverse effect on safety	Potential problems: Adverse effect on morals, culture or society	Potential problems: Other adverse effects
Molecules	21	Application of human genome analysis methods to other animals and plants, and practical use of technology to analyse whole genome sequence in livestock breeding, and fisheries, agriculture and forestry.	1	281	22	40	38	55	26	47	22	4	19	23	33	74		9	12	86	52	1	39	0	7	53	15	20	67	48	3	0	7	18	35	1
			2	219	22	36	42	60	29	56	14	1	25	23	31	75		5	4	95	56	0	47	0	4	63	11	15	73	55	2	0	5	16	45	0
			X	49	100	0	0	73	51	43	4	2	31	22	27	76		6	0	98	53	0	59	0	0	78	12	10	67	59	2	0	4	8	51	0
	22	Establishment of technology enabling to decipher human DNA modification (methylization) information for all genomes.	1	217	20	33	47	56	24	53	22	1	11	3	52	69		1	11	84	45	0	29	0	10	64	18	22	48	52	2	0	3	16	25	1
			2	173	20	34	47	54	19	62	19	1	9	2	47	77		1	5	95	52	0	29	0	5	75	9	16	55	54	2	0	3	13	32	0
			X	34	100	0	0	65	35	56	6	3	9	3	44	74		3	3	100	59	0	26	0	0	76	12	12	47	50	3	0	0	15	35	0
	23	Elucidation of the transcription cascade for all genes, from fertilized egg to individual, in a single higher animal species, e.g. mice, and the mechanism by which differentiation and functions are manifest.	1	236	20	31	49	65	39	45	15	1	11	3	57	78		11	11	89	51	0	31	0	7	72	15	27	42	60	3	0	3	18	39	1
			2	193	17	33	50	63	31	61	8	0	6	4	47	89		8	7	93	59	1	33	0	4	81	8	20	40	65	3	0	1	11	44	0
			X	32	100	0	0	79	58	42	0	0	6	0	50	100		6	0	100	72	0	41	0	0	91	9	22	22	72	0	0	0	16	34	0
	24	Development of technology to clarify the genes manifested in a single cell in higher animals with an accuracy in the order of 1 mRNA molecule.	1	240	22	34	44	56	25	52	21	2	17	5	41	72		3	13	79	39	0	28	0	14	63	23	25	30	50	3	0	3	8	17	3
			2	195	16	38	46	55	18	67	15	1	10	2	35	85		2	5	88	36	0	27	0	8	73	15	21	26	54	2	0	1	7	24	1
			X	31	100	0	0	72	45	52	3	0	10	0	39	90		0	0	97	42	0	35	0	3	84	32	35	19	55	6	0	0	3	19	0
	25	Establishment of technologies enabling prediction of the functions of proteins from their higher-order structures.	1	269	20	36	43	68	41	48	10	0	52	16	41	70		3	6	88	52	1	35	0	6	58	28	32	41	49	1	0	4	6	7	3
			2	218	17	36	47	66	35	58	7	0	55	7	31	78		5	3	91	51	1	34	0	1	67	20	27	43	55	1	0	3	6	9	1
			X	38	100	0	0	81	63	34	3	0	61	11	24	76		11	0	89	53	3	34	0	3	68	26	32	39	61	0	0	3	3	8	0
	26	Practical use of methods for directly determining DNA sequences by physical means such as X-rays.	1	189	14	35	51	55	24	49	25	2	28	6	32	64		9	16	69	35	1	25	0	21	57	29	37	19	45	0	1	5	5	11	2
			2	157	11	36	53	53	19	56	24	2	22	1	23	78		8	12	76	29	0	24	0	15	61	23	34	15	54	0	1	4	5	17	1
			X	18	100	0	0	54	29	35	29	6	17	0	0	72		22	0	72	44	0	11	0	11	50	22	39	11	56	0	0	0	0	11	0
Cells	27	Elucidation of the immune mechanisms which distinguish between "self" and "not self".	1	228	14	34	52	70	45	45	9	0	14	3	80	58		2	4	91	53	0	46	0	4	72	24	26	17	61	1	0	2	11	18	3
			2	198	11	32	57	70	42	54	5	0	8	2	83	61		1	2	96	55	0	46	0	2	79	14	23	10	67	1	1	2	8	22	1
			X	22	100	0	0	86	73	27	0	0	23	0	82	82		0	0	100	64	0	68	0	0	95	32	9	9	82	5	0	5	0	14	5
	28	Control of signal transduction in the carcinogenesis of cells, and widespread use of treatment methods for dysdifferentiating carcinogenic cells.	1	255	16	36	49	79	61	33	6	0	25	2	93	32		11	11	85	44	0	45	1	7	68	32	25	16	59	5	0	2	13	23	2
			2	205	16	33	51	82	67	29	4	0	16	0	96	22		6	9	93	50	0	49	0	4	77	26	21	8	69	3	0	0	10	25	0
			X	32	100	0	0	92	84	16	0	0	16	0	100	28		13	0	97	72	0	66	0	0	75	31	22	16	81	6	0	0	19	31	0
	29	Complete understanding of the factors contributing to stem cell multiplication, and widespread use of the practice of multiplying stem cells, as necessary, in test tubes and using them for treatment purposes.	1	223	17	39	44	79	61	34	5	0	27	4	91	34		2	8	88	45	0	42	0	5	64	35	28	14	57	8	0	2	14	28	0
			2	181	13	40	47	81	64	32	4	0	16	2	93	29		1	4	92	44	0	44	1	3	75	35	24	7	60	4	0	2	12	35	0
			X	23	100	0	0	91	83	17	0	0	17	4	96	30		0	0	96	52	0	70	0	0	83	39	17	9	70	9	0	0	17	35	0
	30	Widespread use of foodstuffs which consist of microorganisms, seaweed, and single-cell organisms as the raw materials.	1	216	22	33	44	61	34	44	18	3	41	87	19	7		9	14	49	32	14	48	2	22	41	52	14	7	41	16	2	27	11	19	4
			2	173	24	27	49	62	34	49	14	3	40	85	13	5		10	8	59	33	10	58	3	17	46	61	9	2	43	14	1	35	12	18	2
			X	41	100	0	0	70	51	32	12	5	41	83	15	10		10	2	63	61	27	73	10	0	56	56	5	0	51	20	0	24	15	15	5

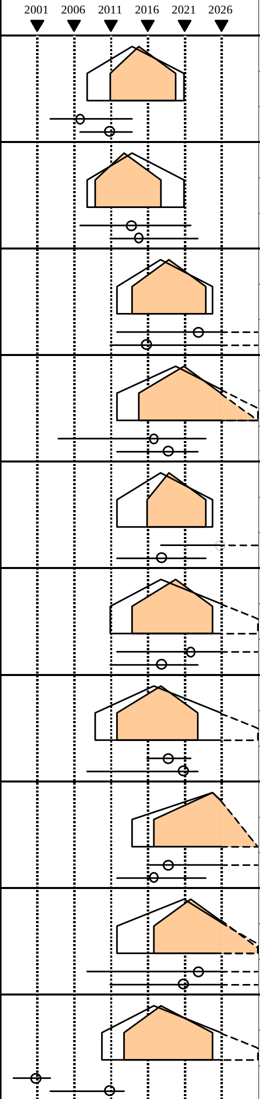
(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic development	Expected effect: Resolution of global problems	Expected effect: People's needs	Expected effect: Expansion of intellectual resources	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Cells	31	Development of technologies, such as biomotors, using the biological energy conversion mechanisms.	1	165	12	32	56	60	31	48	21	1	68	41	25	28	5	11	75	27	1	50	0	13	54	49	28	1	51	2	2	11	5	6	3
			2	137	10	31	58	59	27	56	15	1	76	31	23	25	3	5	80	23	1	52	0	9	64	53	23	1	54	1	2	12	6	5	2
			X	14	100	0	0	79	57	43	0	0	86	29	21	36	0	0	79	21	0	57	0	14	50	43	36	7	64	0	7	21	14	7	0
	32	Development of technology for synthesizing artificial cells that replace cellular functions such as cell membrane transport, substance conversion, energy conversion, etc.	1	189	11	32	57	62	33	49	17	1	53	40	41	38	5	16	63	28	1	28	0	28	59	43	28	4	51	1	1	13	5	11	4
			2	155	10	28	62	58	22	65	12	1	65	37	36	28	9	9	73	27	0	23	0	23	67	47	24	1	56	2	1	17	4	13	3
			X	15	100	0	0	72	47	47	7	0	73	47	40	47	0	7	93	53	0	53	0	7	67	53	20	0	67	0	0	20	13	0	0
	33	Development of artificial membranes with similar functions (active transport, energy conversion, information transmission) as biological membranes.	1	199	13	33	54	65	35	54	10	1	57	35	44	30	2	11	72	29	1	38	0	19	60	51	27	3	54	2	1	10	5	8	3
			2	163	12	30	58	63	29	65	7	0	69	26	45	23	1	6	82	28	1	38	0	13	68	56	21	1	59	1	1	17	4	9	2
			X	19	100	0	0	84	68	32	0	0	79	37	42	16	0	5	89	32	0	58	0	11	58	58	16	0	68	0	0	16	11	0	0
	34	Development of experimental techniques for recording and analyzing the activities of a large numbers of neurons simultaneously and over a long period of time.	1	145	15	30	55	68	41	48	11	0	22	2	56	68	2	10	79	34	0	40	1	11	72	37	35	1	62	0	1	1	3	15	1
			2	118	14	29	58	65	34	56	9	0	21	1	56	76	2	7	84	30	0	39	0	11	79	33	30	0	64	0	1	0	3	20	0
			X	16	100	0	0	81	63	38	0	0	31	0	50	75	0	0	100	50	0	63	0	0	81	44	50	0	56	0	6	0	0	25	0
	35	Widespread production of bioplastics using microorganisms and plants, accounting for 10% of the total volume of worldwide plastic production.	1	182	21	26	53	78	60	34	6	1	71	88	18	7	3	8	62	42	1	58	0	16	42	66	21	4	51	15	1	42	4	3	3
			2	153	17	27	56	87	75	23	3	0	70	90	14	4	3	6	76	48	1	67	1	10	41	73	16	1	59	13	1	49	3	1	1
			X	26	100	0	0	86	73	23	4	0	73	92	12	4	0	0	85	58	0	81	0	0	23	62	19	0	50	27	0	46	0	0	0
	36	Widespread production of alcohol and other fuel oils utilizing microorganisms, seaweed, etc., accounting for 10% of total worldwide fuel oil production.	1	174	22	30	48	76	56	36	6	2	57	88	7	5	7	13	53	34	6	40	5	25	43	57	19	5	49	15	1	39	5	3	3
			2	145	21	26	53	81	65	30	4	1	58	90	5	1	7	9	68	39	4	53	1	16	47	63	10	2	59	13	1	44	3	1	1
			X	31	100	0	0	82	67	27	7	0	65	84	3	3	10	3	74	48	13	68	0	6	52	48	13	3	65	19	0	42	3	3	0
	37	Widespread use in chemical industry processes of biological catalysts which are resistant to organic solvent, heat, and highly-concentrated products.	1	143	31	26	43	71	46	46	7	0	78	70	10	9	2	6	69	36	1	67	0	12	46	60	22	4	45	6	1	23	6	3	3
			2	126	27	25	48	72	46	52	2	1	82	71	5	2	3	2	75	29	1	71	0	10	49	63	15	2	51	6	2	30	3	1	2
			X	34	100	0	0	81	65	32	0	3	82	82	0	3	3	0	71	26	0	65	0	3	62	56	12	9	71	3	3	26	0	3	3
	38	Establishment of a system for biologically reducing and fixation CO_2 using energy other than light.	1	140	11	29	60	66	43	38	16	3	37	88	5	16	10	17	52	29	4	27	0	28	51	28	27	4	51	3	1	31	6	2	3
			2	116	7	28	66	65	41	43	13	3	33	91	3	4	8	11	62	25	2	26	1	24	66	25	21	1	57	3	1	37	4	0	2
			X	8	100	0	0	75	63	13	25	0	25	100	0	0	25	0	88	38	0	63	0	0	75	13	13	0	50	0	0	13	0	0	0
	39	Practical use of technology for biologically fixation of highly-concentrated carbon dioxide emitted from steam power plants.	1	154	16	25	58	73	53	35	11	1	40	89	11	8	12	8	49	29	2	42	2	21	47	50	25	3	50	8	0	32	6	3	3
			2	128	14	25	61	78	62	28	8	2	35	90	5	2	13	5	60	26	1	55	2	19	54	59	15	1	58	6	0	36	4	1	2
			X	18	100	0	0	88	78	17	6	0	39	94	0	0	11	6	72	33	6	78	6	0	67	44	17	0	61	0	0	22	0	0	0
	40	Widespread use of worldwide environmental remediation using genetically-engineered microorganisms released into the environment.	1	193	21	35	44	68	42	46	9	3	34	91	19	10	9	14	73	38	2	32	2	13	50	43	19	11	44	30	1	67	9	15	1
			2	152	20	38	42	70	45	49	5	1	32	93	13	3	6	4	84	41	1	35	1	8	62	48	13	7	52	26	1	72	8	12	0
			X	30	100	0	0	83	67	30	3	0	43	97	3	7	7	3	97	57	0	40	0	3	77	30	10	3	57	47	3	80	7	7	0

(Note) See page 7 for the interpretation of the graphs.

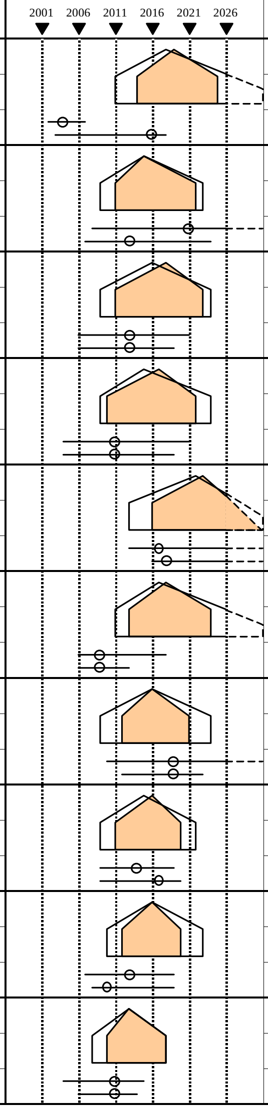
Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%) High	Degree of expertise (%) Medium	Degree of expertise (%) Low	Importance (index, %) Index	Importance High	Importance Medium	Importance Low	Importance Unnecessary	Expected effect (%) Socioeconomic development	Expected effect Resolution of global problems	Expected effect People's needs	Expected effect Expansion of intellectual resources	Forecasted realization time 2001 2006 2011 2016 2021 2026 	Will not be realized (%)	Do not know (%)	Leading countries (%) USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%) Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%) Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Cells	41	Elucidation of relationships between higher-order structures and functions of the nuclei in eukaryotic cells.	1	229	17	36	48	57	26	51	22	2	5	7	30	87		2	12	84	48	1	31	0	11	75	21	27	14	61	0	0	3	4	10	3
			2	180	15	34	51	54	19	61	19	1	3	3	25	93		2	7	91	52	0	31	0	7	82	13	21	8	66	1	0	3	3	13	2
			X	27	100	0	0	72	46	50	4	0	0	0	15	100		0	4	100	70	0	33	0	0	85	11	26	19	63	4	0	4	4	19	0
	42	Development of technology that artificially alters organella genes and causes the altered organella genes to function within cells.	1	192	16	40	44	52	20	52	27	2	17	32	36	58		2	10	78	39	0	29	0	15	67	24	22	18	55	1	0	11	5	15	2
			2	158	14	38	48	53	17	62	21	1	14	25	33	72		3	6	85	39	0	27	0	10	77	20	14	9	59	1	0	12	3	17	1
			X	22	100	0	0	65	33	62	5	0	18	27	23	77		5	9	95	59	0	41	0	0	82	14	18	0	64	0	0	9	5	23	0
	43	Development of technology capable of synthesizing living cells by using only artificially produced chemical compounds.	1	198	5	34	61	42	13	41	35	11	29	22	23	66		44	17	40	16	2	13	0	38	47	26	19	7	36	4	1	18	5	25	2
			2	154	5	27	69	44	11	49	33	7	26	13	18	80		48	14	45	12	1	9	0	42	60	18	14	4	41	3	2	18	3	33	1
			X	7	100	0	0	39	14	43	14	29	29	29	14	86		71	0	86	14	14	29	0	0	71	14	29	14	43	0	0	29	0	43	0
	44	Elucidation of the entire molecular mechanisms of signal transduction in plants, from the perception of external signal such as low temperature, to the phenotypic expression such as cold resistance.	1	171	16	35	49	62	31	56	11	2	29	82	6	50		1	9	74	44	1	39	1	17	67	27	25	22	57	1	0	29	2	4	2
			2	134	15	30	55	63	27	70	3	0	25	85	1	47		1	5	81	49	0	46	1	10	78	25	22	14	64	1	0	32	1	2	1
			X	20	100	0	0	78	55	45	0	0	20	90	0	65		0	5	85	65	0	55	5	0	75	15	45	10	70	0	0	45	0	0	0
	45	Elucidation of the entire molecular mechanisms of the construction of cytoskeleton in plants.	1	147	9	34	57	50	18	49	29	4	15	44	4	69		1	12	71	44	0	29	0	15	66	15	23	13	50	1	0	10	1	3	2
			2	114	10	27	63	49	13	57	29	1	11	46	0	79		1	6	82	45	0	28	0	15	79	11	18	7	58	0	0	17	0	1	0
			X	11	100	0	0	64	27	73	0	0	18	45	0	82		0	0	82	64	0	55	0	0	82	0	27	9	64	0	0	9	0	0	0
	46	Practical use of elementary particle beam technology in genetic engineering.	1	109	6	34	61	52	21	46	30	3	45	23	23	37		0	12	68	21	1	30	0	19	47	41	33	6	39	0	0	4	7	6	2
			2	85	7	27	66	53	19	57	23	1	65	19	14	36		1	7	85	18	0	35	0	12	61	44	34	1	47	1	0	2	6	5	0
			X	6	100	0	0	50	17	50	33	0	67	17	0	50		0	0	100	0	0	50	0	0	83	50	17	17	33	0	0	0	0	0	0
Tissues and organs	47	Elucidation and artificial control of the molecular mechanisms of the morphogenesis of human organs.	1	201	12	29	59	65	39	44	16	1	21	2	83	46		6	15	76	37	1	29	0	15	67	30	27	10	56	5	0	3	10	37	2
			2	163	11	26	63	66	37	54	9	1	15	2	87	43		6	10	86	29	0	26	0	10	74	27	23	5	64	4	0	2	10	44	0
			X	18	100	0	0	79	59	41	0	0	6	6	89	67		6	6	94	44	0	39	0	6	78	28	17	6	67	22	0	0	17	44	0
	48	Development of drugs capable of preventing the occurrence of certain types of cancer.	1	259	16	33	51	83	68	27	4	1	37	3	97	18		3	7	84	42	1	48	0	12	58	49	22	11	53	7	1	3	11	19	3
			2	212	15	32	53	87	75	23	2	0	33	1	96	9		2	5	91	44	0	54	0	6	66	53	17	6	59	6	1	2	8	22	1
			X	32	100	0	0	95	91	9	0	0	38	6	97	13		3	0	100	50	0	78	3	0	66	59	19	6	75	19	0	13	16	19	0
	49	Practical use of effective means to prevent metastasis of cancer.	1	246	18	34	48	87	76	22	2	0	24	1	95	18		4	7	84	46	0	46	0	8	60	45	26	15	58	4	0	2	11	16	2
			2	203	15	31	54	91	82	16	2	0	22	0	97	11		3	2	91	48	0	49	0	6	70	51	19	9	67	2	0	1	10	19	1
			X	31	100	0	0	97	94	6	0	0	29	3	97	23		6	0	97	58	0	65	0	3	68	45	23	10	74	10	0	3	16	19	0
	50	Widespread use of technologies for long-term (semi-permanent) culturing and preservation of organs.	1	202	9	34	57	71	48	41	11	1	30	3	94	16		4	12	81	37	1	29	0	11	55	46	23	6	49	16	0	3	17	49	2
			2	167	10	29	62	72	48	46	6	0	28	2	95	7		5	7	88	34	1	26	0	10	65	48	15	4	57	16	1	1	16	62	0
			X	16	100	0	0	84	69	31	0	0	44	13	81	6		6	0	88	44	0	56	0	6	69	69	13	0	50	6	0	0	31	63	0

(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Medium	Low	Importance (index, %): Index	High	Medium	Low	Unnecessary	Expected effect (%): Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Forecasted realization time 	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Tissues and organs	51	Practical use of artificial organs (pancreases, kidneys, livers, etc.) incorporating human cells and tissues.	1	177	9	32	59	75	53	43	4	1	37	0	98	9		2	8	80	33	2	37	0	11	56	58	25	3	54	16	0	1	17	42	2
			2	147	10	29	62	78	58	40	3	0	35	1	98	4		1	4	87	28	1	38	0	7	61	63	20	2	62	15	0	1	16	47	0
			X	14	100	0	0	88	77	23	0	0	50	0	93	7		7	7	100	43	7	71	0	0	50	71	14	0	57	21	0	0	14	36	0
	52	Development of an entirely implantable artificial kidney.	1	144	10	27	63	79	60	34	5	1	26	0	95	8		3	8	70	30	1	37	0	17	53	65	26	2	49	9	1	0	13	26	3
			2	119	8	22	70	83	67	30	3	0	20	1	98	5		4	4	84	28	0	38	0	10	61	72	21	0	57	3	2	0	14	29	1
			X	10	100	0	0	90	80	20	0	0	30	0	100	0		10	0	90	30	0	60	0	0	40	100	30	0	60	0	0	0	0	20	0
	53	Development of an artificial cornea, allowing the visually impaired to regain their sight.	1	112	5	21	73	68	45	42	12	2	22	0	96	9		19	12	56	19	1	13	0	27	54	46	24	1	45	4	0	0	11	21	3
			2	95	4	22	74	74	52	41	6	1	22	0	100	3		16	7	69	15	1	18	0	26	67	53	21	0	58	2	1	0	15	23	1
			X	4	100	0	0	56	25	50	25	0	25	0	100	0		0	0	100	25	0	50	0	0	75	25	25	0	50	0	0	0	0	0	0
	54	Establishment and clinical application of technology enabling organs to regenerate through the multiplication of their own cells.	1	179	9	28	62	74	51	43	6	1	25	2	95	17		9	15	66	31	1	28	1	23	58	43	23	6	51	11	1	1	15	37	1
			2	150	8	29	63	80	60	40	1	0	22	1	99	11		7	6	78	23	0	28	1	18	69	47	20	3	63	8	1	0	13	42	0
			X	12	100	0	0	96	92	8	0	0	50	0	100	17		8	0	100	50	0	50	0	0	67	58	25	8	50	0	0	0	0	25	0
	55	Development of artificial muscle elements.	1	94	10	24	66	58	28	50	20	2	23	0	86	14		5	14	52	24	2	26	0	31	56	46	24	2	41	1	0	0	12	18	3
			2	80	6	19	75	57	23	61	16	0	25	0	95	8		6	6	64	18	1	30	0	26	64	50	24	0	49	1	0	0	13	19	0
			X	5	100	0	0	75	60	20	20	0	80	0	100	20		0	0	80	40	0	80	0	0	60	60	60	0	60	0	0	0	20	20	0
	56	Establishment of interface technology between neural information and artificial organism structures.	1	101	10	26	64	65	39	46	11	3	49	1	77	29		7	10	70	23	0	31	0	18	55	53	30	2	48	2	1	0	12	23	1
			2	91	9	18	74	61	30	58	10	2	47	1	78	23		5	5	84	20	0	37	0	12	64	51	24	1	54	1	0	0	11	26	1
			X	8	100	0	0	81	63	38	0	0	75	0	88	50		0	0	100	50	0	88	0	0	63	63	38	0	75	0	0	0	0	0	0
	57	Development of neural-computers with new logic structures modeled on brain functions.	1	118	6	25	69	73	50	44	4	2	74	2	38	53		4	8	86	30	1	42	0	6	65	55	31	2	52	1	0	2	8	27	1
			2	104	3	19	78	74	50	46	3	1	85	0	33	49		3	6	90	26	1	42	0	2	69	57	24	0	55	0	0	1	8	31	1
			X	3	100	0	0	100	100	0	0	0	67	0	0	100		33	0	100	33	0	100	0	0	100	100	33	0	33	0	0	0	0	33	0
	58	Development of interfaces enabling direct linkage between the computer and the brain.	1	102	8	26	66	68	43	44	9	3	58	1	57	38		22	10	70	24	0	30	0	13	54	49	32	0	41	2	0	2	15	36	1
			2	93	6	19	74	65	37	52	10	2	69	0	57	34		17	6	81	22	0	28	1	13	61	48	26	0	47	2	0	1	13	41	0
			X	6	100	0	0	83	67	33	0	0	50	0	50	67		17	0	100	50	0	83	0	0	83	67	33	0	50	0	0	0	0	33	0
	59	Development of devices with self-assembling, self-organizing, and self-recovering capabilities.	1	93	10	27	63	62	34	49	11	6	65	3	41	34		11	18	67	22	0	26	0	26	55	52	34	2	43	1	0	2	4	15	2
			2	80	6	24	70	61	27	66	6	1	75	0	38	30		10	10	75	18	0	25	0	21	61	56	29	1	44	0	0	1	5	20	0
			X	5	100	0	0	80	60	40	0	0	60	0	20	40		0	20	100	20	0	80	0	0	40	100	40	0	40	0	0	0	0	0	0
	60	Development of electric circuits with similar self-organization and self-restoration functions as neural networks.	1	83	7	27	66	66	41	42	15	1	69	0	37	36		8	11	71	19	2	35	0	17	55	55	34	1	37	2	0	1	6	14	1
			2	75	4	28	68	63	31	58	11	0	81	0	35	32		5	8	79	17	3	35	0	15	65	55	24	0	39	1	0	1	5	19	0
			X	3	100	0	0	83	67	33	0	0	67	0	0	100		0	33	100	33	0	100	0	0	100	100	0	0	67	0	0	0	0	0	0

(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic development	Expected effect: Resolution of global problems	Expected effect: People's needs	Expected effect: Expansion of intellectual resources	Forecasted realization time: Will not be realized (%)	Forecasted realization time: Do not know (%)	Leading countries (%): USA	Leading countries: EU	Leading countries: Former Soviet Union and Eastern Europe	Leading countries: Japan	Leading countries: Other countries	Leading countries: Do not know	Measures the government should adopt (%): Foster human resources	Measures: Promote exchanges among industrial, academic and government sectors and different fields	Measures: Upgrade advanced facilities and equipment	Measures: Develop a research base	Measures: Increase government research funding	Measures: Adjust regulations (relax/toughen)	Measures: Others	Potential problems (%): Adverse effect on the natural environment	Potential problems: Adverse effect on safety	Potential problems: Adverse effect on morals, culture or society	Potential problems: Other adverse effects
Tissues and organs	61	Development of materials similar to organisms, which have self-recognizing and judging functions.	1	104	5	21	74	60	31	47	20	2	61	5	55	27	10	11	62	23	1	30	0	23	54	51	26	2	46	1	0	6	6	19	2
			2	80	3	23	75	55	19	65	15	1	70	1	65	18	11	8	69	19	1	25	0	25	60	53	15	0	46	1	0	4	4	23	1
			X	2	100	0	0	50	0	100	0	0	100	0	100	0	0	0	100	0	0	100	0	0	100	50	0	0	100	0	0	0	0	0	0
	62	Development of diagnostic and medical treatment micromachines capable of traveling on their own inside organisms (body cavity organs).	1	114	8	22	70	71	46	47	5	1	54	0	90	17	6	11	66	24	1	54	0	21	54	65	29	2	47	2	1	3	17	14	4
			2	91	5	23	71	69	40	55	4	0	47	0	96	9	3	3	77	19	0	51	0	18	66	75	19	0	51	2	2	1	20	14	0
			X	5	100	0	0	90	80	20	0	0	60	0	100	20	0	0	100	40	0	100	0	0	60	80	60	0	60	0	20	0	0	0	0
	63	Elucidation of the molecular mechanisms for formation of neuronal networks at the molecular level.	1	159	11	31	58	66	37	53	8	1	16	0	62	74	3	6	86	45	0	39	0	9	72	25	35	10	62	1	0	1	6	13	2
			2	130	7	28	65	64	30	65	5	0	9	0	62	82	0	5	92	45	0	36	0	3	78	17	28	5	64	0	0	1	6	15	0
			X	9	100	0	0	94	89	11	0	0	33	0	44	89	0	0	89	56	0	44	0	0	78	0	33	0	56	0	0	0	0	11	0
	64	Elucidation of relationship between learning/memory and synaptic plasticity.	1	153	10	31	58	68	41	50	9	1	16	0	58	75	2	6	86	42	1	42	0	8	73	27	37	7	61	1	0	0	8	20	2
			2	126	8	29	63	68	39	56	5	0	10	0	58	81	0	2	92	41	1	39	0	2	79	18	31	2	64	0	0	0	5	21	1
			X	10	100	0	0	95	90	10	0	0	30	0	50	90	0	0	90	40	0	50	0	0	80	10	60	0	70	0	0	0	10	10	0
	65	Elucidation of brain mechanisms for logical reasoning.	1	138	7	26	67	67	40	47	11	1	17	1	43	81	9	14	78	38	1	36	0	14	68	28	33	4	59	1	0	1	7	21	1
			2	113	4	25	72	67	36	59	5	0	15	0	40	88	9	8	87	37	1	35	0	9	74	24	25	1	61	0	0	0	4	24	0
			X	4	100	0	0	88	75	25	0	0	50	0	25	100	0	0	100	25	0	50	0	0	75	50	75	0	75	0	0	0	25	25	0
	66	Elucidation of the whole molecular mechanisms for synaptic plasticity in the mammalian brain. (e.g. hippocampal long-term potentiation and depression).	1	139	9	29	62	64	36	52	11	1	8	1	54	71	4	6	81	40	1	42	0	13	71	25	37	7	67	0	0	1	7	14	1
			2	117	5	30	65	63	30	60	9	0	8	1	51	80	5	5	89	39	0	43	0	5	77	16	30	2	68	0	0	1	3	18	1
			X	6	100	0	0	92	83	17	0	0	33	0	50	67	0	0	100	50	0	33	0	0	100	0	67	0	100	0	0	0	0	17	0
Individuals	67	Become possible to cure senile dementia of Alzheimer type.	1	187	8	27	65	83	67	29	3	1	19	1	95	17	8	10	83	40	1	39	0	11	69	37	23	14	59	6	1	1	14	26	3
			2	154	6	31	64	86	73	25	1	0	14	1	98	12	6	6	88	42	0	42	0	8	75	34	19	11	64	3	1	1	12	31	0
			X	9	100	0	0	100	100	0	0	0	11	0	100	11	0	0	100	56	0	44	0	0	56	11	22	22	100	0	0	0	11	33	0
	68	Elucidation of the cause of manic-depressive psychosis at the molecular level.	1	145	11	24	65	73	49	47	4	1	12	1	95	25	3	3	79	43	3	29	0	15	73	31	28	16	58	4	0	1	19	29	2
			2	127	5	27	69	74	50	46	4	0	9	1	99	21	2	3	87	46	1	28	0	9	81	29	25	6	59	3	0	1	13	31	0
			X	6	100	0	0	75	50	50	0	0	17	0	100	50	0	0	100	83	0	67	0	0	50	67	67	17	83	0	0	0	33	33	0
	69	Elucidation of the cause of schizophrenia at the molecular level.	1	143	12	23	65	73	49	48	3	1	15	1	95	26	4	4	77	43	3	27	0	16	73	32	27	17	57	4	0	1	21	31	1
			2	127	6	26	69	74	50	48	2	0	11	1	99	22	2	4	87	50	0	26	0	9	80	34	22	6	60	2	0	1	17	33	0
			X	7	100	0	0	86	71	29	0	0	14	0	100	57	0	0	100	86	0	57	0	0	57	86	43	0	86	0	0	0	14	29	0
	70	Widespread use of methods for controlling the immune system locally.	1	193	18	29	53	75	52	43	4	1	20	1	97	19	4	7	80	42	1	45	2	13	68	37	24	10	61	4	0	1	10	17	2
			2	158	16	27	56	76	54	41	5	0	18	0	98	16	1	3	88	44	0	49	1	8	77	34	18	6	64	3	0	1	16	16	0
			X	26	100	0	0	84	69	27	4	0	35	0	100	12	0	0	100	73	0	77	4	0	96	54	15	0	85	0	0	0	12	8	0

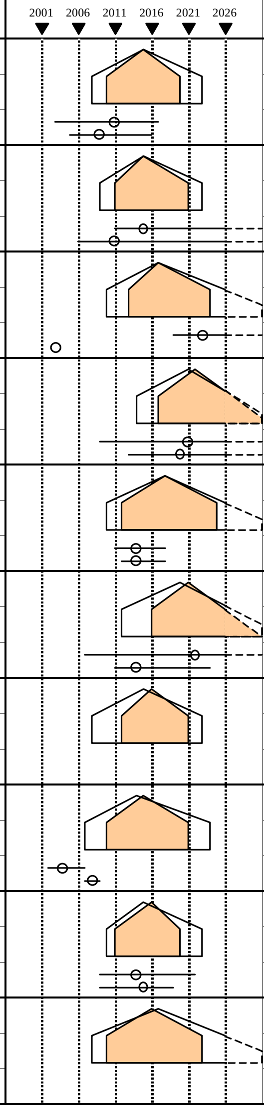


(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%) High	Degree of expertise (%) Medium	Degree of expertise (%) Low	Importance (index, %) Index	Importance High	Importance Medium	Importance Low	Importance Unnecessary	Expected effect (%) Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%) USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%) Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%) Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Individuals	71	Elucidation of the mutual regulatory mechanisms of the immune system, nervous system, and endocrine system, and utilization of such knowledge in the treatment of disease and promotion of health.	1	196	14	37	49	75	54	41	5	1	19	1	92	36		2	7	84	48	0	46	1	10	68	38	28	12	64	1	0	2	8	18	2
			2	165	10	39	50	78	57	41	1	0	13	1	96	35		1	3	90	50	0	46	1	7	76	38	21	7	65	1	0	2	7	21	1
			X	17	100	0	0	88	76	24	0	0	29	12	100	59		0	0	88	53	0	76	0	0	82	47	12	12	82	0	0	6	12	18	0
	72	Scientific elucidation of the factors within daily life (eating habits, air quality, etc.) which influence the process of carcinogenesis.	1	239	14	33	54	79	61	33	5	1	16	18	95	23		2	8	77	40	1	57	0	13	64	38	21	15	59	3	0	7	6	16	2
			2	197	11	31	58	83	68	31	2	0	11	14	97	19		1	3	86	38	1	63	0	9	71	36	17	10	64	4	0	6	4	18	1
			X	22	100	0	0	91	82	18	0	0	14	14	91	36		0	9	100	50	5	86	0	0	77	55	23	14	73	9	0	14	5	18	0
	73	Development of a complete in vitro embryo cultivation technique based on artificial placentas for small mammals.	1	127	10	25	65	50	18	54	21	7	29	20	50	34		8	13	61	34	1	23	0	25	56	37	32	6	46	6	0	9	12	41	2
			2	102	8	26	66	54	18	62	18	2	29	14	58	33		6	6	75	35	0	26	0	17	64	32	27	2	47	4	0	5	8	44	0
			X	8	100	0	0	75	50	50	0	0	38	0	63	75		0	13	100	75	0	63	0	0	88	50	13	13	63	13	0	13	25	63	0
	74	Identification and classification by the molecular etiology of the genes related to diabetes, hypertension, and arteriosclerosis, typical geriatric diseases which exhibit multiple-factor hereditary traits.	1	221	17	31	52	83	68	26	4	1	20	1	93	32		1	5	87	52	1	45	0	7	64	29	23	38	62	2	0	1	21	23	2
			2	180	16	32	52	88	77	22	1	0	16	1	98	26		0	3	94	54	1	49	0	3	73	22	18	34	66	3	0	1	16	29	1
			X	28	100	0	0	95	93	4	4	0	21	4	100	29		0	0	100	71	0	64	0	0	75	11	18	43	57	4	0	4	11	32	0
	75	Widespread use of remote surgery systems utilizing virtual reality technology.	1	112	9	21	71	56	27	48	21	5	31	0	89	7		4	8	68	23	0	41	0	17	46	57	25	0	51	5	1	1	15	12	3
			2	93	6	22	72	53	18	57	24	1	30	1	94	3		6	2	81	17	0	38	0	13	51	61	22	0	48	1	1	0	17	11	0
			X	6	100	0	0	67	33	67	0	0	67	17	100	0		0	0	83	17	0	67	0	0	67	83	50	0	67	0	0	0	17	17	0
	76	Widespread use of vicarious experience devices (using virtual reality technology) which allow bed-ridden patients to take vacations, etc.	1	96	9	20	71	48	16	46	32	5	30	0	90	6		5	1	60	17	0	40	0	22	30	60	20	1	36	2	1	1	8	24	3
			2	81	7	21	72	47	10	59	28	2	31	1	94	1		2	0	69	11	0	41	0	21	35	64	11	4	41	1	1	0	7	30	0
			X	6	100	0	0	46	17	50	17	17	67	17	67	0		0	0	67	17	0	67	0	0	33	83	33	0	50	0	17	0	17	33	0
	77	Elucidation of the molecular mechanisms of flower bud differentiation in higher plants and its application in agriculture.	1	155	15	32	54	69	44	46	10	1	35	80	12	39		1	5	69	40	2	34	1	19	66	31	23	16	52	5	0	28	3	3	3
			2	123	15	26	59	69	41	53	7	0	34	84	7	31		0	1	77	39	2	40	1	15	78	26	15	9	64	2	0	34	2	2	1
			X	18	100	0	0	74	50	44	6	0	39	89	11	39		0	6	100	39	0	44	6	0	94	17	17	11	72	0	0	61	0	0	6
	78	Practical use of technology for producing cloned individuals from the cells of livestock.	1	188	11	25	64	64	36	49	13	1	41	69	20	24		12	13	72	40	2	29	1	17	58	37	27	11	45	9	1	18	6	27	2
			2	145	9	23	68	61	28	62	9	1	41	76	9	16		11	6	81	39	2	26	1	12	68	37	21	8	51	6	1	17	4	32	1
			X	13	100	0	0	83	69	23	8	0	69	54	8	31		8	8	92	54	0	46	8	0	77	46	31	15	54	15	0	23	0	46	8
	79	Production of genetically engineered plants and microorganisms which are resistant to or able to reduce NOx, as a means of preserving the environment.	1	182	15	31	54	70	43	50	7	0	26	91	20	9		1	5	65	35	1	41	1	23	60	32	26	14	53	7	0	43	2	7	3
			2	150	14	29	57	68	39	55	5	1	22	91	12	3		1	3	73	35	1	46	0	19	72	31	17	9	58	5	0	45	1	3	1
			X	21	100	0	0	76	52	48	0	0	38	90	10	5		0	0	95	33	5	57	0	0	86	24	14	5	57	10	0	52	0	10	0
	80	Production of genetically engineered plants with high CO_2 fixing ability, as a means of preserving the environment.	1	187	17	30	52	74	52	40	8	0	27	93	14	13		1	6	65	35	1	39	0	25	62	32	27	15	57	7	0	48	3	4	3
			2	155	14	32	54	77	57	37	5	1	21	92	10	6		1	1	74	34	1	41	0	19	70	32	19	10	65	5	0	49	1	1	1
			X	21	100	0	0	82	67	29	5	0	38	86	10	10		0	0	95	57	5	52	0	0	81	29	19	14	67	0	0	57	0	0	0

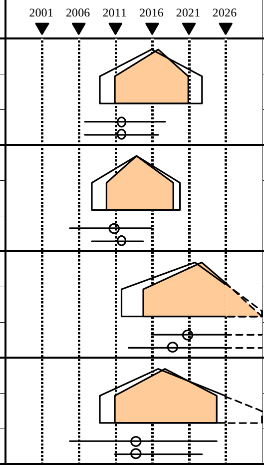
(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Medium	Low	Importance (index, %): Index	High	Medium	Low	Unnecessary	Expected effect (%): Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Individuals	81	Practical use of plants accumulating high amount of hydro-carbon as fuel sources.	1	141	11	34	55	66	42	39	16	3	33	92	11	9		11	13	55	29	1	20	3	28	52	36	21	15	42	6	1	33	3	4	4
			2	120	7	33	61	68	45	42	12	2	33	96	6	3		7	8	68	31	1	23	4	22	66	37	14	12	52	2	1	43	1	3	2
			X	8	100	0	0	72	50	38	13	0	38	88	13	0		13	0	88	25	0	25	0	0	75	25	0	25	38	0	0	25	0	0	0
	82	Elucidation of the entire molecular mechanisms which generate the internal rhythms in organisms.	1	177	7	29	63	53	22	45	31	2	11	11	51	71		2	10	72	40	1	29	0	16	68	22	22	10	53	0	0	7	2	14	3
			2	145	3	33	64	50	15	55	27	2	8	6	47	75		1	3	82	39	1	23	0	12	82	17	19	6	57	0	0	3	2	21	1
			X	4	100	0	0	38	0	75	0	25	0	0	50	75		0	0	100	25	0	50	0	0	75	0	50	0	100	0	0	0	0	25	0
	83	Elucidation of the neural mechanisms of sleep and dreams.	1	118	3	19	78	48	16	48	36	1	8	2	69	62		6	9	65	30	2	29	0	25	69	19	25	5	49	0	0	1	12	19	2
			2	99	1	22	77	48	12	57	30	1	7	0	72	66		5	5	78	28	1	30	0	17	84	14	21	3	56	0	0	1	12	25	0
			X	1	100	0	0	50	0	100	0	0	0	0	100	0		0	0	100	0	0	0	0	0	100	0	0	0	100	0	0	0	100	0	0
	84	Complete elucidation of the molecular mechanisms of development and differentiation.	1	242	23	32	45	71	48	40	11	0	15	13	48	81		5	14	86	56	1	40	0	6	73	22	26	22	66	1	0	5	6	21	3
			2	201	21	31	47	71	48	44	8	1	10	7	46	84		7	8	92	60	0	41	0	3	82	16	21	12	68	1	0	3	4	25	1
			X	43	100	0	0	82	67	28	2	2	14	12	47	91		7	5	98	81	0	65	0	0	93	23	26	19	70	0	0	2	2	23	5
	85	Elucidation of the environmental and genetic factors which determine the sizes and shapes of trees.	1	130	10	23	67	55	22	54	24	1	22	78	8	47		5	10	55	39	2	25	2	27	58	23	22	19	50	0	0	24	2	8	4
			2	108	9	19	71	56	19	67	13	1	14	77	5	44		4	6	72	38	1	25	1	19	76	18	17	14	54	1	0	28	1	6	1
			X	10	100	0	0	75	50	50	0	0	30	80	10	20		0	0	100	40	0	20	0	0	80	20	40	10	70	0	0	50	0	0	0
	86	Elucidation of the neurobiological basis for emotion.	1	118	8	25	67	56	22	59	18	1	8	2	66	62		2	14	71	36	4	27	0	22	71	19	29	8	54	2	0	0	17	26	2
			2	102	5	25	70	57	20	69	11	1	6	0	71	68		4	9	76	36	3	24	0	19	80	19	25	2	57	1	0	1	14	30	2
			X	5	100	0	0	70	40	60	0	0	20	0	100	60		0	0	80	40	0	40	0	20	100	60	0	20	100	0	0	0	20	60	0
	87	Elucidation of physiological effects of gravity-free state and development of measures for preventing deterioration in biological functions caused by the weightless state.	1	92	0	29	71	42	9	48	36	7	14	11	51	48		5	10	85	22	16	11	0	11	48	32	38	2	51	1	0	7	2	8	1
			2	82	0	28	72	45	10	53	34	4	11	9	59	54		5	5	88	22	18	10	0	5	62	29	37	0	62	1	0	7	1	7	1
			X	0	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	88	Development of technologies for breeding and cultivating organisms in (cosmo) space.	1	116	5	24	71	43	14	38	41	7	29	47	13	34		7	7	82	15	14	12	0	11	47	34	30	3	48	0	2	16	4	3	3
			2	99	3	23	74	43	12	42	42	4	23	61	6	34		1	3	87	17	15	11	0	7	55	31	21	3	58	0	2	20	2	1	1
			X	3	100	0	0	75	50	50	0	0	67	67	0	0		0	0	67	67	0	0	0	0	67	33	33	0	67	0	0	0	0	0	0
	89	Development of perfect testing procedures to replace testing on animals.	1	193	18	27	55	71	48	42	8	1	41	20	64	24		20	13	64	40	1	27	0	22	52	37	22	8	49	7	0	6	5	20	2
			2	166	14	27	58	71	46	45	7	2	40	16	70	20		18	5	72	47	1	25	0	19	64	35	16	4	58	7	0	2	5	22	0
			X	24	100	0	0	79	67	25	0	8	58	33	58	29		38	0	79	63	0	50	0	17	63	50	8	0	79	13	0	0	8	29	0
	90	Widespread use of novel educational curriculums through the elucidation of the physiological and psychological mechanisms of independence formation, personality development, etc. in humans.	1	79	1	19	80	69	48	33	18	1	32	1	56	43		9	16	57	33	1	14	0	29	62	30	25	4	47	8	0	0	16	46	3
			2	68	0	25	75	75	55	35	9	0	31	1	60	40		10	10	68	38	0	12	0	25	68	25	16	1	50	6	1	0	9	40	0
			X	0	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-



(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time			Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001 2006 2011 2016 2021 2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Groups	91	Development of technologies which dramatically improve photosynthetic ability in order to increase food production.	1	183	17	33	49	83	68	30	2	1	38	96	14	15		4	14	70	40	2	40	1	19	64	40	25	16	62	2	1	43	2	5	3
			2	149	15	32	52	86	73	23	3	1	38	93	7	8		2	7	79	44	2	44	1	13	73	38	17	12	70	2	1	47	1	4	2
			X	23	100	0	0	93	87	13	0	0	48	87	0	13		0	4	96	48	4	52	9	0	87	30	13	13	70	0	0	35	0	0	4
	92	Practical application of breeding techniques for plants resistant to dry and saline conditions aimed at desertification prevention.	1	180	14	30	56	62	35	45	18	2	30	94	12	12		1	9	61	33	2	35	4	23	57	36	27	17	57	2	1	44	1	3	3
			2	148	11	30	58	61	30	55	14	1	25	95	7	4		1	4	74	34	1	38	5	17	69	39	14	9	67	1	1	44	0	1	1
			X	17	100	0	0	79	65	24	12	0	29	94	0	0		0	0	94	41	6	53	18	0	65	24	18	6	59	0	0	47	0	0	0
	93	Emergence of experimental evidence of the evolutionary mechanism of organisms.	1	216	12	29	59	48	18	43	35	4	5	14	10	92		13	16	66	40	3	26	0	20	64	16	24	21	53	0	0	7	2	27	4
			2	177	10	25	64	47	14	49	34	2	4	5	7	95		11	15	75	45	3	20	0	15	77	9	19	18	58	1	0	5	1	32	1
			X	18	100	0	0	78	61	28	11	0	11	11	17	100		11	11	94	61	0	39	0	6	78	11	33	22	61	0	0	0	0	33	0
	94	Advancement of the analysis of the human genome diversity regarding individual races, and the elucidation of the origin and phylogeny of human being.	1	235	10	26	64	44	13	42	37	8	3	6	22	87		2	11	80	49	1	32	0	11	55	14	17	43	47	2	2	1	18	49	2
			2	196	11	23	66	45	11	49	37	3	1	4	15	95		2	8	84	48	1	28	0	10	71	9	10	45	54	2	2	1	13	55	0
			X	22	100	0	0	60	32	50	14	5	0	5	18	95		0	0	100	68	0	36	0	0	82	14	18	41	64	0	0	0	14	59	0



(Note) See page 7 for the interpretation of the graphs.

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5. Survey Results in "Space"

5.1. Trends in noteworthy domains

5.1.1. Earth observation/global environment

Trends that have emerged in the areas of earth observation and the global environment in the last five or so years will be discussed. In the space development field, the end of Cold War between the United States and the former Soviet Union put an end to the fierce space race between the two superpowers, and marked the beginning of cooperative relationships in space science and technology under a new political framework — a dramatic turnaround which was unthinkable only a few years ago. Compared to other fields, international cooperation and joint research in this field is rapidly gathering momentum. Many countries are putting efforts into fostering a civilian space industry with the aim of reducing military spending and revitalizing the industry as a whole. The active promotion of the space industry in the areas of communication and broadcasting, where communications satellites are used, has begun to have an impact on the development of new social infrastructure over the last few years, spurred on by the popularization of multimedia and the Internet as the pillars of an advanced information society.

In contrast to the contraction experienced by the military industry, growth in the civilian space industry is gradually accelerating, with efforts being made to expand its market by identifying new needs. Communication systems and broadcasting systems exhibit rapid technological progress, boosted by a relaxation in the regulatory control of frequency bands, advances in digitalization technology, and the like. Remote sensing is attracting attention as a new marketing opportunity. Against this backdrop is a relaxation in the restrictions placed on the use of high resolution satellite images, which was until recently severely restricted due to international inspection and military reconnaissance needs.

Along with global environmental problems, the observation of the earth from space has been a focus of attention for some time from a global point of view, amid a surge in international public awareness. Earth observation satellite technology, which came to existence with a Landsat satellite launched in 1972, made steady progress, and is now in the middle of tackling its 90's challenge — high resolution imagery based on 10-m high resolution sensors pioneered by France's SPOT satellite system. An expansion in spectral bandwidth, particularly from the visible region to the microwave region, and the practical application of synthetic aperture radar (SAR) is noteworthy. The nature of earth observation is undergoing a transformation from image-based wide-area qualitative survey to quantitative measurement of physical quantities, and this is thought to have had a major impact on the progress made over the last five years. Following the path set by the commercialization of image data obtained via Russian military satellites, commercially-oriented meter-class high-resolution satellites have been already developed, and the technology is moving into a new era.

The launch costs of vehicles that carry satellites into orbit have been falling due to intensified competition involving Europe's Ariane, China's Chang Zheng (Long March) and Russian commercial rockets, which have been converted from military rockets. As a result, the number of rocket launch opportunities has increased. To further reduce costs, the development of small rockets is also under way. Meanwhile, the downsizing of observation satellites is making process through improvements in the performance of satellite-borne sensors and R&D on integration etc.

On the heels of these developments, technological forecasts in this field have undergone a significant change. In areas relating to earth observation, sensor development has been taking place in accordance with actual needs, and, as a general trend, forecasted realization times have been brought forward. While it is not surprising to see the bulk of R&D efforts directed towards satisfying research needs close to practical application, the overall social situation also seems to have been playing a part. Of course, in areas where technical difficulties exist with regard to development efforts, forecasting is difficult, even for experts, and this generally leads to long forecasted realization times. Needless to say, forecasting is even harder for non-experts.

In other words, in these areas (earth observation and the global environment), there are many unknown factors in the early stages of research and development, while there are only a limited number of experts, and this tends to work against the formation of a clear long-term outlook. For this reason, the forecast topics, including those concerning related areas, happened to contain technologies which were more like fanciful dreams and therefore need to be reviewed from the present perspective.

As a general trend over the last five years, research, development and practical application in the areas of earth observation and the global environment have been making rapid progress, with the proportion of technologies put to practical use increasing.

(Toshifumi Sakata)

5.1.2. International space science activities

The study of the evolutionary history of the universe, investigation of the process of planetary formation and elucidation of the environment/conditions for the emergence of life constitute the major goals of space science, and the findings of these research efforts will become common valuable assets for all mankind. Space science transcends the political or economic interests of any nation, and must inevitably be pursued through international efforts. In fact, progress made in the area of space science in recent years has prompted a rise in the size, sophistication and precision of space observation vehicles, giving rise to a situation in which both technical and economic constraints make further progress impossible without international cooperation. Against this background, Japan's X-ray astronomical satellites, solar observation satellites, earth magnetosphere observation satellites, etc. have been made available for use by researchers worldwide, and significant results have been achieved in this regard. As this example shows, Japan's international standing in these areas has been steadily strengthening, giving rise to expectations for a significant international contribution.

With regard to the observation of deep space, hopes are held for the installation of larger observation systems at more favorable locations. In the near future, it is planned to put infrared observation satellites into orbit under the United States' ORIGIN program, Japan's ASTRO-F program, etc., to obtain clues about the birth of galaxies and planetary systems in space. Further down the track, “49: Establishment of a large-scale optical/infrared astronomical observatory at the Lagrange point of the sun and the Earth” is planned. In the area of the observation of cosmic far-infrared radio waves, the “development of an observation system based on a satellite-based interferometer” (“03: Development of a satellite-mounted infrared space interference system with ultra-high space resolution capabilities” and “13: Development of a system to measure cosmic radio waves in the sub-millimeter and sub-sub-millimeter wave band”) is envisaged. In the observation of cosmic radio waves using a satellite-based very long baseline interferometer, Japan's “Haruka” satellite, which was launched in February 1997, is playing a pioneering role. Future plans include “39: Set of optical or radio telescopes on the surface of the moon”. With such use of the lunar surface in mind, Japan's solar probe program aimed at studying the moon itself is about to begin.

With regard to the study of the solar system /planets, programs such as the following are envisaged: “47: Investigation of Mercury with orbiter” and “48: Exploration of Saturn and other planets beyond it”, aimed at probing distant planets; and “44: Long-term observation of the atmosphere of Venus by means of balloons”, “45: Analysis of the surface substances of Mars, etc. via an unmanned Mars exploration unit” and “43: Return of samples from other planets”, aimed at probing relatively close planets in detail. Of these, Mars probing looks set to weigh heavily in the United States' ORIGIN program, partly due to the recent speculation about the possibility of the past existence of life on the planet. Japan’s Mars probe program “PLANET-B” is also in progress. Regarding sample return, Japan's MUSE-C program aimed at collecting samples from asteroids is under way.

Alongside these individual programs, space science research using an international space station will soon become a reality. The space station program relies heavily on international cooperation — to an even greater degree than individual programs — and, for this reason, harbors many political and economic problems. It is therefore hoped that greater efforts will be made by those directly involved in the program, as well as scientists who support it, to ensure that great scientific results are produced by overcoming the above problems.

International space science activities are expected to involve not only the existing players in space development, which are mainly developed countries, but also developing countries in the future. For this reason, it seems necessary for Japan to seek close cooperation with other Asian countries in proceeding with international pursuits in these areas. (Hajime Inoue)

5.1.3. Space transportation

As space transportation constitutes an essential component of space exploration, various countries have been developing their own technologies. For example, over the last five years, the following launch vehicles have been developed: H-II (1994), J-1 (1996) and M-V (1997) by Japan; ASALV (1994) and PSLV (1997) by India; and Ariane V by the European Space Agency.

On the other hand, in an effort to increase transportation capacities and reduce transportation costs to help implement national projects or further stimulate commercial activities, international cooperation agreements have been drawn up between companies from different countries. Examples include the planned joint modification of the first-stage engine of the Zenit, a Ukrainian rocket, by Russian company NPO Energomash and U.S. company P & W (presently Lockheed Martin Corp.) and its adoption in Atlas 2AR.

In Japan, the development of H-IIA, a low-cost high-reliability launch vehicle, is under way based on the experience of the development of H-II, its predecessor, through system simplification, greater efficiency, the automation of inspection and maintenance work and improved transportation capacity, with the year 2000 targeted for its maiden flight.

Topic 25 has been retained from the previous survey in light of the fact that cost reduction and reliability improvement continue to be priorities for space transportation systems.

In the area of reusable launch vehicles, X-33, Lockheed Martin's experimental demonstration model for the SSTO (Single Stage to Orbit) reusable launch vehicle intended to be the successor to the Space Shuttle, was selected in 1996.

Japanese efforts include the following: the launch of OREX (an orbital reentry experiment vehicle) via H-II in 1994, aimed at obtaining technical data, including basic data on aerodynamic heating during reentry into the atmosphere — as part of building up technological know-how for an unmanned winged reusable launch vehicle; and the launch of HYFLEX, a hypersonic flight experiment vehicle, via J-1 in 1996 to obtain design data for a hypersonic lift-force flight vehicle. In addition, a flight experiment using ALFLEX, an automatic landing flight experiment vehicle, was conducted in 1996 with the aim of obtaining technical data for automatic landing. Incorporating all these achievements, the development of HOPE-X (H-II Orbiting Plan-X), an unmanned reusable launch vehicle experiment model, is under way.

Moreover, with the aim of establishing a rocket-propelled fully-reusable space transportation structure, a study on an SSTO-type space transport vehicle is being undertaken, and research on its component technologies, centered on structural weight reduction technology and reusable rocket engine technology, has begun.

In addition to Topic 21, Topic 20 was incorporated into the questionnaire, in light of the fact that research is under way on an air-breathing propulsion system (the scramjet and air-turbo ramjet) and related technologies with the aim of making a space plane a reality in the future.

In the area of manned space flight, the United States has maintained a manned space program by regularly sending space shuttles into space — approximately seven times a year. Russia has also been launching its Soyuz rockets about twice a year to transport cosmonauts to its Mir space station, and achieved the longest human stay in space for both sexes (437 days for males and 169 days for females) in 1995. Japanese astronauts have also experienced manned space activities, with Dr. Mori, Dr. Mukai and Mr. Wakata participating in space shuttle missions in 1992, 1994 and 1996, respectively.

Currently, the Soyuz and the Space Shuttle are the only manned space flight transportation vehicles. Although this situation will not change for some time to come, Europe is conducting a study on a space station crew transport vehicle called CTV, while the United States (NASA) is engaged in research on a space station crew emergency return vehicle called CRV.

Once the permanent operation of the planned space station becomes a reality, efforts may possibly be directed towards manned and unmanned exploration of the Moon and planets as next-stage projects (topics 37,46 and 51).

(Tsuguhiko Katagi)

5.1.4. Communication and control

(1) Trends in miniature satellites

Generally, as a satellite becomes lighter, the project cost falls, so that low cost is one of the factors that motivate the development of miniature satellites. According to the University of Surrey's definition, satellites are classified as follows: large satellites (1,000 kg and over), small satellites (500-1,000 kg), mini satellites (100-500 kg), micro satellites (10-100 kg) and nano satellites (under 10 kg). While UoSATs, the university's small miniature satellites, are micro satellites normally weighing 10-100 kg, a first study on smaller “nano satellites” was undertaken by the British Ministry of Defense around 1990. It investigated a military communications system involving 52-100 softball-sized 1-kg satellites (called Nanosats) with a service life of 50-300 days without a solar cell (four years with a solar cell according to some reports) deployed in a 400 km-high circular orbit to relay message transmissions. The system envisages the short-term use of UHF telex communication channels for tactical purposes. The unit price was estimated to be £10,000 ($17,000) subject to volume production, but experts at the University of Surrey were skeptical about the feasibility of a 1-kg satellite. Recently, however AeroAstro, a miniature satellite venture business, designed a 1-kg nano satellite called “Bitsy”.

In the latest survey, the “14. Development of satellites weighing 1 kg or less and having communications function” was forecasted to be realized by 2009. Attitudes towards nano satellites vary widely. While some people are very negative about such satellites with communications functions, or are concerned about the increase in space debris, others actively support the idea, identifying it as an area where Japan can make a positive contribution, or believe they would bring space use closer to people’s daily lives.

(2) GPS in satellite positioning technology

Regarding satellite positioning technology, the following proposition was included in the latest survey: “15. Realization of a high-accuracy satellite positioning system operated by an international organization”. Today, the technology is widely used in Japan in car navigation, geodesy, etc., but it relies almost entirely on the United States' GPS. As a result, some people think that Japan should develop its own system or a system that is complementary to GPS. However, it is not appropriate to pass a judgment on the issue of GPS from only a technical point of view for reasons including the following: it is an extremely well-designed system; it is very expensive and fundamentally a military system, but being a precision satellite positioning system and being a military system are basically two sides of the same coin; and the United States expressed its continued commitment to free access to GPS and intention to push for international standardization in the President's statement issued in March 1996. In March 1997, the Planning and Coordination Subcommittee of the Space Activities Commission prepared a report titled “Approach to Satellite Positioning Technology Development in Japan” in response to the commission’s request to deliberate the present state of satellite positioning systems and problems, needs for satellite positioning and future trends, and technological development topics to be tackled by Japan.

In this regard, the report concludes that it is appropriate to start from the following scenario: while basically relying on GPS, Japan should develop the three most fundamental technologies (satellite-borne atomic clock technology, satellite cluster time management technology and high precision satellite orbit determination technology), and conduct R&D on satellite components on the ground in preparation for moving on to satellite development as soon as a concrete plan for the launch of positioning satellites by an international organization emerges, with a minimum number of satellites necessary for demonstration purposes developed. In the United States, the ordering procedure for Block IIF satellites, planned for launch between 2001 and 2016, has been completed. Although the latest survey puts the realization time for the establishment of the above international organization at 2008, this may be a little too optimistic.

(3) Activities relating to info-communications infrastructure with giga-bit satellites as typical example

The United States' National Information Infrastructure (NII) initiative, also known as the Information Highway concept, was announced by President Clinton in September 1993, followed by Vice President Gore's Global Information Infrastructure (GII) proposal in March 1994. Spurred on by these U.S. initiatives, discussions on info-communications infrastructure also became brisk in Japan. In clear realization of the fact that Japan lags behind the United States in info-communications infrastructure technology, the strengthening of R&D activities in this area is also being fairly vigorously debated. In this regard, the view that the Information Highway means optical fiber cable networks was dominant in the United States around the time the NII proposal was made (until late 1994 in Japan). However, apart from optical fiber cables, communications media could include conventional copper cables as well as satellites. In the Unites States, the fact that the use of satellites makes the implementation of the Information Highway stretching right down to end users easy has been well recognized, and Ka-band satellite communication is booming like LEO satellite communication, with 14 companies having filed applications with the U.S. Federal Communications Commission (FCC). In Japan, too, there has been a renewed recognition of the merit of satellite communication since the tragedy of the Great Hanshin-Awaji Earth Quake. As optical fiber cables are ideal for high-capacity communication between fixed points, it is advantageous to use them for main communication circuits. Satellite communication is particularly suitable for broadcasting, while fiber cables are useless for mobile stations. However, as different sets of bit error rate (BER), communication capacity and delay from those of fiber cables apply, care needs to be taken when designing a circuit.

In Japan, there is a plan to develop a giga-bit experimental satellite for launch around 2002 as the core technology of the info-communications infrastructure. The latest survey included a question regarding “35. Widespread use of gigabit-class global satellite communication systems” as a topic relating to info-communications infrastructure, with the realization time forecasted as 2009. This is probably fairly realistic.

Future tasks in the area of info-communications infrastructure include (1) further utilization of satellite communications for dynamic and flexible system configuration, (2) development of new technologies for high-speed communications satellites, and (3) utilization of the millimeter-wave range and Ka-band, (4) investigation into the development of a 2nd-generation or otherwise special LEO system in Japan, and (5) globalization of and international cooperation over info-communications services.

(Takashi Iida)

5.1.5. New outlook of space environment utilization

Japan's full-fledged space environment utilization began with programs based on the use of NASA's space shuttle missions. In 1979, Japan's first shuttle-based primary material experiment program (FMPT) was adopted, with the public invited to enter proposed experiment themes. Although the FMPT was scheduled to be conducted in 1988, the program was significantly delayed by the explosion of the Challenger and other factors. It was later undertaken in 1992 by Japan's first payload scientist, Dr. Mori, onboard the Endeavor. With subsequent space experiments smoothly carried out, Japan's basic experiment techniques for a manned space lab have by and large been established.

Apart from the FMPT in 1992, space experiment projects implemented using space shuttles over the last five years include: the IML-2 (international microgravity laboratory) carried out by Astronaut Mukai in 1994 and semiconductor experiments conducted in 1995 as part of the D-2 program, a shuttle-based experiment program organized under German initiative, in which the Institute of Space Environment Utilization Research, which is affiliated with the Ministry of International Trade and Industry participated. In addition, space experiments were conducted onboard unmanned experimental satellite SFU, which was launched in 1995 using the National Space Development Agency's H-2 rocket, as a joint project of the Institute of Space Science Research, the National Space Development Agency and the Unmanned Space Experiment System Research and Development Organization. SFU was recovered by the Space Shuttle “Endeavor” during a mission in which Astronaut Wakata took part. These projects mainly took advantage of microgravity conditions in space, and made it possible to identify potential problems which could hinder the effective utilization of a space station, through actual experiments.

The five-year period starting in 1992 was epoch-making in terms of the utilization of short-time microgravity experiments as well. The operation of two large free-fall experiment facilities owned by the Underground Weightless Experiment Center (Kamisunagawa Town, Hokkaido Pref.) and the Japan Institute of General Weightless Research (Toki City, Gifu Pref.) began, as well as the provision of commercial microgravity experiment services by Diamond Air Service (Nago City, Aichi Pref.) based on the ballistic flight of an aircraft.

Experiment results obtained by NASDA using its TR-1A small rocket are first-class by international standards.

As of 1997, the permanent operation of the International Space Station is scheduled to begin in 2002. Although the launch of the space station's first module was originally scheduled for 1997, the production of the Russian portion of the module has been delayed due to the country's economic problems, giving rise to concerns over possible delays to the entire International Space Station program, of which Russia is a partner.

In 1997, the National Space Development Agency invited the public to enter proposed experiment themes for the initial utilization of the exposed facility of JEM (Japanese Experiment Module), to be built by Japan under the space station program, and screened them. Later in the year, it also plans to invite the public to enter proposed research programs, including those for basic research leading to the future use of the space station, and extend research grants, in order to facilitate the effective utilization of the space station. In recent years, it has begun to be recognized through the experience of short microgravity experiments, which are positioned as preliminary experiments for space experiments in Japan, that much of the research which was in the past considered only possible through the use of a space shuttle or space station can be carried out with relative ease using simpler arrangements and ingenuity. Space environment utilization technology is progressing steadily, and in the unfortunate event that the construction of the International Space Station is delayed, its impact can be minimized by rigorously screening experiment topics to retain only those which absolutely require the use of space, with the rest left to alternative methods.

(Akira Sawaoka)

5.2. Forecast topic framework

In the course of compiling forecast topics, a framework representing the organization of technologies in tabulated matrix form was drawn up for each field, with objectives and technological domains defining the rows and columns of the table, respectively. The framework is designed to present an overall picture of technological development in each field in terms of future prospects, importance, etc. as seen from the present perspective, and is also used as a working framework for future reviews of forecast topics.

Table 5.2-1 Forecast Topic Framework for Space Field

<table>
<tr><th>Domain / Objective</th><th>Low and intermediate orbit</th><th>Stationary orbit</th><th>Moon and its neighborhood</th><th>Planets and deep space</th></tr>
<tr><td rowspan="2">Probing and observation</td><td>01</td><td></td><td rowspan="2">39 40</td><td rowspan="2">43 44 45 46 47 48 49</td></tr>
<tr><td colspan="2">02 03</td></tr>
<tr><td rowspan="2">Positioning</td><td>04 05 06 07 08 09 10 11 12 13 14</td><td>33 34 35</td><td></td><td></td></tr>
<tr><td colspan="3">15</td><td></td></tr>
<tr><td>Environmental applications</td><td>16 17 18</td><td></td><td></td><td></td></tr>
<tr><td>Material and energy-related applications</td><td>19</td><td>36</td><td>41 42</td><td>50</td></tr>
<tr><td rowspan="3">Transportation</td><td rowspan="2">20 21 22 23 24</td><td>37</td><td></td><td rowspan="3">51</td></tr>
<tr><td colspan="2">38</td></tr>
<tr><td colspan="3">25</td></tr>
<tr><td rowspan="2">Technologies relating to human activities</td><td>26 27 28 29</td><td></td><td></td><td></td></tr>
<tr><td colspan="3">30 31 32</td><td></td></tr>
</table>

* Figures appearing in the table represent topic numbers.

5.3. Topics with high degree of importance

Degree of importance index scores (Note 1) averaged at 56.2 for topics in the space field as a whole. Topics considered of particular importance to Japan (top 20 topics in terms of degree of importance index score) are listed in the table below. As many as 8 out of the 10 most important topics, including No. 1 and No. 2, were from the low and intermediate orbit domain, although this is partly attributable to the fact that this domain accounted for a large proportion of the forecast topics in the first place. By objective, 5 out of the 10 most important topics related to positioning.

Table 5.3-1 Top 20 Topics in Terms of Degree of Importance Index

Topic	Degree of importance index	Forecasted realization time (year)
25 The cost of rocket thrusted space transportation will be reduced to less than 1/10 current levels.	93	2014
09 Realization of precision down to less than a centimeter in measurement of crustal movement using VLBI (very long baseline inter-ferometers), satellite lasers, inverse laser ranging, and synthetic aperture radar to improve accuracy in such as earthquake forecasting.	84	2009
02 Widespread use of a global-scale environmental surveillance network in which environmental changes for the earth as a whole are monitored around the clock in real time, and this information is integrated, systematically analyzed, and distributed around the world.	81	2008

15 Realization of a high-accuracy satellite positioning system operated by an international organization.	81	2008
05 Development of technology for measuring, in real time, the distribution and movement of air pollution via observation from space.	80	2007
35 Widespread use of gigabit-class global satellite communication systems.	78	2009
33 Development in Japan of a satellite broadcast system for each individual region (Kanto, Tokai, Kinki, etc.) based on multibeam technology.	75	2007
20 Development of two-stage-to-orbit, completely re-usable, space transport system.	72	2011
16 Full-scale operation of a space station as a laboratory on the low earth orbit, and realization of next-generation facilities using the space environment for research, development, and trial production of semiconductors, pharmaceuticals, etc.	70	2010
21 Development of a space plane capable of transporting between the earth and space stations in the similar manner as conventional airplanes.	70	2016
29 Removal of large (tens of centimeters and larger) space debris such as pieces of spent satellites, rockets, etc.	68	2015
28 Realization of the identification of relatively large space debris on the order of several millimeters in size (orbiting trash such as shards from satellites and rockets, man-made material ejected into space, etc.), and the development of technology making it possible for space stations and other space structures to avoid collisions with such debris.	68	2014
36 Capability for transmission of electrical power to earth by microwave from solar power generation plants with huge solar cell panels, constructed in space.	65	2020
11 Practical use of global-scale marine and land mapping using satellite-mounted multi-frequency/multi-polarization synthetic aperture radar.	63	2008
32 Development of fail operational space robot with self-diagnostic capabilities and self-restoration capabilities.	62	2014
34 Realization of highly reliable satellite communications and highly accurate earth observation satellites, using clustered geostationary satellites (aggregated geostationary satellites flying in formation).	60	2010
30 Development of life support technology applied to a closed ecosystem, able to self-supply vegetable, grain, animal protein, and other food.	59	2017
10 Practical use of satellite-mounted microwave sensors capable of measuring biomasses within an accuracy of 1Kg/m^2 or less. (The dry weight of plants determines the amount of carbon dioxide exhausted, and this is related to global warming. The current status is 1.4Kg/m^2 with the shuttle SIR-C.)	58	2008
04 Development of technology to construct of artificial satellites with large-scale antenna (several tens of meters in diameter) at permanent manned space stations in low earth orbit.	58	2008
41 Practical use of substances (Si, O_2, ^{3}He, etc.) which exist on the moon as resources on the moon surface.	58	2026 or later

Note 1: Degree of importance index = (number of “high” responses × 100 + number of “medium” responses × 50 + number of “low” responses × 25 + number of “unnecessary” responses × 0) ÷ total number of degree of importance responses

5.4. Forecasted realization times

Forecasted realization times were distributed as shown in the diagram below.

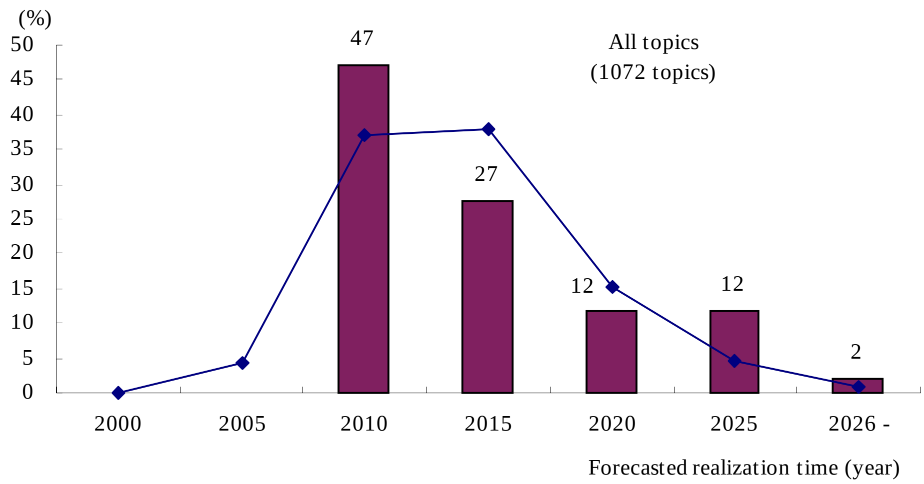

Fig. 5.4-1 Trends in Forecasted Realization Times

About half the forecasted realization times in this field fell between 2006 and 2010, and the rest were distributed after this period, spread over a wide range. A relatively large number of topics had their realization times pushed into the fairly remote future. Compared to the general trend covering all topics, the pattern of the distribution of forecasted realization times displayed was characteristic.

5.5. Current leading countries etc.

Responses to the question concerning current leading countries etc. were as shown in the diagram below. Named by about 90% of respondents, the U.S. ranked No. 1 by an overwhelming margin in the space field as a whole, trailed by Japan, the former Soviet Union/Eastern Europe and the EU in that order.

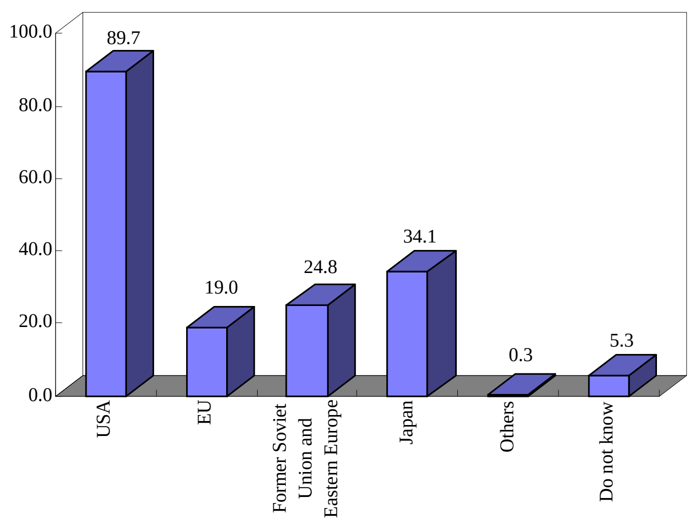

Fig. 5.5-1 Current Leading Countries etc. (%)

5.6. Comparison with the 5th Survey (previous survey)

Of the 51 topics included in the latest survey, 20 (39%) were identical to the previous survey, 9 (18%) were modified, and 22 (43%) were newly introduced. For identical topics, the results of the latest survey were compared with those of the previous survey in terms of degree of importance index scores and forecasted realization times, as shown in the table below.

Degree of importance index scores rose for 2 topics and fell for the remaining 18 topics. 50. Practical use in Japan of isotope batteries for probing deep space saw the greatest drop, down 31 points, with seven other topics experiencing a fall of more than 20 points.

From the 4th to the 5th Survey, forecasted topics were pushed back for all topics. Likewise, from the 5th to the 6th Survey, forecasted realization times were pushed further into the future for all topics, by 2-8 years.

Table 5.6-1 Comparison with 5th Survey for Identical Topics

Topic	Importance index / forecasted realization time	
	6th survey	5th survey
01 Space weather forecasting in order to allow humans to stay and work in space.	48/2007	72/2003
04 Development of technology to construct of artificial satellites with large-scale antenna (several tens of meters in diameter) at permanent manned space stations in low earth orbit.	58/2008	70/2006
06 Practical use of scattero-meter to be mounted on artificial satellite for measuring wind velocity on sea in the accuracy less than 1 m/s.	51/2009	59/2004
07 Practical use of a sea color sensor to be mounted on artificial satellites with a spectral resolution of 10 nm or less.	56/2008	63/2004
08 Practical use of microwave radiometers to be mounted on satellites, which are designed for measuring water, soil moisture, salt deposit concentration, and ice/snow distribution on land over the entire earth with a space resolution of 1 Km or less.	56/2009	72/2005
22 Realization of space tours business by spacecraft in vicinity of earth.	44/2022	42/2016
24 Use of a method in which two satellites or a space station and a satellite are connected with long tethers for variable gravity, power generation, payload acceleration, etc.	41/2013	49/2009
25 The cost of rocket thrusted space transportation will be reduced to less than 1/10 current levels.	93/2014	88/2010
26 Development of technologies for removing micro-organisms that lead to uncomfortable factors in space life such as mildew and offensive smells in space stations.	56/2008	73/2004
30 Development of life support technology applied to a closed ecosystem, able to self-supply vegetable, grain, animal protein, and other food.	59/2017	76/2009
31 Development of high-pressure (1 atmosphere), flexible space suit for use outside of a spaceship.	46/2009	76/2006
32 Development of fail operational space robot with self-diagnostic capabilities and self-restoration capabilities.	62/2014	85/2010
36 Capability for transmission of electrical power to earth by microwave from solar power generation plants with huge solar cell panels, constructed in space.	65/2020	67/2018
37 Development of high-performance orbital transfer vehicle to transfer large structures between lower and geostationary orbits.	56/2015	80/2009
38 Development of manned orbital transfer vehicle for trips to and from geostationary orbits and the moon.	49/2021	72/2014
39 Set of optical or radio telescopes on the surface of the moon.	50/2017	59/2012
42 Practical use of nuclear power generating system at lunar bases.	43/2025	54/2018
46 Realization of landing of manned spacecraft on Mars and the return to the Earth.	38/2025	54/2018
50 Practical use in Japan of isotope batteries for probing deep space.	44/2011	75/2004
51 Practical use of space nuclear propulsion systems.	40/2022	64/2016

Note: Up until the 5th Survey, realization meant realization in Japan unless otherwise specified. However, this was changed to mean realization somewhere in the world in the 6th Survey. Therefore, care should be taken when comparing forecasted realization times from the two surveys.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%) High	Medium	Low	Importance (index, %) Index	High	Medium	Low	Unnecessary	Expected effect (%) Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Forecasted realization time (2001 2006 2011 2016 2021 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%) USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%) Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%) Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Low and intermediate orbit	1	Space weather forecasting in order to allow humans to stay and work in space.	1	251	10	33	57	49	17	49	33	2	18	46	19	38		1	4	90	14	22	32	0	7	50	18	28	11	52	2	4	16	8	3	2
			2	229	7	31	62	48	12	54	32	1	11	56	14	41		0	3	90	10	17	39	0	7	59	14	26	10	63	1	0	14	5	1	1
			X	17	100	0	0	69	47	35	18	0	29	41	35	59		0	0	94	12	12	53	0	0	82	24	18	0	71	0	0	6	6	6	6
	2	Widespread use of a global-scale environmental surveillance network in which environmental changes for the earth as a whole are monitored around the clock in real time, and this information is integrated, systematically analyzed, and distributed around the world.	1	287	13	33	53	80	61	35	4	0	23	95	35	12		0	3	94	45	9	49	1	4	52	35	39	13	60	9	7	18	16	7	3
			2	258	10	32	57	81	63	36	1	0	21	97	34	9		0	2	96	47	4	56	0	1	61	30	36	11	75	4	2	15	14	4	2
			X	27	100	0	0	87	74	26	0	0	26	100	48	15		4	0	100	52	11	59	4	0	74	26	44	0	70	7	11	15	26	4	4
	3	Development of a satellite-mounted infrared space interference system with ultra-high space resolution capabilities, in order to search for extraterrestrial life and earth-like planets outside of our solar system.	1	207	8	31	61	40	8	41	47	4	5	10	0	95		2	10	85	24	5	28	0	12	56	17	24	2	61	1	1	4	2	20	3
			2	181	8	24	69	38	5	41	51	3	4	7	0	94		2	6	89	20	2	29	0	7	60	13	27	1	70	1	1	3	1	19	1
			X	14	100	0	0	50	21	43	29	7	0	0	0	100		7	0	93	50	0	36	0	7	64	14	7	0	71	0	7	0	0	29	0
	4	Development of technology to construct of artificial satellites with large-scale antenna (several tens of meters in diameter) at permanent manned space stations in low earth orbit.	1	296	19	46	35	60	28	55	16	1	65	29	22	26		1	2	93	18	25	41	0	2	46	33	31	0	71	2	1	7	8	6	3
			2	262	17	44	39	58	23	64	13	1	74	28	18	24		0	2	96	16	25	50	0	2	54	27	27	0	82	1	1	6	6	5	1
			X	45	100	0	0	72	47	47	7	0	73	20	31	16		0	0	96	13	20	58	0	2	58	29	31	0	82	0	0	9	7	2	0
	5	Development of technology for measuring, in real time, the distribution and movement of air pollution via observation from space.	1	280	13	31	56	76	57	35	8	0	20	93	39	11		1	4	87	44	7	50	0	8	56	33	30	8	69	2	2	16	10	4	1
			2	254	11	30	59	80	63	31	6	0	14	96	36	6		1	3	93	44	3	64	0	2	65	29	28	4	77	1	1	12	7	2	1
			X	28	100	0	0	85	71	25	4	0	25	93	54	7		0	0	93	68	7	79	4	0	82	32	36	7	79	7	0	18	14	4	4
	6	Practical use of scattero-meter to be mounted on artificial satellite for measuring wind velocity on sea in the accuracy less than 1 m/s.	1	181	10	32	58	53	21	51	26	2	21	73	35	15		4	10	78	24	3	29	0	15	59	25	20	6	60	1	2	13	10	1	3
			2	170	9	25	65	51	15	59	25	1	19	79	34	14		5	6	87	23	1	35	0	10	68	23	16	2	71	1	1	11	6	1	1
			X	16	100	0	0	63	38	44	13	6	13	81	38	6		13	0	100	31	0	38	0	0	75	25	19	0	56	0	6	13	6	0	0
	7	Practical use of a sea color sensor to be mounted on artificial satellites with a spectral resolution of 10 nm or less.	1	163	13	32	55	56	24	53	21	1	24	88	18	12		1	9	82	37	2	50	1	8	61	29	23	7	68	1	2	17	9	1	2
			2	151	11	25	64	56	21	62	17	1	21	91	15	9		1	7	85	29	1	64	1	9	74	25	15	3	77	0	0	13	7	1	0
			X	17	100	0	0	76	59	29	12	0	12	94	29	0		0	0	100	41	0	100	6	0	76	41	18	6	71	0	0	12	6	0	0
	8	Practical use of microwave radiometers to be mounted on satellites, which are designed for measuring water, soil moisture, salt deposit concentration, and ice/snow distribution on land over the entire earth with a space resolution of 1 km or less.	1	184	13	31	56	57	25	52	22	1	25	89	29	17		2	3	80	36	8	53	1	8	60	28	23	9	65	2	2	16	7	1	2
			2	162	13	29	58	56	20	65	15	0	22	94	22	11		1	2	86	32	4	66	0	5	70	21	18	2	76	1	0	14	6	1	0
			X	21	100	0	0	69	43	48	10	0	19	100	29	5		0	0	90	48	5	81	0	0	81	14	24	0	67	0	0	19	5	0	0
	9	Realization of precision down to less than a centimeter in measurement of crustal movement using VLBI (very long baseline inter-ferometers), satellite lasers, inverse laser ranging, and synthetic aperture radar to improve accuracy in such as earthquake forecasting.	1	226	12	28	61	79	62	32	6	0	16	56	64	23		4	7	79	30	8	66	1	8	59	32	24	8	67	1	2	9	14	4	2
			2	200	11	25	65	84	70	27	3	0	12	63	65	19		3	6	86	24	5	76	1	6	72	24	21	2	78	1	1	8	13	2	1
			X	21	100	0	0	88	76	24	0	0	24	67	52	29		5	0	90	48	0	86	10	0	76	33	33	0	71	0	0	33	19	0	0
	10	Practical use of satellite-mounted microwave sensors capable of measuring biomasses within an accuracy of $1kg/m^2$ or less. (The dry weight of plants determines the amount of carbon dioxide exhausted, and this is related to global warming. The current status is $1.4kg/m^2$ with the shuttle SIR-C.)	1	133	12	26	62	63	36	46	17	2	17	92	14	13		2	7	85	32	2	38	1	10	62	32	18	11	65	1	2	19	6	3	3
			2	122	11	25	65	58	26	55	19	0	14	95	8	11		3	5	87	30	1	50	1	9	75	28	11	4	71	1	0	13	5	2	0
			X	13	100	0	0	58	23	62	15	0	0	100	15	15		15	0	92	46	0	69	8	0	85	38	15	8	62	0	0	23	0	8	0

(Note) See page 7 for the interpretation of the graphs.

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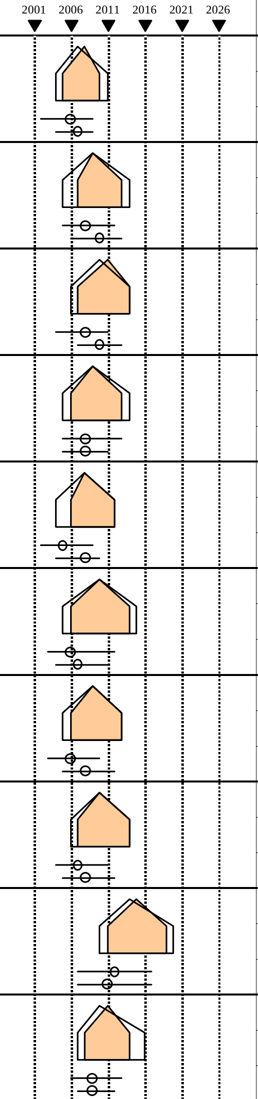
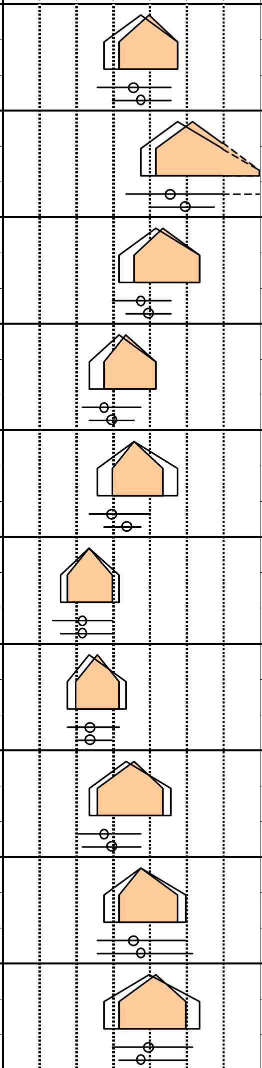
Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Medium	Low	Importance (index, %): Index	High	Medium	Low	Unnecessary	Expected effect (%): Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Forecasted realization time: Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Low and intermediate orbit	11	Practical use of global-scale marine and land mapping using satellite-mounted multi-frequency/multi-polarization synthetic aperture radar.	1	212	14	31	55	64	37	47	17	0	29	83	29	16	0	8	87	49	12	63	4	7	52	31	24	10	73	2	2	11	9	3	2
			2	188	12	29	59	63	33	53	14	0	27	87	27	13	0	5	94	52	7	73	3	4	62	28	20	5	80	1	1	11	5	2	1
			X	23	100	0	0	85	70	30	0	0	30	96	30	17	0	4	96	65	13	91	4	0	78	39	26	0	83	0	0	26	13	0	0
	12	Development of satellite-mounted Doppler LIDAR capable of measurement of three-dimensional distribution of wind, with a swath width of over 500 km along the satellite flight direction.	1	164	10	32	59	54	22	51	26	1	13	78	32	25	1	9	76	27	4	37	0	16	60	22	23	4	65	2	1	10	12	0	3
			2	150	10	25	65	51	16	58	25	1	11	85	27	23	1	7	87	30	1	49	0	11	71	19	17	3	75	1	1	10	8	0	2
			X	15	100	0	0	68	40	53	7	0	33	93	27	20	0	0	93	53	0	93	0	0	67	13	13	0	60	7	0	40	20	0	13
	13	Development of a system to measure cosmic radio waves in the sub-milli meter and sub-sub-milli meter wave band, using space interferometers.	1	163	9	28	64	48	14	50	34	1	13	18	1	82	0	12	75	25	6	52	1	12	66	20	28	2	66	1	1	9	1	7	2
			2	153	8	21	71	45	13	42	43	2	7	12	0	90	0	10	84	21	1	59	0	8	75	11	25	2	67	1	1	8	1	2	0
			X	12	100	0	0	79	67	17	17	0	8	17	0	92	0	0	83	42	0	75	0	0	92	25	25	0	67	0	0	17	0	8	0
	14	Development of satellites weighing 1 kg or less and having communications function.	1	260	18	36	47	54	28	39	27	6	74	17	35	17	9	10	74	20	3	30	0	13	44	38	18	1	52	9	5	10	15	7	5
			2	237	17	35	49	57	31	40	23	5	81	9	39	11	7	8	83	20	3	39	0	8	54	41	16	0	62	7	3	7	15	3	3
			X	40	100	0	0	71	53	33	10	5	85	18	43	23	3	8	88	20	5	35	0	8	55	50	20	0	65	10	3	15	18	8	0
	15	Realization of a high-accuracy satellite positioning system operated by an international organization.	1	261	12	34	54	76	56	38	6	0	74	28	57	8	3	5	97	22	23	26	0	2	35	32	24	3	62	15	5	3	18	8	3
			2	232	11	34	56	81	64	33	3	0	84	19	66	4	3	3	97	16	22	29	0	1	41	33	18	1	72	13	3	1	16	3	3
			X	25	100	0	0	95	92	4	4	0	76	16	68	12	4	0	100	24	48	32	0	0	52	32	20	0	72	8	8	4	20	4	4
	16	Full-scale operation of a space station as a laboratory on the low earth orbit, and realization of next-generation facilities using the space environment for research, development, and trial production of semiconductors, pharmaceuticals, etc.	1	292	24	37	39	71	49	40	11	1	86	18	29	51	3	2	94	46	59	44	1	1	57	47	26	8	68	5	2	8	7	12	3
			2	263	22	40	39	70	45	45	9	0	89	11	28	49	3	1	97	44	64	46	1	1	60	46	19	6	76	4	1	8	5	9	2
			X	57	100	0	0	75	58	27	15	0	89	12	32	53	2	0	98	67	72	60	5	0	56	53	19	5	79	4	2	7	5	7	2
	17	Realization of a micro gravity research facility capable of an environment of 10^{-6} G or less for several days.	1	246	23	33	45	58	28	49	21	2	62	10	11	63	7	6	80	37	37	37	0	9	42	29	35	4	61	2	2	5	2	4	2
			2	225	21	34	45	54	19	60	20	1	64	3	9	69	4	2	91	39	42	46	0	5	49	19	35	2	72	2	1	5	3	3	0
			X	48	100	0	0	67	41	48	9	2	65	4	10	71	0	0	96	44	46	48	2	0	56	25	40	4	79	2	0	10	4	2	0
	18	Realization of large-scale, ultra-high vacuum facility utilizing WAKE (a shielding plate placed perpendicular to the direction of flight on the orbit in order to remove ions and molecules in space).	1	173	18	25	56	44	10	48	36	5	45	5	4	64	5	12	69	14	13	19	0	18	47	25	23	3	53	2	1	8	4	5	5
			2	164	15	22	63	40	7	44	43	5	39	2	2	78	3	10	76	9	7	18	0	18	57	19	16	2	61	2	0	7	2	3	2
			X	25	100	0	0	50	17	54	25	4	32	4	0	88	8	0	88	8	16	24	0	8	60	32	24	4	68	4	0	12	4	8	0
	19	Practical use of electricity transmission technology in space using laser beams.	1	240	13	24	63	56	30	42	22	6	55	58	13	14	9	13	71	15	18	29	0	16	50	28	24	2	57	5	1	39	16	3	2
			2	218	11	24	65	55	27	46	21	6	63	56	9	11	6	10	83	11	17	37	0	10	55	23	22	2	63	4	0	44	18	2	0
			X	24	100	0	0	61	38	33	29	0	58	54	4	17	8	13	83	8	33	54	0	4	46	21	42	4	71	4	0	25	25	4	0
	20	Development of two-stage-to-orbit, completely re-usable, space transport system.	1	285	31	32	37	70	46	42	11	1	85	23	5	19	4	6	95	21	26	22	0	1	57	26	29	0	75	5	1	17	8	4	4
			2	259	29	32	38	72	49	42	9	0	88	22	3	17	2	4	95	21	29	25	0	1	64	18	27	0	85	4	0	20	6	2	2
			X	76	100	0	0	87	75	21	4	0	93	32	7	25	0	4	97	25	33	37	0	0	67	22	41	0	88	4	0	24	3	4	4



(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time	Will not be realized (%)	Do not know (%)	Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001 2006 2011 2016 2021 2026			USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Low and intermediate orbit	21	Development of a space plane capable of transporting between the earth and space stations in the similar manner as conventional airplanes.	1	312	29	29	41	70	46	43	10	1	90	21	11	23		2	5	96	20	24	26	0	2	61	28	30	2	76	4	3	22	9	5	4
			2	278	28	31	41	70	45	45	9	1	94	17	9	22		1	4	96	19	26	29	0	3	67	21	31	1	84	5	1	29	6	3	2
			X	79	100	0	0	80	62	33	5	0	91	20	13	30		0	1	99	20	28	41	0	1	70	29	41	1	86	3	0	29	6	5	1
	22	Realization of space tours business by spacecraft in vicinity of earth.	1	275	19	26	55	46	19	35	38	8	78	6	24	20		4	11	77	9	22	15	0	15	27	34	17	1	43	27	5	15	12	21	3
			2	254	19	26	56	44	15	36	44	5	80	4	26	19		6	9	83	7	26	16	0	12	27	38	14	0	54	28	4	18	10	17	2
			X	47	100	0	0	56	28	43	28	2	74	13	34	17		2	2	96	6	32	34	0	4	34	43	36	0	60	28	6	17	9	11	2
	23	Realization of bases for transporting to the moon and planets in middle or low-level orbiting transport	1	293	21	36	43	54	23	53	21	3	58	27	4	53		3	5	91	16	44	13	0	4	52	25	20	0	68	2	3	7	5	6	3
			2	263	19	38	43	51	16	58	23	3	59	20	3	62		3	3	94	11	50	11	0	3	53	20	18	0	76	3	2	7	4	4	2
			X	49	100	0	0	68	42	48	10	0	57	27	0	71		0	0	96	18	55	18	0	2	59	29	29	0	84	2	2	4	0	8	4
	24	Use of a method in which two satellites or a space station and a satellite are connected with long tethers for variable gravity, power generation, payload acceleration, etc.	1	231	17	30	53	42	11	43	39	7	42	19	4	42		7	13	77	35	8	17	0	9	53	19	21	2	50	0	2	5	3	2	4
			2	212	14	29	57	41	8	48	40	5	54	12	3	48		3	11	88	40	6	20	0	6	67	13	17	2	62	0	2	5	4	1	2
			X	30	100	0	0	61	37	40	17	7	50	10	10	63		0	10	83	53	17	47	0	3	53	10	30	0	70	0	7	0	0	3	7
	25	The cost of rocket thrusted space transportation will be reduced to less than 1/10 current levels.	1	300	28	34	37	89	79	19	2	0	93	28	16	20		7	7	85	35	33	27	7	7	43	37	26	1	61	18	3	13	8	5	2
			2	266	26	36	38	93	86	13	2	0	95	26	13	17		6	6	89	36	32	28	5	4	50	33	23	0	72	14	1	17	6	2	1
			X	70	100	0	0	96	93	6	1	0	94	34	19	29		3	3	93	37	36	36	9	1	51	41	33	0	73	13	1	13	3	3	1
	26	Development of technologies for removing micro-organisms that lead to uncomfortable factors in space life such as mildew and offensive smells in space stations.	1	132	19	20	61	55	25	48	25	2	42	9	46	14		1	5	82	15	38	19	0	11	52	41	20	9	49	1	1	6	5	1	3
			2	127	17	17	67	56	23	56	20	1	44	6	65	8		1	4	86	14	46	19	0	8	66	39	13	6	57	1	0	6	6	0	1
			X	21	100	0	0	76	57	33	10	0	33	10	71	10		0	0	95	33	71	24	0	0	81	38	10	10	67	0	0	0	10	0	0
	27	Establishment of a remote medical diagnosis/treatment system for astronauts.	1	143	16	20	64	54	25	43	29	2	36	6	56	15		1	6	88	22	41	18	0	6	53	39	22	11	53	6	0	2	12	10	3
			2	133	13	17	70	52	20	52	28	1	39	5	68	13		1	5	89	19	49	17	0	5	62	38	19	6	61	3	0	2	11	7	2
			X	17	100	0	0	75	59	24	18	0	53	0	76	29		0	0	100	53	76	24	0	0	65	59	29	0	76	6	0	0	6	12	0
	28	Realization of the identification of relatively large space debris on the order of several millimeters in size (orbiting trash such as shards from satellites and rockets, man-made material ejected into space, etc.), and the development of technology making it possible for space stations and other space structures to avoid collisions with such debris.	1	269	16	34	50	66	40	43	15	2	47	28	17	13		7	9	87	19	23	20	0	6	55	20	27	9	64	2	3	7	6	2	3
			2	239	14	36	51	68	40	50	10	0	62	32	14	10		4	7	93	16	26	23	0	3	65	15	23	5	71	1	2	6	4	2	2
			X	33	100	0	0	80	67	18	15	0	70	33	21	12		9	6	100	30	33	36	0	0	70	18	27	9	76	3	6	6	0	0	3
	29	Removal of large (tens of centimeters and larger) space debris such as pieces of spent satellites, rockets, etc.	1	269	16	33	50	64	40	38	20	1	50	38	19	7		9	13	79	16	19	14	0	11	53	22	24	7	61	3	3	10	7	1	3
			2	241	14	35	51	68	45	40	15	1	60	45	12	4		8	10	87	12	20	12	0	7	63	16	24	4	71	2	2	9	6	0	2
			X	33	100	0	0	80	70	12	18	0	79	45	24	3		9	9	82	21	27	15	0	3	64	12	18	3	64	9	3	12	6	0	0
	30	Development of life support technology applied to a closed ecosystem, able to self-supply vegetable, grain, animal protein, and other food.	1	171	15	19	66	62	35	43	19	2	62	49	26	26		3	6	89	18	37	27	0	5	62	38	30	13	61	3	1	9	6	12	4
			2	156	12	17	72	59	27	58	14	1	69	49	24	22		1	7	95	13	44	34	0	1	72	37	23	8	67	2	1	6	6	10	2
			X	18	100	0	0	79	61	33	6	0	78	56	44	39		0	0	100	28	50	56	0	0	89	44	28	11	83	0	0	11	6	11	0

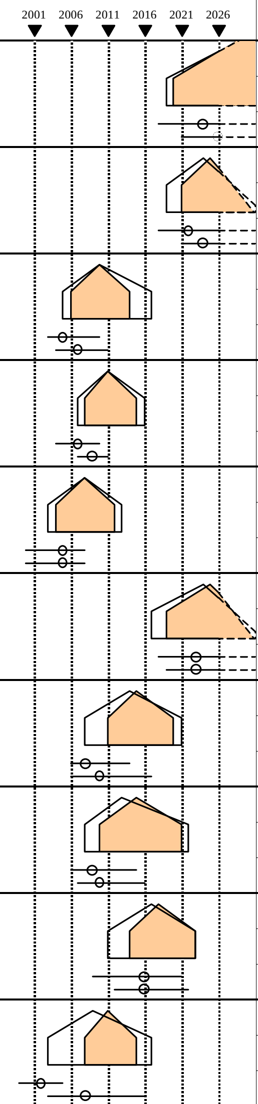


(Note) See page 7 for the interpretation of the graphs.

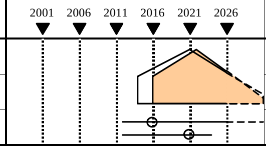
Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic development	Expected effect: Resolution of global problems	Expected effect: People's needs	Expected effect: Expansion of intellectual resources	Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Low and intermediate orbit	31	Development of high-pressure (1 atmosphere), flexible space suit for use outside of a spaceship.	1	154	14	25	61	48	19	43	33	5	54	9	18	23		4	9	93	10	56	8	0	3	49	31	19	3	59	1	1	4	8	1	3
			2	144	11	15	74	46	12	52	33	3	70	4	16	20		3	10	95	5	66	3	0	3	60	28	11	1	68	1	1	4	8	0	1
			X	16	100	0	0	64	38	50	6	6	75	6	25	19		13	0	100	0	75	0	0	0	56	19	13	0	69	0	0	6	19	0	0
	32	Development of fail operational space robot with self-diagnostic capabilities and self-restoration capabilities.	1	220	16	31	53	65	37	50	13	0	79	11	20	25		3	6	87	22	6	60	2	5	63	42	23	1	66	2	0	4	6	5	2
			2	198	14	27	59	62	29	61	10	0	87	7	20	22		2	6	90	21	4	68	1	6	66	38	18	2	75	1	0	3	6	4	1
			X	27	100	0	0	84	70	26	4	0	93	7	15	11		4	0	93	30	4	78	0	4	78	44	19	0	70	0	0	0	4	7	7
Stationary orbit	33	Development in Japan of a satellite broadcast system for each individual region (Kanto, Tokai, Kinki, etc.) based on multibeam technology.	1	212	19	32	49	68	48	33	15	4	83	6	60	4		3	6	67	32	2	71	0	6	33	37	23	1	48	24	2	2	6	16	2
			2	190	19	29	52	75	58	29	11	2	87	2	70	3		2	3	74	31	1	84	0	4	39	44	18	0	57	25	2	1	4	16	1
			X	37	100	0	0	86	76	19	5	0	89	3	84	0		0	0	68	35	0	97	0	0	38	43	24	0	57	30	3	0	5	22	0
	34	Realization of highly reliable satellite communications and highly accurate earth observation satellites, using clustered geostationary satellites (aggregated geostationary satellites flying in formation).	1	222	17	32	51	61	34	47	17	2	77	39	43	11		4	8	74	23	9	32	0	9	45	24	23	2	56	9	1	5	8	9	2
			2	195	16	31	52	60	29	54	15	1	79	33	48	8		1	6	86	25	4	45	0	6	53	26	21	0	68	6	1	4	7	7	1
			X	32	100	0	0	72	52	32	16	0	81	25	41	9		3	0	78	28	0	63	0	0	53	31	25	0	66	9	0	3	6	9	0
	35	Widespread use of gigabit-class global satellite communication systems.	1	214	20	28	53	74	54	37	9	1	89	9	53	7		1	3	86	28	2	51	0	5	44	34	27	1	60	19	1	4	12	12	1
			2	191	19	26	54	78	58	37	5	0	93	6	63	5		1	3	94	27	0	71	0	3	50	39	21	0	71	15	1	3	10	9	1
			X	37	100	0	0	87	76	22	3	0	95	3	65	3		0	0	95	35	0	78	0	0	49	30	35	0	78	16	0	0	16	8	0
	36	Capability for transmission of electrical power to earth by microwave from solar power generation plants with huge solar cell panels, constructed in space.	1	287	12	33	55	63	42	33	18	6	58	77	16	5		18	14	75	15	10	43	0	10	47	27	21	2	61	10	1	59	20	5	3
			2	248	11	31	58	65	45	35	14	7	65	75	16	2		17	11	81	10	6	51	0	9	56	25	17	1	70	6	1	60	23	3	2
			X	28	100	0	0	78	64	25	4	7	86	79	21	4		14	0	93	11	4	75	0	0	61	21	29	7	75	11	0	54	11	0	4
	37	Development of high-performance orbital transfer vehicle to transfer large structures between lower and geostationary orbits.	1	279	23	34	43	57	27	51	20	3	73	26	6	16		2	9	87	19	33	22	0	4	51	27	21	1	72	3	2	6	5	3	2
			2	251	20	37	43	56	21	60	17	2	83	22	3	13		2	6	92	18	37	26	0	3	59	21	14	0	83	2	1	6	5	1	0
			X	51	100	0	0	70	45	45	8	2	84	24	2	10		0	0	94	24	45	41	0	0	61	24	16	0	84	0	0	6	4	2	0
	38	Development of manned orbital transfer vehicle for trips to and from geostationary orbits and the moon.	1	276	21	36	43	51	20	45	31	3	66	24	4	45		4	12	91	10	38	8	0	3	55	27	20	1	70	2	2	4	8	7	3
			2	248	18	37	46	49	17	50	30	3	71	19	2	56		4	10	96	7	46	8	0	1	63	21	17	0	79	1	1	4	6	3	1
			X	44	100	0	0	65	41	39	18	2	75	18	5	66		0	0	100	9	55	11	0	0	77	27	23	0	89	0	0	0	7	7	2
Moon and its neighborhood	39	Set of optical or radio telescopes on the surface of the moon.	1	256	10	26	64	53	20	50	29	0	15	11	0	94		2	5	88	16	18	29	1	6	59	25	22	2	77	1	2	5	1	7	3
			2	235	8	21	71	50	14	57	28	1	12	8	0	94		2	4	92	15	14	39	0	5	66	22	17	1	83	0	1	6	0	5	1
			X	19	100	0	0	68	42	47	11	0	11	11	5	79		0	0	95	21	16	68	0	0	74	21	21	0	89	0	5	11	0	11	0
	40	Creation of a permanent, manned station on the surface of the moon, executing geological surveys of the moon, scientific observations from the moon, and development of technology to utilize the moon's resources.	1	288	12	28	60	55	27	42	29	2	57	50	5	75		6	10	91	12	34	18	0	4	60	33	20	3	73	2	2	10	5	14	2
			2	255	10	26	64	53	22	49	28	1	56	43	2	79		7	7	95	9	41	19	0	2	70	27	16	2	82	1	1	8	2	11	1
			X	26	100	0	0	79	62	31	8	0	65	58	8	77		0	0	96	19	50	35	0	0	81	27	31	0	88	4	4	12	0	15	4

(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%) High	Degree of expertise (%) Medium	Degree of expertise (%) Low	Importance (index, %) Index	Importance High	Importance Medium	Importance Low	Importance Unnecessary	Expected effect (%) Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Forecasted realization time: Will not be realized (%)	Do not know (%)	Leading countries (%) USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%) Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%) Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Moon and its neighborhood	41	Practical use of substances (Si, O_2, ^3He, etc.) which exist on the moon as resources on the moon surface.	1	231	10	25	65	59	35	37	24	4	66	65	4	29	7	14	78	14	23	22	0	10	54	30	16	3	59	3	2	14	3	6	3
			2	207	9	23	68	58	29	47	19	4	74	63	2	26	7	11	87	9	24	27	0	7	65	32	13	2	72	2	2	12	3	4	1
			X	18	100	0	0	85	76	18	0	6	89	61	11	28	0	0	100	28	22	50	0	0	78	50	28	0	78	0	0	17	0	6	6
	42	Practical use of nuclear power generating system at lunar bases.	1	200	9	22	70	45	19	35	35	12	48	53	3	24	16	18	69	10	36	17	0	13	45	28	14	2	50	11	2	31	15	8	3
			2	183	7	20	74	43	16	37	37	11	56	54	2	23	16	13	83	8	48	13	0	9	57	29	11	0	60	9	3	39	17	4	2
			X	12	100	0	0	64	45	27	18	9	67	50	17	25	0	8	92	8	58	8	0	0	75	33	33	0	50	25	0	42	33	8	8
Planets and deep space	43	Return of samples from other planets.	1	276	18	24	58	52	22	45	32	1	12	14	2	93	0	4	92	13	37	34	0	3	66	22	22	3	73	1	1	8	5	6	2
			2	251	16	26	58	51	19	52	27	2	10	9	1	96	0	3	95	10	43	38	0	3	76	18	20	0	80	0	1	6	5	4	2
			X	39	100	0	0	73	53	37	8	3	8	3	0	95	0	0	97	21	38	62	0	0	77	15	31	0	90	0	0	5	8	8	5
	44	Long-term observation of the atmosphere of Venus by means of balloons.	1	196	10	22	68	42	10	42	43	5	4	8	0	96	2	10	86	9	44	23	0	6	59	17	16	3	64	1	3	3	0	6	3
			2	176	7	18	74	41	8	43	45	4	2	4	0	98	2	7	91	5	53	22	0	5	67	13	14	1	73	0	2	2	0	3	1
			X	13	100	0	0	63	42	33	17	8	0	0	0	92	0	0	100	23	69	46	0	0	77	23	23	0	77	0	0	0	0	23	0
	45	Analysis of the surface substances of Mars, its with weather observation and earthquake observation, etc., via an unmanned Mars exploration unit.	1	271	11	25	63	47	14	48	36	2	10	15	0	92	0	4	94	11	44	18	0	2	59	21	18	3	68	2	1	4	1	6	3
			2	243	9	24	67	46	11	52	35	2	7	9	0	97	0	3	95	6	51	15	0	2	71	16	15	1	80	0	1	3	1	4	2
			X	22	100	0	0	76	57	38	0	5	5	9	0	95	0	0	95	9	55	36	0	0	77	18	23	0	77	0	0	0	0	9	5
	46	Realization of landing of manned spacecraft on Mars and the return to the Earth.	1	271	13	22	65	40	11	34	48	7	27	16	1	87	5	13	93	4	39	6	0	3	58	20	19	1	62	2	2	4	3	10	3
			2	239	11	21	68	38	10	27	56	6	19	9	1	93	6	12	96	3	46	3	0	2	69	15	13	0	71	1	2	3	2	7	1
			X	27	100	0	0	64	42	35	19	4	22	19	4	85	0	0	100	7	59	7	0	0	74	26	19	0	70	0	0	7	0	15	4
	47	Investigation of Mercury with orbiter.	1	233	12	19	69	40	11	32	52	5	8	5	0	94	2	13	88	14	31	19	0	4	58	18	16	1	64	1	1	1	0	6	2
			2	213	9	18	73	37	7	28	62	3	5	2	0	98	2	13	94	9	34	15	0	3	70	12	12	0	71	0	1	1	0	4	1
			X	20	100	0	0	64	44	28	22	6	5	5	0	90	0	10	95	20	50	35	0	0	80	15	30	0	65	0	0	0	0	10	5
	48	Exploration of Saturn and other planets beyond it.	1	231	11	19	70	39	11	30	55	4	7	4	0	93	0	11	90	7	22	9	0	2	58	17	15	2	61	0	1	1	0	5	2
			2	211	9	17	74	35	7	25	65	4	4	2	0	98	0	8	97	4	28	5	0	2	70	12	11	0	73	0	1	0	0	4	1
			X	19	100	0	0	64	44	28	22	6	5	5	0	95	0	11	95	11	37	11	0	0	79	16	32	0	74	0	0	0	0	11	5
	49	Establishment of a large-scale optical/infrared astronomical observatory at the Lagrange point of the sun and the Earth, in order to efficiently avoid the effects of thermal radiation from the sun and the Earth.	1	176	12	19	69	41	11	37	46	5	11	14	2	90	6	19	75	21	15	19	0	14	56	19	18	2	59	1	1	3	1	4	2
			2	171	9	15	76	38	9	28	60	3	5	11	0	95	6	15	85	19	13	20	0	12	71	13	10	1	70	0	0	1	0	2	1
			X	16	100	0	0	60	40	27	27	7	6	6	0	94	0	6	100	38	25	38	0	0	69	19	25	0	75	0	0	0	0	13	0
	50	Practical use in Japan of isotope batteries for probing deep space.	1	150	10	24	66	48	19	41	36	4	33	11	3	62	3	13	79	6	43	5	0	9	48	16	17	2	48	13	5	27	17	10	2
			2	145	6	21	73	44	11	48	35	6	37	6	0	80	3	14	90	3	66	3	0	6	68	14	10	1	65	10	2	35	26	6	1
			X	9	100	0	0	61	33	44	22	0	33	0	0	67	0	11	100	11	67	11	0	0	67	22	44	0	56	22	0	33	33	22	0



(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic development	Expected effect: Resolution of global problems	Expected effect: People's needs	Expected effect: Expansion of intellectual resources	Forecasted realization time (2001 2006 2011 2016 2021 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Planets and deep space	51	Practical use of space nuclear propulsion systems.	1	197	12	24	64	43	15	36	39	10	47	25	2	49		14	20	77	9	48	5	0	9	50	19	13	3	52	14	4	46	25	12	3
			2	189	8	23	68	40	11	35	42	11	54	18	2	56		16	19	86	3	63	5	0	6	60	14	13	0	62	11	3	57	37	7	2
			X	16	100	0	0	52	31	25	31	13	56	13	0	69		25	13	88	0	56	6	0	6	69	13	25	0	50	25	6	50	38	19	6

(Note) See page 7 for the interpretation of the graphs.

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6. Survey Results in “Marine Science and Earth Science”

6.1. Trends in noteworthy domains

The “marine science and earth science” field has an intrinsically broad interdisciplinary coverage, so that trends in its closely related fields, such as “resources and energy” and “environment” must also be looked at for comparison and extra information in conducting a forecast survey, as mentioned earlier.

The global environment has various aspects and how you understand it depends on your stance. In the realm of “marine science and earth science”, focusing on topics relating to “disasters” and “education” may be one way of covering areas of attention, partly because these are closely related to people's everyday lives. (See Table 7.3-3 in Part II “Survey Results (outline)”.)

In concrete terms, the following two areas deserve close attention:

(1) Disaster prevention/preparedness technologies

Examples of topics 01, 12, 13, 14 (marine science) and 41, 45, 56, 58 and 60–63 (earth science)

(2) Human resource development and technological advancement

Examples of topics 69–74 (marine science and earth science)

In our technology forecast surveys, which are conducted every five years, the selection of questions in each survey tends to reflect the background conditions of the period in which it takes place. In the latest survey, the Great Hanshin-Awaji Earthquake, which struck southern Hyogo Prefecture in January 1995, weighed heavily. The high level of interest it aroused can be clearly seen in survey responses, as well as topic selections.

People usually talk about global environmental problems thinking only about global environmental pollution associated with human causes in some way or other. Needless to say, however, from a social safety point of view, it is highly desirable that natural disasters triggered by extreme natural phenomena, such as earthquakes, volcano eruptions, tsunamis, torrential rains and abnormal weather conditions, be included in people's perspectives. In modern times, when advanced science and technology, aging of the population and overpopulation are already facts of life, natural disasters almost always contain elements of a human disaster, and this tends to increase damage and casualties. Therefore, when examining the survey results, it is important to keep the above perspective in mind and not lose sight of the overall picture.

In this sense, the marine accident involving the Russian oil tanker “Nakhodka” in early 1997 and the ensuing wide-area oil spill disaster, which affected a wide stretch of the Sea of Japan coast, are expected to have a major impact on the selection of topics in the next survey. Because the incident is interdisciplinary in nature, it is expected to have implications for many fields, apart from “marine science and earth science”.

Topics 45–53 and 60–63 represent areas of attention relating to diastrophism. Compared to similar topics in the last survey, the forecasted realization times have been pushed back in the latest survey, and, while this is consistent with many other topics, it may reflect respondents' frustration over slower-than-expected technological progress made in these areas. Among topics that a high proportion of the respondents said “will not be realized” — a response which can be taken as a concrete expression of the above sentiment — were 60 and 61, which feature a little too optimistic propositions, and this seems to reflect respondents' realistic attitudes.

While the general high interest in disasters is not surprising, a comparison between earth science and marine science shows that attention is drawn more to observation technology for atmosphere-marine systems, which are of a global nature, permanent or rapidly expanding, than to seismic or volcanic disasters, which are one-off incidents.

In concrete terms, hopes are pinned on technologies aiming to elucidate behaviors of the atmosphere and oceans as subsystems of the hydrologic cycle that holds the key to solutions to global environmental problems. Notably, many of these technologies score over 90% for “expected effect”, and forecasted realization times generally fall into a relatively early period (around 2010) compared to other topics. This may be interpreted as reflecting both the developmental trends of the technologies themselves and being influenced by respondents' sense of hope to a considerable degree.

In general, to solve environmental problems, the following two aspects must be given priority: concrete measures to tackle existing problems; and improvements in monitoring technologies to predict the future occurrence or spread of problems at an early stage. However, attention must be paid to the fact that, according to the observation of present social and international circumstances, progress in the former is extremely slow — so much so that even the formulation of topics regarding concrete solution technologies is not easy.

While topics relating to educational/learning institutions, such as museums and research centers, that put emphasis on academic/educational activities and systems, were chosen as proposals for the consideration of a long-term outlook, it should not be overlooked that a high proportion of respondents identified them as "effective government measures" to address the above problems". It is probably reasonable to interpret this as a sign that people involved in R&D pin their hopes on the spread of a fundamental understanding of global environmental problems through human resource development, rather than hasty Band-Aid measures.

6.1.1. Degree of importance to Japan

Overall, topics in the three fields of "marine science and earth science", "resources and energy" and "environment" as a group ranked high in terms of the degree of importance index.

Featured in the top 20 were two disaster-related topics from the "marine science and earth science" field and six nonfossil-energy-related topics from the "production and machinery", "electronics" and "materials and processing" fields. Looking to the 21st century, this clearly reflects the prevailing social trend of giving preference to technologies that are "gentle" to the global environment, and shows that a narrow perspective focusing solely on the "marine science and earth science" field would not lead to a grasp of the overall technical issues involved in global environmental problems.

In terms of the degree of importance index by field or purpose for each frame, the sea surface, atmosphere and geochemical cycle, as well as (marine) environmental conservation/creation, ranked high, as will be discussed below — highlighting the high level of interest held in topics relating to the global matter cycle, which lies at the core of global environmental problems.

6.1.2. Expected effect

A quick look at summaries of the results of the latest survey in the "marine science and earth science" field shows that forecasted realization times were pushed back, more or less following the general trend — although the recognition of its importance increased — as can be seen from a comparison with the results of the 5th Survey (last survey) for the same topics.

An examination of individual topics in terms of their expected effects, such as contribution to society and resolution of global environmental problems, brings to the fore the huge disparity between analysis results relating to topics from only the "marine science and earth science" field and the general trend of technologies relating to the Earth as a whole, as discussed above.

(1) Contribution to socioeconomic development

"Marine science and earth science", "resources and energy" and "environment", the three fields which ranked high in terms of the degree of importance in section 6.1.1., came last in terms of contribution to socioeconomic development, contrary to expectations — scoring far below the average for all 14 fields. This shows that production technologies still tend to receive disproportionate credit, highlighting a problem that exists in our preparedness for tackling global environmental issues in the future.

(2) Resolution of global-scale problems

The paradox observed in section 6.1.1. or the previous subsection, (1), is also very noticeable here. Namely, contrary to the fact that the above three fields ranked overwhelmingly high in terms of overall scores, the top 20 only contained 2 topics each from the "marine science and earth science" and "environment" fields.

(3) Response to people’s needs

As a logical consequence, the above three fields ranked very low with respect to people's everyday lives. This seems to reveal a typically Japanese short-sighted attitude towards people's daily lives, driven by short-term goals and immediate gains, which have become ingrained in the national psyche and group consciousness of technically-oriented people.

(4) Expansion of human intellectual resources

Notably, while “resources and energy” and “environment” were given thumbs down in terms of the expansion of human intellectual resources, “marine science and earth science” ranked No. 2, possibly because of the high rating given to the progress in plate tectonics, volcanic disaster prevention/preparedness measures, and the like. It also has two topics in the top 20.

6.1.3. Forecasted realization times

Across all the fields covered in the survey, a clear shift in peak locations can be seen between the group of topics relating to the practical development of info-communications technology and that relating to its application, e.g. resources and energy and life science topics, highlighting the latter's dependence on the former.

6.1.4. Leading countries

The results clearly show that, due to low government funding and weak government human resources development policy in this field, the technical standard of Japan as a sea-bound country was not rated high at all. If anything, the fact that the top 20 featured no topics from “marine science and earth science” must be taken seriously.

However, practical S&T activities in “marine science and earth science” have been moving increasingly towards international cooperation projects in recent years, so that there is a view that the concept of country-to-country comparison itself is no longer relevant.

6.1.5. Effective measures government should adopt in Japan

Hopes were overwhelmingly pinned on “life science”, “health, medical care and welfare”, and this seems to reflect people's tendency to attach more importance to immediate gains mentioned in 6.1.2. (3). This may also reflect the heavy media coverage of topics such as O157 and malignant neoplasm during the survey period. Understandably, both human resources and equipment/facilities ranked high in “marine science and earth science”, perhaps because of the perception that the private sector was almost powerless in this field. The very low expectation held for public sector research infrastructure seems to be inseparable from the fact that requests for government funding ranked second.

6.1.6. Potential problems in Japan

It is a healthy attitude that attention was paid to the natural environment, safety and morals/society as a whole. However, when focusing on “marine science and earth science”, their relevance tended to be rated low, perhaps because this field is perceived as something very remote from people's daily lives.

(Takashi Hamada)

6.2. Forecast topic framework

In the course of compiling forecast topics, a framework representing the organization of technologies in tabulated matrix form was drawn up for each field, with objectives and technological domains defining the rows and columns of the table, respectively. The framework is designed to present an overall picture of technological development in each field in terms of future prospects, importance, etc. as seen from the present perspective, and is also used as a working framework for future reviews of forecast topics.

Table 6.2-1 Forecast Topic Framework for Marine Science Field

	Sea surface	Sea-land interface	Water mass	Circulation
Marine Observation, forecasting, monitoring and surveying (elucidation of phenomena, accumulation of data, and predication/forecasting)	01 02 03	04	05 06 07 08 09 10 11	12 13 14 15 16
Protection/creation of marine environment	17	18 19 20 21 22 23 24	25	26
Resources, energy and space utilization	27 28 29	30 31 32	33 34 35 36 37 38 39	40

* Figures appearing in the table represent topic numbers.

Table 6.2-2 Forecast Topic Framework for Earth Science Field

	Atmosphere		Geosphere		
	Stratosphere	Troposphere	Atmosphere-geosphere boundary	Crust	Interior of earth
Earth Observation, forecasting, (elucidation of phenomena, accumulation of data, and predication/forecasting)	41 42	43 44		45 46 47 48 49 50 51	52
Protection/creation of global environment				53 54 55	
Natural disaster prevention/preparedness		56 57	58 59	60 61 62 63	
Common/other (marine/earth science)	64 65 66 67 68 69 70 71 72 73 74				

* Figures appearing in the table represent topic numbers.

6.3. Topics with high degree of importance

Degree of importance index scores (Note 1) averaged at 65.2 for topics in the marine science and earth science field as a whole. Topics considered of particular importance to Japan (top 20 topics in terms of degree of importance index score) are listed in the table below. Eleven topics from the marine science field and 7 topics from the earth science field featured in the top 20. Rated most important and second most important, respectively, 60. Development of technology capable of forecasting the occurrence of major earthquakes (magnitude 7 or above) several days in advance and 01. Practical use of satellite-based tsunami forecasting systems both scored more than 90 points.

Table 6.3-1 Top 20 Topics in Terms of Degree of Importance Index

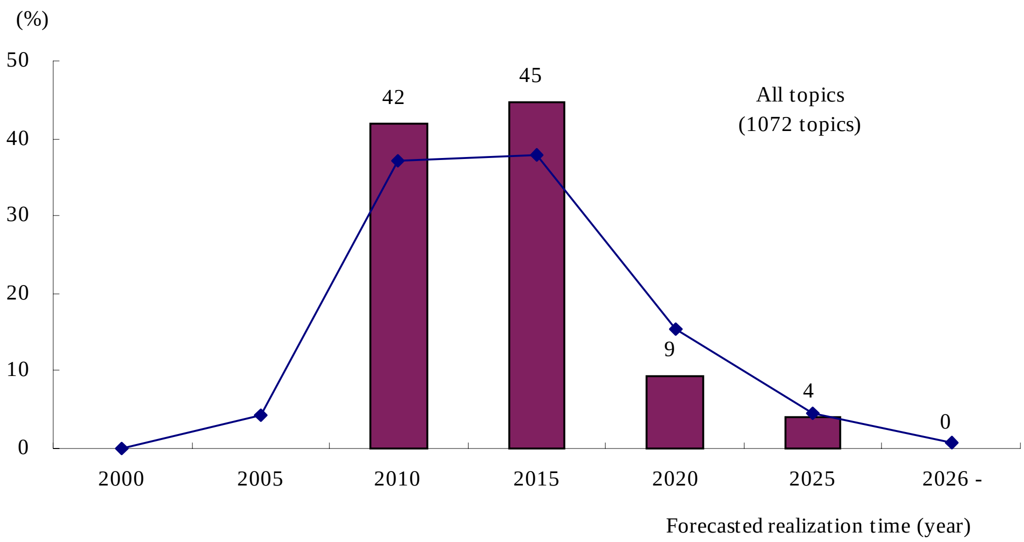
Topic	Degree of importance index	Forecasted realization time (year)
60 Development of technology capable of forecasting the occurrence of major earthquakes (magnitude 7 or above) several days in advance.	92	2023
01 Practical use of Tsunami forecasting systems based on tide and Tsunami observation through satellites and on other data including shelf topography.	91	2007
14 Development of a numerical model of the correlation between climatic changes and changes in marine living resources.	88	2013
43 Establishment of scientific methods for long-range weather forecasting (1-6 months in advance).	88	2014
45 Nationwide installation of bore-hole-type observation equipment integrating various types of gauges (e.g., seismometers, tiltmeters, and strain-gauges) for use in earthquake forecasting.	86	2011
58 Practical use of technology for predicting and forecasting landslides and rockslides caused by intense rainfall in certain locations in Japan.	86	2010
12 Practical use of technologies for predicting and forecasting changes in the ocean currents in the seas adjoining Japan.	85	2011
22 Development of safe, economically feasible technology for the removal/detoxification of sea-bottom sludges, enabling the widespread application of methods for decontamination and recovery of fishery grounds.	83	2013
17 Practical use of systems for monitoring water pollution on a global scale.	82	2012
18 Practical use of man-made off-shore islandsprocessing of living disposal. (total dissassemblyand decomposition of waste materials in order to dump harmful matter and recycle useful matter)	80	2012
26 Establishment of a quantitative marine ecosystem model, enabling elucidation of impacts on the ecosystem arising from ocean development.	80	2014
27 Widespread use of technologies for the comprehensive use and conservation of entire bays with high utilization densities, such as Tokyo Bay, Osaka Bay, etc.	80	2013
56 Development of technology to alleviate dangerously heavy rainfall through the application of nephology.	79	2020
13 Development of technologies based on large-scale numerical models for forecasting changes in the global oceans.	79	2010
23 Development of a model for predicting the occurrence of Red Tides.	79	2009
64 Elucidation of the entire aspect of the movement and storage of carbon dioxide extending over the air, land, oceans, and sea bottoms.	79	2016
69 Inauguration in Japan of global science and technology educational organizations in the broad sense, in order to foster international scientists and technologists contributing to conservation of the global environment, development and maintenance of global resources, etc.	78	2008
42 Widespread use of international monitoring systems to detect variations of atmospheric components in the stratosphere.	77	2009
04 Practical use of satellite remote sensing technology capable of yielding precise information on water temperature, currents,. and chlorophyl concentration to 200 m depth.	76	2009
41 Elucidation of the mechanisms of formation, variation and extinction of the ozone layer surrounding the earth.	76	2009

Note 1: Degree of importance index = (number of “high” responses × 100 + number of “medium” responses × 50 + number of “low” responses × 25 + number of “unnecessary” responses × 0) ÷ total number of degree of importance responses

6.4. Forecasted realization times

Forecasted realization times were distributed as shown in the diagram below.

Fig. 6.4-1 Trends in Forecasted Realization Times

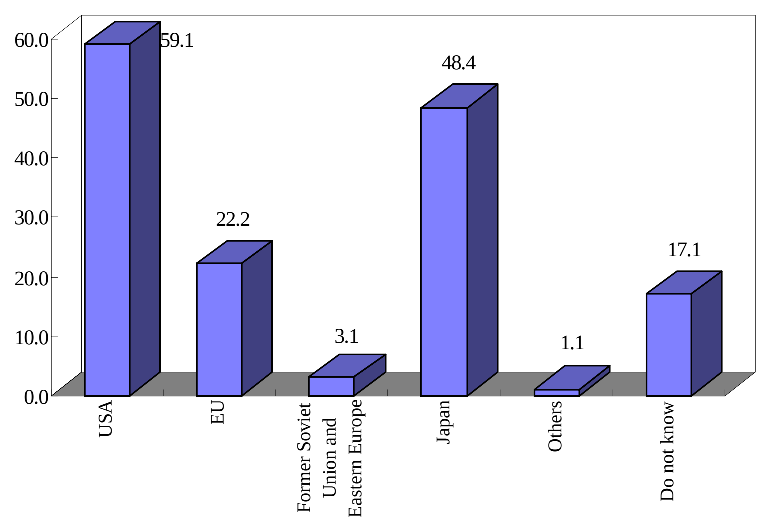


With nearly 50% of topics in this field forecasted to be realized between 2011 and 2015, the peak of the distribution of forecasted realization times was in line with that of the general trend covering all topics. Moreover, about 90% of all topics are predicted to be realized between 2006 and 2015 ó which is also very similar to the general trend.

6.5. Current leading countries etc.

Responses to the question concerning current leading countries etc. were as shown in the diagram below. Named by about 60% of the respondents, the U.S. ranked No. 1 in the marine science and earth science field as a whole, followed by Japan, which was some 10 percentage points behind. The score of the third-ranking EU was less than half that of Japans, and very few respondents chose the former Soviet Union or Eastern Europe.

Fig. 6.5-1 Current Leading Countries etc. (%)



6.6. Comparison with the 5th Survey (previous survey)

Of the 74 topics included in the latest survey, 39 (53%) were identical to the previous survey, 20 (27%) were modified, and 15 (20%) were newly introduced. For identical topics, the results of the latest survey were compared with those of the previous survey in terms of degree of importance index scores and forecasted realization times, as shown in the table below.

Degree of importance index scores rose for 16 topics, remained the same for 1 topic and fell for 22 topics. “01: Practical use of satellite-based tsunami forecasting systems” saw the greatest jump, up 20 points, while 41. Elucidation of the mechanisms of formation, variation and extinction of the ozone layer and “63: Realization of forecasting of the outbreak and scale of pyroclastic flows (nuee ardente, etc.) accompanying volcanic eruption” saw the greatest drop, both down 15 points.

From the 4th to the 5th Survey, forecasted realization times were either pushed back or remained the same for all but one topic. Likewise, from the 5th to the 6th Survey, all but one topic “36: Development of a revolutionary new underwater navigation system which dramatically improves performance” saw their forecasted realization times pushed further into the future. The topic whose forecasted realization time was pushed back most was “60: Development of technology capable of forecasting the occurrence of major earthquakes (magnitude 7 or above) several days in advance” (13 years).

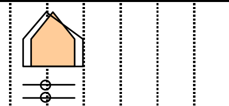
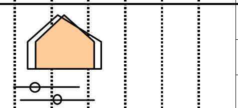
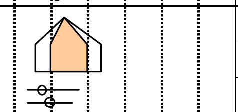
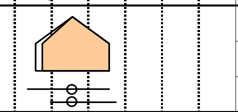
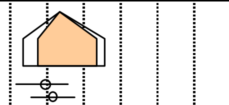
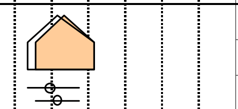
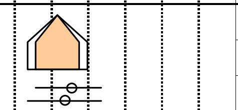
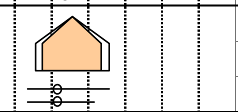
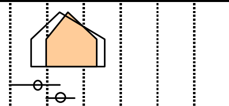
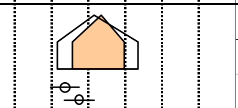
Table 6.6-1 Comparison with 5th Survey for Identical Topics

Topic	Degree of importance index / forecasted realization time	
	6th survey	5th survey
01 Practical use of Tsunami forecasting systems based on tide and Tsunami observation through satellites and on other data including shelf topography.	91/2007	71/2001
02 Practical use of marine observation system using sea plane by which samples are collected, instruments are installed and retrieved.	55/2008	51/1999
04 Practical use of satellite remote sensing technology capable of yielding precise information on water temperature, currents,. and chlorophyl concentration to 200 m depth.	76/2009	73/2005
05 Practical use of automatic observation systems which are fixed in open waters and are capable of long-term (year oder) monitoring of marine phenomena and conditions from the vicinity of the sea surface down to 6,000 m depth.	70/2008	65/2003
08 Widespread use of high-technology survey vessels exclusively specializing in geological, geophysical, physical or biological research, in addition to the multi-functional survey vessels currently in vogue.	69/2009	62/2002
11 Practical use of unmanned, untethered submersibles for gathering abyssal specimens.	63/2008	62/2001
12 Practical use of technologies for predicting and forecasting changes in the ocean currents in the seas adjoining Japan.	85/2011	76/2002
13 Development of technologies based on large-scale numerical models for forecasting changes in the global oceans.	79/2010	83/2004
14 Development of a numerical model of the correlation between climatic changes and changes in marine living resources.	88/2013	82/2006
15 Development of remote sensing technology using subsea stations that monitor temperature, current direction and speed, salinity, oxygen concentration, and other parameters throughout the water column.	63/2012	60/2003
16 Practical use of systems capable of continuously monitoring environmental changes and the interaction between sea ice and seawater for an extended period of time (several months) under sea ice in the polar regions.	50/2011	50/2003
18 Practical use of man-made off-shore islands processing of living disposal. (total dissassembly and decomposition of waste materials in order to dump harmful matter and recycle useful matter)	80/2012	74/2003

Topic	Degree of importance index / forecasted realization time	
	6th survey	5th survey
21 Advancement in the development of sea water decontamination systems such as decontaminating concrete blocks and bio-filters, and widespread use of water affinity space creating technologies.	70/2008	71/2003
22 Development of safe, economically feasible technology for the removal/detoxification of sea-bottom sludges, enabling the widespread application of methods for decontamination and recovery of fishery grounds.	83/2013	80/2002
25 Practical use of highly reliable automatic observation systems (chemical oceanography) located on the open sea, capable of monitoring marine pollution on a long-term basis (at least one year, without maintenance).	67/2012	73/2002
26 Establishment of a quantitative marine ecosystem model, enabling elucidation of impacts on the ecosystem arising from ocean development.	80/ 2014	83/2010
27 Widespread use of technologies for the comprehensive use and conservation of entire bays with high utilization densities, such as Tokyo Bay, Osaka Bay, etc.	80/2013	84/2004
28 Practical use of marine cities (bases for transportation, communication, research, production and recreational activities) mainly of the legged or floating structures.	60/2013	55/2007
35 Practical use of autonomous three-dimensional navigation systems for underwater vehicle	50/2009	59/2003
36 Development of a revolutionary new underwater navigation system which dramatically improves performance through twisting the body of the vessel or other innovative means.	43/2012	41/2013
37 Practical use of wireless technology for underwater communications in the horizontal plane over distances of several Km in order to facilitate smooth underwater operations.	57/2010	63/2002
39 Practical use of fuel cells that last for long period (at least one year) at abyssal depths.	59/2010	72/2003
41 Elucidation of the mechanisms of formation, variation and extinction of the ozone layer surrounding the earth.	76/2009	91/2002
45 Nationwide installation of bore-hole-type observation equipment integrating various types of gauges (e.g., seismometers, tiltmeters, and straingauges) for use in earthquake forecasting.	86/2011	82/2004
46 Widespread use of non-invasive (non-destructive) geological inspection equipment which allows the 3-D structures of strata, rocks, and fossils to be identified from meter-size CT images.	46/2012	53/2005
49 Practical use of boring technology capable of reaching the depth of 15 Km.	55/2012	62/2003
50 Development of technologies for digging into the crust at the ocean floor to gather mantle materials.	50/2016	60/2008
51 Elucidation of the series of processes including the generation, rise, storage, and extrusion of magma.	70/2016	81/2005
53 Widespread use of radar designed to be inserted into bored holes, in order to observe the behavior of water inside the earth's crust.	48/2012	61/2004
54 Practical use of analytical methods capable of tracing gradual changes (primitive fluctuations) involved in fossilization which cause material in organisms corpses to be replaced by silica.	38/2016	46/2007
57 Widespread use of observation systems for predicting downbursts (sudden downstreams) at airports and their vicinity in Japan.	68/2009	69/2000
58 Practical use of technology for predicting and forecasting landslides and rockslides caused by intense rainfall in certain locations in Japan.	86/2010	88/2001
60 Development of technology capable of forecasting the occurrence of major earthquakes (magnitude 7 or above) several days in advance.	92/2023	94/2010
61 Elucidation of the correlation, if any, between animal behavior and the occurrence of earthquakes, in order to be used as earthquake prediction data.	57/2016	50/2005
62 Realization of time-series observation of the condition of magma inside volcanoes.	75/2015	77/2006

Topic	Degree of importance index / forecasted realization time	
	6th survey	5th survey
63 Forecasting of the outbreak and scale of pyroclastic flows (nuee ardente, etc.) accompanying volcanic eruption to be realized.	75/2015	90/2005
69 Inauguration in Japan of global science and technology educational organizations in the broad sense, in order to foster international scientists and technologists contributing to conservation of the global environment, development and maintenance of global resources, etc.	78/2008	88/2001
70 Inauguration in Japan of international research centers for comparative planetology, including the science of the earth, based on the development of planetology through specimens obtained from meteorites and planets.	52/2011	60/2001
74 Adaptation of natural history and scientific education methods to hands-on science museums capable of developing scientific skills in an enjoyable and playful atmosphere, and their spread throughout Japan.	63/2010	53/2001

Note: Up until the 5th Survey, realization meant realization in Japan unless otherwise specified. However, this was changed to mean realization somewhere in the world in the 6th Survey. Therefore, care should be taken when comparing forecasted realization times from the two surveys.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time			Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001 2006 2011 2016 2021 2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Marine observation, forecasting, monitoring and surveying (elucidation of phenomena, accumulation of data, and predication/forecasting)	1	Practical use of Tsunami forecasting systems based on tide and Tsunami observation through satellites and on other data including shelf topography.	1	208	13	38	49	88	77	20	3	0	13	26	86	4		2	8	68	17	1	62	0	12	56	31	28	2	64	2	1	8	25	3	3
			2	179	15	39	46	91	81	19	0	0	5	26	89	1		2	7	73	8	1	68	0	7	69	28	18	0	72	0	0	6	25	1	1
			X	27	100	0	0	98	96	4	0	0	11	33	89	4		4	7	78	15	0	78	0	4	89	44	4	0	78	0	0	11	26	4	0
	2	Practical use of marine observation system using sea plane by which samples are collected, instruments are installed and retrieved.	1	209	19	33	47	56	25	50	23	2	7	88	10	26		9	7	61	13	1	14	2	30	30	33	24	1	63	8	2	22	10	1	3
			2	179	16	32	52	55	21	60	17	2	4	88	6	25		6	4	66	11	0	11	2	24	29	40	22	0	74	6	0	26	7	1	2
			X	28	100	0	0	68	39	54	7	0	7	96	0	36		7	4	71	11	0	18	4	21	32	36	21	0	79	14	0	18	0	0	0
	3	Development of methods for accurately calculating the amount of heat transfer in the water cycle of evaporation, cloud formation and rainfall over the oceans.	1	165	10	30	60	70	43	52	4	1	9	96	25	32		2	7	81	27	1	36	0	15	70	27	23	6	63	1	0	19	8	1	1
			2	142	9	28	63	69	39	59	1	0	6	97	20	27		1	5	82	24	0	37	0	11	75	25	18	2	68	0	0	21	5	0	1
			X	13	100	0	0	88	77	23	0	0	15	100	15	38		0	0	100	38	0	54	0	0	85	23	8	0	92	0	0	23	0	0	0
	4	Practical use of satellite remote sensing technology capable of yielding precise information on water temperature, currents,. and chlorophyl concentration to 200 m depth.	1	225	26	32	43	74	51	42	6	0	13	96	13	31		12	10	84	30	3	27	1	9	59	41	30	7	61	1	0	19	4	1	2
			2	190	23	30	47	76	54	44	2	1	12	93	9	25		8	7	88	30	2	27	1	7	68	44	26	1	67	0	1	18	2	0	2
			X	43	100	0	0	88	79	19	0	2	19	93	9	35		12	0	93	47	0	42	2	2	70	44	14	2	77	0	2	16	0	0	5
	5	Practical use of automatic observation systems which are fixed in open waters and are capable of long-term (year oder) monitoring of marine phenomena and conditions from the vicinity of the sea surface down to 6,000 m depth.	1	230	27	31	42	69	44	43	12	0	10	92	13	41		2	6	77	20	1	30	1	16	44	41	27	3	76	2	0	20	7	0	3
			2	185	25	34	41	70	44	50	7	0	9	94	7	35		1	3	84	21	1	33	1	11	51	44	23	1	78	1	0	21	3	0	3
			X	46	100	0	0	85	70	30	0	0	11	96	11	39		2	0	96	26	0	43	2	0	46	52	15	2	85	2	0	17	7	0	7
	6	Practical use of 3-D image analysis systems capable of identifying minute oceanic life (microorganisms, plankton, etc.)	1	176	19	28	52	60	31	50	17	2	15	86	6	40		1	9	65	26	0	30	1	23	57	48	24	10	48	0	1	18	1	1	2
			2	145	17	26	57	59	26	60	13	1	12	88	6	38		1	4	77	23	1	32	0	14	64	54	22	8	52	0	0	17	1	0	1
			X	24	100	0	0	77	54	46	0	0	13	83	8	54		4	0	92	46	0	42	0	0	75	67	8	8	63	0	0	8	0	0	4
	7	Development of sensors capable of accurately identifying objects under water at distances of several hundred meters.	1	160	8	31	61	52	21	48	29	2	39	46	24	25		1	11	72	20	9	28	0	19	43	51	19	1	53	1	1	16	14	1	2
			2	140	4	35	61	53	18	59	22	1	38	49	17	24		1	10	79	19	6	31	1	15	41	60	18	1	55	0	1	14	12	1	1
			X	6	100	0	0	79	67	17	17	0	17	67	17	17		0	0	83	33	0	67	0	17	33	67	17	0	50	0	0	17	0	17	17
	8	Widespread use of high-technology survey vessels exclusively specializing in geological, geophysical, physical or biological research, in addition to the multi-functional survey vessels currently in vogue.	1	251	31	29	39	66	41	42	15	2	17	88	10	48		10	12	75	34	9	25	1	12	42	34	29	2	65	3	4	16	4	1	4
			2	205	28	32	40	69	43	47	10	1	12	86	5	43		10	9	83	34	4	29	0	8	46	37	25	1	72	1	5	16	4	0	4
			X	57	100	0	0	78	63	26	9	2	18	93	7	56		16	7	77	30	2	25	0	11	46	32	25	0	74	2	14	16	4	0	9
	9	Widespread use of ocean observation systems employing continuous acoustic tomography.	1	178	13	30	57	59	28	53	19	0	15	86	14	40		3	8	78	20	4	33	1	16	53	46	24	2	63	0	0	21	8	1	2
			2	152	12	30	58	60	26	63	11	0	14	84	9	39		2	5	84	17	3	38	1	11	55	43	22	1	67	0	0	22	6	0	2
			X	18	100	0	0	79	65	24	12	0	17	78	11	56		6	0	100	39	0	56	6	0	39	39	11	0	83	0	0	33	11	0	6
	10	Development of maintenance-free devices capable of selectively monitoring subjects according to sudden and dramatic environmental changes on the ocean floor.	1	122	8	32	60	62	34	49	16	2	15	84	26	34		7	15	57	17	3	25	1	28	51	42	23	1	60	0	2	23	6	0	1
			2	111	5	25	69	59	26	60	12	2	9	79	16	37		8	11	62	15	1	29	0	25	53	39	17	0	67	0	2	26	3	0	2
			X	6	100	0	0	88	83	0	17	0	33	83	17	50		0	17	50	50	0	17	0	33	33	50	17	0	50	0	17	50	0	0	17

(Note) See page 7 for the interpretation of the graphs.

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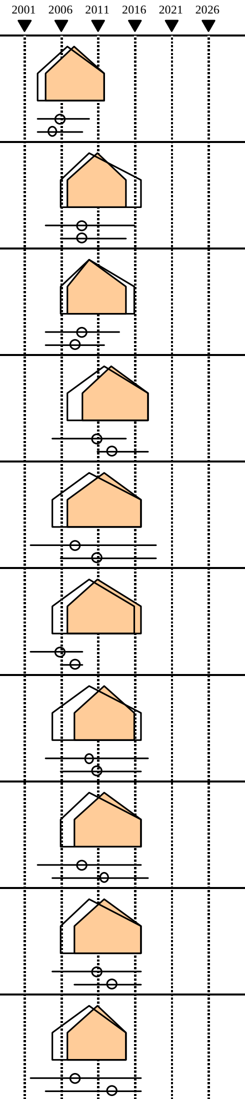
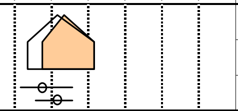
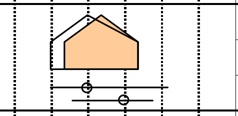
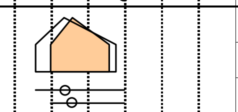
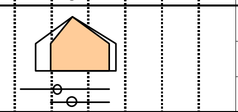
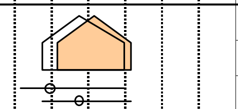
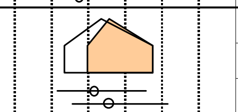
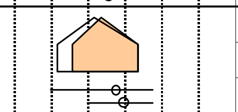
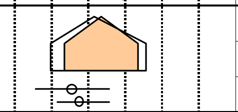
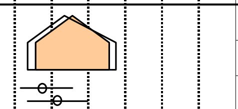
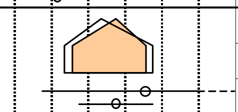
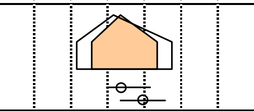
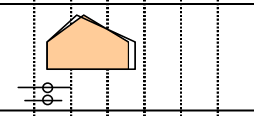
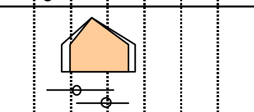
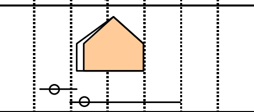
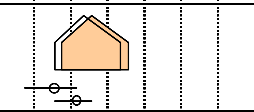
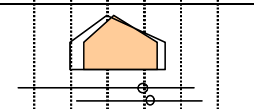
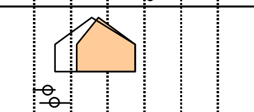
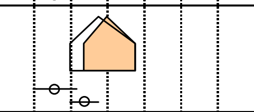
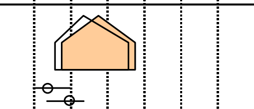
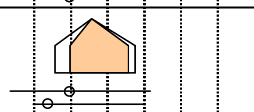
Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Medium	Low	Importance (index, %): Index	High	Medium	Low	Unnecessary	Expected effect (%): Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Forecasted realization time: Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Marine observation, forecasting, monitoring and surveying (elucidation of phenomena, accumulation of data, and predication/forecasting)	11	Practical use of unmanned, untethered submersibles for gathering abyssal specimens.	1	205	11	33	57	62	34	48	17	1	29	82	8	39	1	6	76	40	4	62	1	9	38	55	27	0	73	1	0	21	8	0	1
			2	174	10	32	58	63	31	61	8	0	22	78	4	47	1	5	79	36	3	68	0	7	35	59	24	0	76	0	1	23	4	1	2
			X	18	100	0	0	82	67	28	6	0	11	78	11	44	6	0	89	33	6	61	0	0	22	61	17	0	83	0	0	17	0	6	11
	12	Practical use of technologies for predicting and forecasting changes in the ocean currents in the seas adjoining Japan.	1	215	21	26	53	80	62	35	3	0	26	87	35	25	3	6	50	13	2	65	0	15	70	26	25	9	60	0	1	20	9	1	3
			2	185	21	29	50	85	69	31	0	0	27	86	30	22	2	3	58	10	1	76	0	9	76	21	21	5	69	0	1	20	6	0	2
			X	39	100	0	0	95	90	10	0	0	26	87	38	41	0	0	77	18	0	90	0	0	85	23	23	8	77	0	0	23	8	0	0
	13	Development of technologies based on large-scale numerical models for forecasting changes in the global oceans.	1	220	12	35	53	78	58	38	4	0	15	95	25	35	4	8	86	35	3	46	1	10	74	30	23	8	65	0	0	18	6	3	1
			2	183	10	38	52	79	61	36	4	0	12	94	14	38	2	7	88	31	2	51	1	7	79	25	23	4	67	0	1	19	5	2	2
			X	19	100	0	0	93	89	5	5	0	16	89	32	63	0	5	95	53	0	63	11	0	58	16	26	0	84	0	5	16	5	0	0
	14	Development of a numerical model of the correlation between climatic changes and changes in marine living resources.	1	178	18	32	50	83	66	31	2	0	34	92	17	26	3	10	54	26	3	47	2	24	73	38	20	12	55	0	1	21	4	4	2
			2	149	15	30	55	88	77	22	1	0	37	89	13	24	3	8	68	24	1	58	1	17	80	36	15	8	62	0	1	21	3	4	2
			X	22	100	0	0	98	95	5	0	0	50	91	14	50	0	5	86	41	0	64	5	0	68	50	14	9	68	0	5	27	5	5	0
	15	Development of remote sensing technology using subsea stations that monitor temperature, current direction and speed, salinity, oxygen concentration, and other parameters throughout the water column.	1	206	16	39	45	64	36	50	13	1	15	94	14	34	4	9	67	18	3	33	0	22	49	47	24	2	69	2	1	21	7	1	2
			2	179	12	41	47	63	32	58	9	1	12	93	9	36	2	7	74	13	2	39	0	17	55	44	18	1	72	0	2	23	6	1	2
			X	21	100	0	0	86	71	29	0	0	14	90	10	52	0	0	86	14	0	57	0	5	57	52	5	0	76	0	5	48	5	5	5
	16	Practical use of systems capable of continuously monitoring environmental changes and the interaction between sea ice and seawater for an extended period of time (several months) under sea ice in the polar regions.	1	167	12	31	57	49	15	53	30	2	10	89	2	39	2	8	77	27	24	22	7	11	51	41	19	2	63	0	1	23	5	1	1
			2	147	12	29	59	50	15	54	30	1	7	88	1	39	1	6	85	26	24	23	6	10	57	37	16	2	69	0	2	24	3	0	2
			X	18	100	0	0	68	39	56	6	0	11	83	0	72	6	0	94	44	22	28	11	0	61	44	6	0	83	0	6	39	0	0	6
Protection/creation of marine environment	17	Practical use of systems for monitoring water pollution on a global scale.	1	222	18	28	53	78	60	34	6	0	21	97	28	18	3	9	72	40	2	38	1	18	55	36	27	11	69	3	1	18	6	4	1
			2	193	18	26	55	82	65	32	3	0	19	96	24	11	3	8	83	38	1	39	1	15	64	36	20	5	77	2	1	17	4	3	2
			X	35	100	0	0	93	86	14	0	0	17	91	29	20	0	11	91	69	0	57	0	9	63	49	14	6	77	3	3	29	9	3	3
	18	Practical use of man-made off-shore islands processing of living disposal. (total dissassembly and decomposition of waste materials in order to dump harmful matter and recycle useful matter)	1	166	17	31	52	73	58	25	11	6	51	67	39	2	12	6	20	16	1	46	0	33	27	48	18	2	55	25	3	62	13	4	1
			2	150	17	31	52	80	68	21	7	4	57	67	37	2	7	7	18	12	0	62	0	24	21	57	10	1	63	25	3	65	9	3	2
			X	26	100	0	0	87	81	12	0	8	73	62	31	0	12	0	19	8	0	88	0	12	15	65	8	0	62	27	12	73	15	0	4
	19	Practical use of systems capable of monitoring changes in living resources on coastal ocean floors over an extended period of time.	1	163	15	36	50	72	49	40	11	0	31	87	14	20	11	12	45	18	1	37	1	33	52	44	22	9	64	2	0	21	6	4	1
			2	140	12	36	51	74	51	43	6	0	36	81	14	15	9	11	51	19	1	45	0	32	59	46	16	4	71	3	0	24	4	2	1
			X	17	100	0	0	85	71	29	0	0	47	76	24	24	18	12	65	47	0	47	0	24	41	59	12	6	65	6	0	41	6	0	0
	20	Initiation of long-term, comprehensive observation on an international basis, and elucidation of the formation mechanism of carbon dioxide fixing coral reefs.	1	190	12	28	59	58	31	44	22	3	9	93	6	32	5	7	59	26	1	47	9	19	67	31	18	8	56	2	3	27	5	3	1
			2	153	10	25	65	57	24	58	16	3	3	92	2	32	5	7	60	22	1	48	8	20	75	30	11	4	63	2	1	28	5	1	0
			X	15	100	0	0	62	40	40	7	13	7	93	7	33	20	0	67	33	0	47	27	7	53	33	20	7	53	0	7	27	7	0	0



(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time			Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001 2006 2011 2016 2021 2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Protection/creation of marine environment	21	Advancement in the development of sea water decontamination systems such as decontaminating concrete blocks and bio-filters, and widespread use of water affinity space creating technologies.	1	140	16	34	50	70	46	43	11	1	46	76	50	4		4	9	31	23	1	59	1	24	39	61	20	5	57	17	4	46	4	4	1
			2	123	11	36	54	70	45	46	7	2	41	72	60	2		2	4	33	26	0	70	0	18	41	70	9	3	62	14	2	54	5	2	1
			X	13	100	0	0	85	69	31	0	0	62	69	62	0		0	8	46	23	0	85	0	8	38	77	8	0	77	8	15	54	15	0	8
	22	Development of safe, economically feasible technology for the removal/detoxification of sea-bottom sludges, enabling the widespread application of methods for decontamination and recovery of fishery grounds.	1	170	18	31	52	79	62	32	6	1	42	79	41	6		7	13	18	11	0	55	1	32	35	56	16	3	58	14	4	41	4	4	1
			2	143	15	32	53	83	69	25	6	0	38	76	42	3		7	5	18	10	0	66	1	26	34	65	8	1	68	14	2	51	3	2	2
			X	21	100	0	0	90	81	19	0	0	43	90	52	0		0	5	48	24	0	81	5	10	43	57	10	0	71	14	10	57	5	5	10
	23	Development of a model for predicting the occurrence of Red Tides.	1	181	22	28	51	74	53	38	8	1	28	80	36	13		4	9	23	12	1	79	1	13	70	33	23	17	54	3	2	22	2	4	1
			2	144	18	34	48	79	62	31	7	0	28	82	40	8		3	5	24	6	0	86	0	8	78	30	15	12	63	2	0	26	2	2	1
			X	26	100	0	0	89	81	15	4	0	31	88	31	15		0	8	42	12	0	92	0	4	81	46	12	19	65	4	0	35	4	4	0
	24	Widespread use of breakwaters which take into account the natural scenery along with the proliferation of microorganisms living in the ocean.	1	155	24	28	48	59	30	47	21	1	41	63	53	4		6	7	22	15	0	55	1	32	41	54	17	3	52	15	2	35	5	5	0
			2	137	19	28	53	60	30	53	16	1	34	60	58	2		4	4	21	15	0	61	1	24	36	69	9	0	61	14	1	41	4	1	1
			X	26	100	0	0	75	56	32	12	0	42	58	62	0		4	4	31	23	0	92	0	0	46	77	4	0	65	23	0	35	4	0	4
	25	Practical use of highly reliable automatic observation systems (chemical oceanography) located on the open sea, capable of monitoring marine pollution on a long-term basis (at least one year, without maintenance).	1	198	14	34	52	66	38	49	12	1	15	91	16	23		2	9	61	20	0	35	2	23	45	55	21	5	65	3	3	18	4	1	1
			2	167	17	32	51	67	38	55	6	1	11	92	8	22		1	7	71	17	1	41	1	19	46	64	14	1	74	1	1	19	3	1	2
			X	28	100	0	0	79	61	36	4	0	7	93	0	36		4	7	79	36	0	43	4	11	46	79	14	0	79	0	4	18	0	0	4
	26	Establishment of a quantitative marine ecosystem model, enabling elucidation of impacts on the ecosystem arising from ocean development.	1	183	25	35	40	77	57	36	6	1	29	90	17	30		10	11	69	34	1	44	1	15	72	43	19	13	59	1	2	21	1	5	1
			2	152	24	35	41	80	62	34	3	1	30	91	16	27		10	8	78	38	0	49	1	11	80	47	13	8	67	0	1	22	1	3	1
			X	36	100	0	0	88	78	17	6	0	44	92	17	33		6	14	89	56	0	58	0	3	78	50	22	6	72	0	3	28	0	0	3
Resources energy and space utilization	27	Widespread use of technologies for the comprehensive use and conservation of entire bays with high utilization densities, such as Tokyo Bay, Osaka Bay, etc.	1	179	27	30	43	79	61	33	6	1	69	60	51	6		6	12	27	15	0	58	0	20	36	61	12	8	50	27	3	38	10	7	2
			2	158	26	30	44	80	63	31	5	1	76	54	52	3		5	8	27	13	0	71	0	15	35	61	11	6	58	25	3	49	8	3	1
			X	41	100	0	0	92	85	12	2	0	78	54	51	2		10	5	37	20	0	80	0	10	44	59	10	10	61	29	5	63	17	0	5
	28	Practical use of marine cities (bases for transportation, communication, research, production and recreational activities) mainly of the legged or floating structures.	1	151	32	17	51	58	33	40	22	6	85	30	40	5		9	9	31	21	0	58	0	22	20	56	17	1	53	32	2	60	23	8	1
			2	133	33	17	50	60	33	43	21	3	87	24	43	3		5	7	34	20	0	74	0	14	20	62	10	2	62	32	2	65	23	2	2
			X	44	100	0	0	75	57	34	5	5	93	32	50	5		7	2	32	20	0	91	0	0	18	70	9	2	75	41	0	64	32	2	2
	29	Practical use of on-site inspection, diagnosis, and maintenance technology for marine facilities.	1	117	23	29	48	63	33	54	12	1	70	29	34	4		1	5	44	33	3	43	0	25	30	61	19	3	47	15	0	23	16	3	1
			2	109	24	27	50	63	30	61	9	0	79	25	27	2		1	2	54	37	1	55	0	20	29	69	13	1	55	14	0	24	11	0	1
			X	26	100	0	0	75	54	38	8	0	77	23	31	0		0	0	69	54	0	69	0	0	42	65	12	0	69	15	0	27	27	0	0
	30	Widespread use of marine ranches with optimal environmental management through incorporation of biological system technology and a wide range of engineering technology.	1	170	15	31	55	64	37	47	13	3	55	74	24	4		13	6	18	15	0	64	1	25	39	66	18	4	54	12	2	52	6	6	0
			2	141	16	28	57	66	38	50	9	2	60	72	20	3		11	2	18	11	1	76	0	19	37	77	11	2	65	10	1	62	5	4	1
			X	22	100	0	0	82	64	36	0	0	86	77	9	5		9	5	32	23	5	86	0	5	68	91	14	0	77	0	5	64	9	0	0

(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%) High	Degree of expertise (%) Medium	Degree of expertise (%) Low	Importance (index, %) Index	Importance High	Importance Medium	Importance Low	Importance Unnecessary	Expected effect (%) Socioeconomic development	Expected effect Resolution of global problems	Expected effect People's needs	Expected effect Expansion of intellectual resources	Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%) USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%) Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%) Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Resources energy and space utilization	31	Development of revolutionary drag-reducing technology for underwater/surface vessel , such as the use of active skin to cover the surface of the hull.	1	72	19	32	49	54	22	54	19	4	72	26	11	17		3	10	42	19	7	56	0	22	42	57	18	0	47	0	0	15	8	1	3
			2	66	14	32	55	54	18	64	17	2	80	26	11	11		5	9	52	18	6	67	0	12	42	55	17	0	55	0	0	18	6	0	2
			X	9	100	0	0	53	11	78	11	0	78	33	0	11		11	22	56	33	0	78	0	0	33	67	11	0	56	0	0	22	0	0	0
	32	Practical use of breakwaters capable of utilizing the wave energy to generate electricity.	1	165	20	24	56	65	39	43	17	1	52	79	17	2		3	5	21	34	1	70	1	15	27	58	19	0	61	15	2	33	12	2	2
			2	148	19	26	55	65	36	51	13	0	59	74	15	1		3	5	19	31	0	76	2	11	22	68	13	0	68	15	1	41	9	1	1
			X	28	100	0	0	68	42	46	12	0	32	71	21	4		4	0	7	32	0	82	4	0	7	46	7	0	54	25	7	32	4	0	4
	33	Widespread use of culture technology allowing engineering applications microbes extracted from sea water or the sea bottom.	1	112	12	21	67	59	29	51	18	2	52	67	14	21		1	12	54	31	1	50	0	26	56	47	21	20	48	1	3	38	12	7	1
			2	93	6	25	69	55	22	59	17	2	61	62	9	16		2	11	66	31	0	65	0	19	66	45	19	16	54	1	1	42	9	4	0
			X	6	100	0	0	75	50	50	0	0	50	100	0	0		0	0	100	33	0	100	0	0	67	67	17	17	50	0	0	33	0	0	0
	34	Development of sea-water (hydrogen) engines to power underwater vehicle.	1	55	7	25	67	58	34	40	19	8	55	55	7	16		4	13	38	16	5	40	0	29	42	51	16	0	60	2	0	20	13	4	5
			2	52	8	21	71	59	31	47	16	6	67	44	2	17		6	8	40	15	4	44	0	33	42	56	13	2	62	4	0	25	12	4	2
			X	4	100	0	0	56	25	50	25	0	100	25	0	25		0	0	25	25	25	75	0	0	25	50	0	25	50	0	0	50	25	0	0
	35	Practical use of autonomous three-dimensional navigation systems for underwater vehicle.	1	79	14	25	61	53	22	50	24	4	70	33	6	25		0	3	66	23	8	52	0	15	38	54	15	1	58	3	0	9	16	3	1
			2	70	13	26	61	50	13	61	26	0	79	23	1	20		1	3	74	24	4	57	0	11	41	61	14	0	67	1	0	4	19	1	1
			X	9	100	0	0	53	11	78	11	0	78	44	0	11		0	0	78	11	0	89	0	0	44	67	0	0	56	0	0	0	22	0	0
	36	Development of a revolutionary new underwater navigation system which dramatically improves performance through twisting the body of the vessel or other innovative means.	1	61	13	33	54	44	14	42	35	9	64	23	3	34		16	26	33	10	3	36	0	34	54	41	8	0	43	0	0	5	11	2	5
			2	60	10	32	58	43	12	47	33	8	65	15	0	28		15	20	32	8	2	48	0	32	62	42	3	0	55	0	0	3	13	2	2
			X	6	100	0	0	46	17	33	50	0	83	33	0	17		17	0	50	0	0	100	0	0	67	33	0	0	50	0	0	0	33	0	0
	37	Practical use of wireless technology for underwater communications in the horizontal plane over distances of several km in order to facilitate smooth underwater operations.	1	71	8	17	75	60	31	49	19	1	76	28	15	15		3	6	69	25	8	34	0	21	51	52	21	0	49	0	0	10	17	0	1
			2	63	6	17	76	57	24	57	17	2	78	24	8	14		2	6	71	29	5	35	0	22	60	56	13	0	60	0	0	8	14	2	3
			X	4	100	0	0	75	50	50	0	0	75	25	0	0		0	0	100	75	0	100	0	0	25	50	0	0	100	0	0	0	25	0	0
	38	Practical use of robots for underwater resource exploration at depths of up to 10,000 m.	1	142	8	20	72	53	20	54	25	2	46	74	5	25		3	9	63	35	4	62	0	11	35	51	29	1	62	0	1	17	8	1	3
			2	129	8	18	74	52	14	67	19	1	44	76	0	26		2	5	73	31	2	70	0	9	43	60	23	0	75	1	0	21	4	2	2
			X	10	100	0	0	53	10	80	10	0	30	80	0	0		10	0	60	20	10	90	0	0	40	40	0	0	60	0	0	30	0	0	0
	39	Practical use of fuel cells that last for long period (at least one year) at abyssal depths.	1	95	4	17	79	62	34	46	20	0	47	65	11	25		3	11	57	27	3	39	1	25	39	53	18	0	62	4	3	22	9	4	1
			2	81	2	16	81	59	26	59	15	0	49	69	4	22		1	6	68	20	0	49	0	21	37	62	12	0	70	1	2	27	4	2	1
			X	2	100	0	0	75	50	50	0	0	50	100	0	0		0	0	50	50	0	100	0	0	100	50	0	0	100	0	0	50	0	0	0
	40	Widespread use of micro-biotelemetry to analyze the migratory activities of marine organisms over extended periods of time.	1	123	6	25	69	58	28	48	23	1	17	73	4	59		1	8	67	27	2	53	3	19	47	59	15	3	61	2	0	19	4	7	2
			2	104	5	21	74	55	20	59	19	1	15	73	5	59		1	3	72	20	0	59	2	17	50	68	12	0	69	1	0	18	2	2	2
			X	5	100	0	0	65	40	40	20	0	20	80	0	80		0	20	80	20	0	100	0	0	80	80	0	0	80	0	0	20	0	0	0

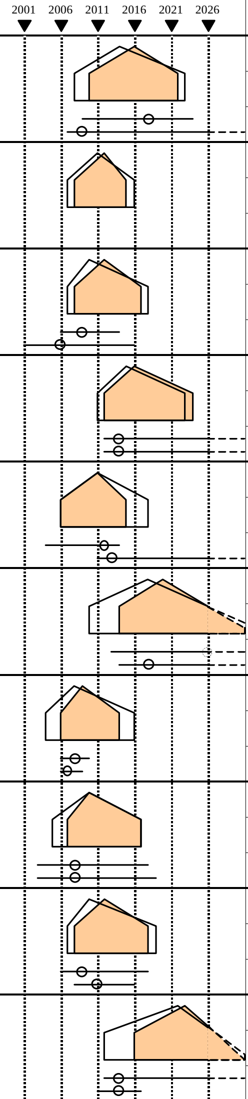
(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time			Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001 2006 2011 2016 2021 2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Earth observation and forecasting (elucidation of phenomena, accumulation of data, and predication/forecasting)	41	Elucidation of the mechanisms of formation, variation and extinction of the ozone layer surrounding the earth.	1	142	4	18	77	75	52	43	4	1	9	95	21	28		4	11	80	43	4	39	1	15	75	23	32	9	65	1	1	23	3	4	0
			2	124	6	17	77	76	54	42	4	0	7	94	14	22		2	8	82	44	2	41	1	12	78	22	31	6	68	0	1	29	1	2	0
			X	7	100	0	0	86	71	29	0	0	14	100	14	57		0	0	100	71	0	57	0	0	86	29	71	0	71	0	0	43	0	0	0
	42	Widespread use of international monitoring systems to detect variations of atmospheric components in the stratosphere.	1	113	4	19	76	71	48	40	11	1	11	93	11	22		3	10	78	43	3	38	1	13	58	25	25	10	68	3	2	19	6	1	0
			2	98	4	17	79	77	56	40	4	0	7	91	3	17		2	8	82	48	0	42	1	10	62	26	18	7	69	3	1	27	4	1	0
			X	4	100	0	0	75	50	50	0	0	0	100	0	50		0	0	100	50	0	50	0	0	50	25	75	25	50	0	0	25	0	0	0
	43	Establishment of scientific methods for long-range weather forecasting (1-6 months in advance).	1	123	7	24	68	82	66	30	3	0	36	83	43	21		10	11	80	48	3	63	2	11	69	21	30	14	53	1	0	15	9	8	1
			2	114	6	24	70	88	77	21	3	0	34	85	42	15		10	5	83	46	0	66	1	10	74	18	32	7	59	1	0	18	5	6	1
			X	7	100	0	0	100	100	0	0	0	29	86	71	29		0	0	100	71	0	86	0	0	71	14	57	14	100	0	0	14	0	0	0
	44	Practical use of unmanned planes for typhoon observation and data/sample collection.	1	85	5	19	76	62	33	49	16	1	20	69	45	18		7	9	62	12	5	22	4	22	36	38	27	1	66	8	1	13	16	0	2
			2	82	4	18	78	63	32	60	7	1	20	78	41	15		6	9	70	9	0	24	2	18	44	33	23	0	73	2	1	13	21	0	2
			X	3	100	0	0	83	67	33	0	0	0	67	33	0		0	0	100	33	0	33	0	0	33	67	0	0	100	0	0	33	33	0	0
	45	Nationwide installation of bore-hole-type observation equipment integrating various types of gauges (e.g., seismometers, tiltmeters, and strain-gauges) for use in earthquake forecasting.	1	109	12	24	64	82	67	25	8	0	16	35	77	27		6	9	44	8	2	80	1	6	48	32	30	5	71	4	4	9	10	2	1
			2	98	11	19	69	86	77	16	7	0	12	34	79	24		4	8	40	4	1	85	0	6	51	31	28	2	77	4	1	9	12	2	1
			X	11	100	0	0	82	73	9	18	0	9	27	91	36		0	0	36	0	0	100	0	0	64	27	27	0	91	0	9	9	0	0	0
	46	Widespread use of non-invasive (non-destructive) geological inspection equipment which allows the 3-D structures of strata, rocks, and fossils to be identified from meter-size CT images.	1	68	13	29	57	45	15	40	40	4	18	41	24	57		1	12	49	19	0	47	0	29	41	41	37	6	44	0	1	13	9	4	0
			2	59	14	24	63	46	16	41	38	5	15	39	19	63		2	8	51	17	0	49	0	29	47	34	36	3	58	0	2	14	5	0	0
			X	8	100	0	0	41	13	38	38	13	0	50	13	75		0	0	63	25	0	50	0	13	75	25	38	13	75	0	0	25	13	0	0
	47	Practical use of super-conducting gravity meters with the capability to detect the movement of material deep inside the earth.	1	47	13	19	68	45	11	52	32	5	6	55	17	62		2	23	53	19	0	38	2	28	51	17	30	6	51	0	0	19	9	4	0
			2	43	14	14	72	43	10	48	40	2	5	56	12	63		5	12	60	16	0	42	2	21	56	12	30	5	65	0	0	23	5	0	0
			X	6	100	0	0	50	33	17	33	17	0	50	17	67		17	0	67	50	0	50	0	0	50	0	17	0	83	0	0	33	17	0	0
	48	Practical use of 6,000 meter-class deep sea excavation technology capable of measuring stresses in the crust of the ocean floor.	1	95	20	26	54	59	29	50	20	1	19	64	31	48		1	4	82	27	13	38	0	9	45	43	26	1	69	1	0	22	5	2	1
			2	82	17	29	54	58	26	56	18	0	15	70	24	52		0	4	87	26	7	40	0	6	46	43	24	0	76	0	0	23	1	1	1
			X	14	100	0	0	71	50	36	14	0	0	86	29	50		0	7	93	36	7	43	0	7	43	50	14	0	79	0	0	29	7	0	0
	49	Practical use of boring technology capable of reaching the depth of 15 km.	1	89	16	27	57	54	25	45	25	5	19	72	25	49		4	10	69	37	49	22	0	7	43	51	22	1	64	0	2	27	8	0	0
			2	77	17	26	57	55	25	45	29	1	16	71	22	51		4	9	77	34	55	21	0	3	38	57	16	0	77	0	0	26	4	0	0
			X	13	100	0	0	63	38	46	8	8	8	85	38	62		8	15	85	69	85	38	0	0	31	77	15	0	85	0	0	31	15	0	0
	50	Development of technologies for digging into the crust at the ocean floor to gather mantle materials.	1	82	16	30	54	51	21	43	32	4	13	56	16	59		7	16	73	29	27	21	0	17	37	46	29	2	68	1	1	33	10	0	0
			2	71	15	30	55	50	19	46	33	3	8	58	11	63		4	6	79	27	32	20	0	14	35	46	24	0	82	0	1	31	7	0	1
			X	11	100	0	0	61	36	45	9	9	0	55	9	82		18	18	82	18	27	27	0	9	18	45	27	0	82	0	9	27	9	0	0

(Note) See page 7 for the interpretation of the graphs.

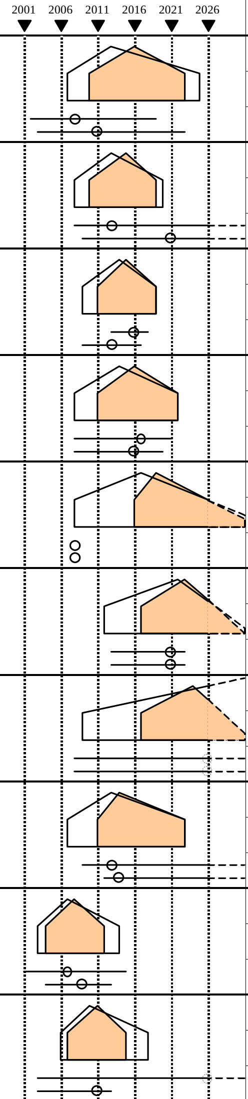
Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%) High	Degree of expertise (%) Medium	Degree of expertise (%) Low	Importance (index, %) Index	Importance High	Importance Medium	Importance Low	Importance Unnecessary	Expected effect (%) Socioeconomic development	Expected effect Resolution of global problems	Expected effect People's needs	Expected effect Expansion of intellectual resources	Forecasted realization time: Will not be realized (%)	Forecasted realization time: Do not know (%)	Leading countries (%) USA	Leading countries EU	Leading countries Former Soviet Union and Eastern Europe	Leading countries Japan	Leading countries Other countries	Leading countries Do not know	Measures the government should adopt (%) Foster human resources	Measures Promote exchanges among industrial, academic and government sectors and different fields	Measures Upgrade advanced facilities and equipment	Measures Develop a research base	Measures Increase government research funding	Measures Adjust regulations (relax/toughen)	Measures Others	Potential problems (%) Adverse effect on the natural environment	Potential problems Adverse effect on safety	Potential problems Adverse effect on morals, culture or society	Potential problems Other adverse effects
Earth observation and forecasting	51	Elucidation of the series of processes including the generation, rise, storage, and extrusion of magma.	1	81	10	27	63	70	47	41	10	3	9	54	65	47	6	12	63	23	7	78	1	9	75	21	25	4	51	1	0	17	6	4	0
			2	68	7	28	65	70	47	41	11	2	7	57	59	56	3	10	68	15	7	81	0	4	82	18	21	3	59	0	0	16	3	3	1
			X	5	100	0	0	75	60	20	20	0	0	100	60	60	20	20	100	20	0	100	0	0	100	20	60	20	60	0	0	20	20	0	0
	52	Positioning in several locations, under an international agreement, of neutrino detectors for the purpose of surveying the earth's internal structure.	1	51	0	14	86	42	13	38	42	8	2	41	8	67	6	18	57	31	6	73	0	16	47	18	31	0	71	0	0	14	2	2	0
			2	43	0	12	88	37	7	34	49	10	5	44	5	70	5	14	60	28	7	84	0	7	44	26	30	0	79	0	0	14	0	0	0
			X	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Protection/creation of global environment	53	Widespread use of radar designed to be inserted into bored holes, in order to observe the behavior of water inside the earth's crust.	1	48	13	17	71	50	19	49	26	6	17	67	38	27	6	10	46	17	4	50	0	25	44	40	25	6	44	0	0	15	8	0	0
			2	36	14	22	64	48	14	53	31	3	17	58	39	33	3	11	56	19	3	56	0	25	50	47	22	0	53	0	0	22	3	0	0
			X	5	100	0	0	75	60	20	20	0	20	80	40	0	20	0	80	60	0	60	0	20	40	40	40	0	20	0	0	0	0	0	0
	54	Practical use of analytical methods capable of tracing gradual changes (primitive fluctuations) involved in fossilization which cause material in organisms corpses to be replaced by silica.	1	53	6	30	64	38	10	31	51	8	9	51	0	60	8	28	42	32	4	28	0	40	64	19	25	9	30	0	2	15	2	6	0
			2	45	7	22	71	38	14	16	66	5	11	44	0	69	7	16	53	29	7	24	0	38	82	18	31	4	36	0	0	22	0	2	0
			X	3	100	0	0	33	0	33	67	0	67	67	0	33	0	0	100	67	33	100	0	0	100	67	67	0	33	0	0	67	0	0	0
	55	Widespread use of systems for forcing water into high-temperature subterranean locations in order to extract thermal energy in the form of steam.	1	101	6	25	69	69	46	41	11	2	37	81	13	9	3	13	44	26	4	65	6	20	31	50	18	1	54	10	1	52	13	2	1
			2	86	5	21	74	65	36	52	11	1	41	73	12	2	3	9	45	29	2	67	2	19	31	56	12	1	67	10	0	57	8	1	1
			X	4	100	0	0	100	100	0	0	0	50	100	0	25	0	0	50	50	0	75	0	0	0	75	25	0	75	50	0	50	0	0	0
Natural disaster prevention/preparedness	56	Development of technology to alleviate dangerously heavy rainfall through the application of nephology.	1	86	8	13	79	76	58	33	8	3	19	50	69	14	13	26	42	13	6	28	1	34	51	21	17	2	36	1	1	34	20	1	0
			2	85	8	9	82	79	63	30	6	1	15	44	73	6	11	24	51	7	6	29	1	31	65	24	15	0	48	2	0	44	14	0	0
			X	7	100	0	0	100	100	0	0	0	29	57	57	0	14	14	71	14	29	43	0	0	57	57	14	0	29	14	0	43	29	0	0
	57	Widespread use of observation systems for predicting downbursts (sudden downstreams) at airports and their vicinity in Japan.	1	87	8	11	80	67	41	46	11	2	25	15	78	8	3	10	72	11	1	37	1	13	55	31	20	3	49	2	1	14	15	1	0
			2	83	7	14	78	68	41	49	7	2	29	12	73	5	2	10	75	8	0	42	0	11	64	34	14	1	58	6	0	12	14	0	0
			X	6	100	0	0	83	67	33	0	0	33	17	83	0	0	33	100	17	0	33	0	0	50	33	17	0	67	33	0	0	17	0	0
	58	Practical use of technology for predicting and forecasting landslides and rockslides caused by intense rainfall in certain locations in Japan.	1	100	13	13	74	78	60	33	5	1	15	20	89	3	6	12	16	6	1	66	0	22	57	35	22	8	61	0	0	16	12	2	0
			2	88	13	16	72	86	75	22	2	1	14	19	88	1	6	9	15	2	0	75	1	17	59	32	19	3	69	0	0	15	8	2	0
			X	11	100	0	0	95	90	10	0	0	0	36	82	0	18	0	9	9	0	64	0	18	73	45	18	0	73	0	0	9	0	0	0
	59	Development of technology for monitoring chronological trends in the location and amount of snowfall, facilitating forecasting of the scale and degree of risk of surface avalanches in certain locations in Japan.	1	85	9	16	74	64	36	49	14	1	13	12	85	6	2	8	16	21	0	51	1	28	51	29	22	6	56	0	0	13	16	2	0
			2	82	11	11	78	64	32	60	9	0	11	10	89	2	1	7	12	18	0	56	0	29	59	28	18	4	65	0	1	7	17	2	1
			X	9	100	0	0	78	56	44	0	0	11	22	89	0	0	0	22	56	0	78	0	11	56	44	11	0	56	0	0	0	11	0	0
	60	Development of technology capable of forecasting the occurrence of major earthquakes (magnitude 7 or above) several days in advance.	1	115	9	24	67	90	85	11	2	3	17	21	85	22	27	16	34	14	3	75	8	10	58	23	34	7	54	3	3	7	16	6	1
			2	102	9	21	71	92	87	9	2	2	15	21	85	19	29	14	31	9	3	78	8	8	59	25	32	5	59	4	1	5	19	3	1
			X	9	100	0	0	100	100	0	0	0	33	33	89	33	22	0	11	11	0	89	0	0	78	33	44	11	44	0	0	0	11	0	0

Forecasted realization time

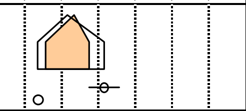
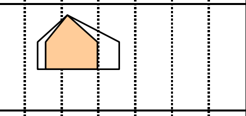
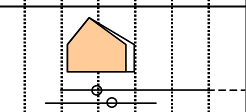
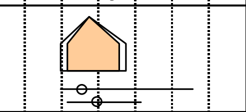


(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%) High	Medium	Low	Importance (index, %) Index	High	Medium	Low	Unnecessary	Expected effect (%) Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Forecasted realization time (2001 2006 2011 2016 2021 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%) USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%) Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%) Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Natural disaster prevention/preparedness	61	Elucidation of the correlation, if any, between animal behavior and the occurrence of earthquakes, in order to be used as earthquake prediction data.	1	89	6	15	80	59	30	47	19	3	6	19	79	31		13	31	11	7	6	38	25	29	51	24	16	13	34	0	3	9	13	6	1
			2	86	7	14	79	57	27	51	20	2	5	16	81	24		15	26	9	2	2	48	23	26	62	21	10	10	30	1	1	8	16	5	1
			X	6	100	0	0	80	60	40	0	0	0	17	67	17		0	0	33	17	0	67	0	17	67	50	0	0	67	0	0	0	33	0	0
	62	Realization of time-series observation of the condition of magma inside volcanoes.	1	73	11	15	74	72	48	45	5	1	5	48	77	33		7	18	52	10	3	74	3	11	66	29	29	4	67	0	0	15	11	1	0
			2	63	13	17	70	75	52	44	5	0	3	48	78	27		5	14	59	11	0	78	0	8	67	24	27	5	71	0	0	13	8	0	0
			X	8	100	0	0	86	71	29	0	0	13	75	63	75		0	25	75	13	0	88	0	0	63	38	50	25	75	0	0	13	25	0	0
	63	Forecasting of the outbreak and scale of pyroclastic flows (nuee ardente, etc.) accompanying volcanic eruption to be realized.	1	60	7	15	78	72	49	42	7	2	10	32	80	17		10	22	50	12	2	72	3	12	68	25	25	2	60	0	0	10	13	2	0
			2	53	11	13	75	75	50	48	2	0	6	30	79	11		8	21	49	13	2	72	0	9	70	25	25	2	66	0	0	8	11	2	0
			X	6	100	0	0	90	80	20	0	0	17	67	50	17		17	33	67	17	0	100	0	0	67	50	33	0	83	0	0	17	33	0	0
Common/other (marine/earth science)	64	Elucidation of the entire aspect of the movement and storage of carbon dioxide extending over the air, land, oceans, and sea bottoms.	1	201	11	33	56	77	57	40	4	0	14	97	17	38		2	11	84	44	1	49	1	9	72	38	26	13	66	4	0	18	4	3	0
			2	170	10	31	59	79	58	41	1	0	10	95	7	31		2	8	83	42	0	49	1	9	80	35	21	7	73	1	1	19	2	3	1
			X	17	100	0	0	97	94	6	0	0	18	88	18	41		6	6	100	59	0	59	12	0	82	29	35	24	71	6	6	18	6	6	0
	65	Development of a positron microscope.	1	15	7	13	80	50	20	47	27	7	20	7	0	80		7	40	53	20	0	20	0	27	33	27	47	0	27	0	0	13	7	7	0
			2	17	6	18	76	53	19	56	25	0	18	6	0	88		6	35	53	12	0	18	0	24	29	24	59	0	35	0	0	18	6	12	0
			X	1	100	0	0	100	100	0	0	0	0	0	0	100		0	0	0	0	0	100	0	0	100	100	0	0	100	0	0	0	0	0	0
	66	Practical use of high-luminosity radiation via electron or positron storage rings with emittance of 0.1 nano radians or less, for use in analysis of the atomic structure of materials deep inside the earth.	1	18	11	28	61	60	33	44	17	6	22	28	11	78		6	22	61	44	0	44	0	33	33	28	50	11	50	0	0	6	6	6	0
			2	16	13	25	63	63	31	56	13	0	13	25	0	88		6	19	69	38	0	44	0	25	38	19	63	0	69	0	0	6	6	13	0
			X	2	100	0	0	63	50	0	50	0	0	0	0	100		0	0	100	100	0	100	0	0	50	50	50	0	100	0	0	0	0	0	0
	67	Practical use of neutron spectrographs via megawatt-class spallation neutron sources, for use in analysis of the atomic structure of materials deep inside the earth.	1	17	12	24	65	59	35	35	24	6	12	29	12	71		6	18	59	29	6	29	0	35	41	41	41	6	59	0	0	6	12	0	0
			2	14	14	21	64	61	36	36	29	0	7	7	0	71		7	14	71	14	7	21	0	21	21	43	43	0	79	0	0	7	21	0	0
			X	2	100	0	0	63	50	0	50	0	0	0	0	100		0	0	100	50	0	100	0	0	50	50	50	0	100	0	0	0	0	0	0
	68	Practical use of 0.1-1.0 nm wavelength lasers, facilitating the observation of material structures via hard X-ray holography.	1	26	15	19	65	59	32	44	20	4	27	27	0	81		12	15	50	27	4	38	0	38	35	46	42	4	50	0	0	8	8	4	0
			2	23	17	17	65	60	30	48	22	0	17	22	0	78		9	13	70	22	4	35	4	22	43	39	39	0	74	0	0	13	13	0	0
			X	4	100	0	0	100	100	0	0	0	25	50	0	100		25	0	100	50	25	75	0	0	100	50	50	0	50	0	0	25	25	0	0
	69	Inauguration in Japan of global science and technology educational organizations in the broad sense, in order to foster international scientists and technologists contributing to conservation of the global environment, development and maintenance of global resources, etc.	1	181	9	25	65	72	50	37	13	1	30	86	27	39		5	20	40	27	2	27	1	29	53	39	20	4	59	4	3	14	5	5	2
			2	157	9	23	68	78	59	35	6	0	25	88	17	34		4	13	52	33	3	32	0	27	63	42	14	3	76	3	2	15	1	2	2
			X	14	100	0	0	89	79	21	0	0	29	93	36	43		0	0	64	43	0	50	0	14	43	43	21	0	71	7	0	21	0	0	0
	70	Inauguration in Japan of international research centers for comparative planetology, including the science of the earth, based on the development of planetology through specimens obtained from meteorites and planets.	1	70	4	20	76	50	21	41	33	4	7	36	6	81		9	30	69	23	6	40	0	17	64	17	34	9	56	3	0	7	3	13	1
			2	65	5	17	78	52	20	48	32	0	2	32	2	85		9	25	83	22	3	45	0	9	80	12	35	5	66	0	0	5	2	15	2
			X	3	100	0	0	100	100	0	0	0	0	67	0	67		0	33	100	100	33	100	0	0	100	0	100	0	100	0	0	33	0	0	0



(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic development	Expected effect: Resolution of global problems	Expected effect: People's needs	Expected effect: Expansion of intellectual resources	Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Common/other (marine/earth science)	71	Widespread, systematic use of re-evaluation programs related to traditional technologies and living cultures, in order to enrich peoples lives through education.	1	103	4	11	85	63	33	52	14	1	42	15	58	37		1	18	26	28	1	16	0	38	29	30	21	6	48	10	5	1	4	26	0
			2	96	2	14	84	63	32	57	11	1	40	8	66	32		2	11	27	34	0	14	0	40	25	36	13	6	58	10	4	1	2	24	0
			X	2	100	0	0	63	50	0	50	0	0	0	50	100		0	50	50	50	0	0	0	50	0	50	0	0	0	100	0	0	0	0	0
	72	Widespread use of education and training systems for advanced career development planning (CDP), aimed at facilitating the acquisition of new knowledge and skills by middle-aged and elderly persons.	1	101	0	15	85	65	40	42	18	1	50	9	61	29		2	12	32	29	1	12	2	33	21	35	25	2	48	19	4	1	3	27	2
			2	92	0	16	84	64	36	49	14	1	55	4	63	20		4	8	40	35	0	8	0	34	17	39	22	2	59	14	3	1	1	23	2
			X	0	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	73	Widespread construction throughout Japan of marine museums.	1	185	5	29	66	52	20	49	28	3	28	29	35	51		14	17	48	30	1	16	2	29	25	26	28	4	50	5	2	8	1	18	2
			2	167	5	26	69	52	19	52	28	1	21	23	37	61		9	10	68	40	1	15	2	20	25	26	29	3	65	5	4	5	1	16	2
			X	9	100	0	0	81	67	22	11	0	44	22	33	56		22	0	67	44	0	22	11	11	33	44	33	0	56	11	0	0	0	11	0
	74	Adaptation of natural history and scientific education methods to hands-on science museums capable of developing scientific skills in an enjoyable and playful atmosphere, and their spread throughout Japan.	1	179	4	21	75	62	35	44	21	1	35	23	39	54		3	16	58	31	2	15	1	25	31	28	28	2	56	7	3	6	1	17	2
			2	164	4	21	75	63	32	55	13	0	35	17	41	62		2	9	73	34	1	16	1	19	32	27	28	2	69	7	2	3	1	15	2
			X	7	100	0	0	86	71	29	0	0	43	14	43	57		0	0	71	71	0	29	0	0	29	57	29	0	71	14	0	0	0	29	0

(Note) See page 7 for the interpretation of the graphs.

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7. Survey Results in “Resources and Energy

7.1. Survey Results in “Resources”

7.1.1. Trends in noteworthy domains

(1) Resources development (recovery of resources, advances in exploration technologies, labor saving, and automation)

i) Recent technical trends and topics

a. Exploration technologies

While surface geologic surveys and exploratory drilling are still the most fundamental exploration methods, technological development is in progress in areas such as remote sensing, geophysical exploration and geochemical exploration as a result of advances in information processing technology and improvements in chemical analysis accuracy, and they may possibly become mainstream exploration techniques in the future. Recent achievements include improvements in surface resolution in remote sensing, reductions in device size and weight, improvements in accuracy and analysis speed in geophysical exploration, progress in 3-D analysis and geotomography technology in seismic exploration, and practical application of georadar technology in electromagnetic exploration. In geochemical exploration, research on the practical application of the geogas technique is in progress.

b. Exploratory drilling technologies

The efficiency of exploratory drilling has increased through the development of semiautomatic drilling machines and advances in the reverse-circulation drilling technique. High-precision directional drilling and horizontal drilling techniques have been put to practical use in well drilling for petroleum and gas, contributing to improvements in oil production productivity and recovery efficiency. In Northern Europe and North America, these drilling techniques are being applied to subsea geologic surveys, metal and mineral resource exploration, etc.

c. Development and production technologies

• Mining

Labor saving and speed improvement are making progress in areas such as digging design, production planning and mine ventilation design, thanks to performance improvements in personal computers and sophistication in software. Regarding operation automation, unmanned trucks have been put to practical use at open-pit mines in the United States, South Africa and Japan, with efforts also being made to improve operation precision. With underground mining, practical application experiments on remote control technology for boring, loading and transportation work are under way in Canada, Sweden and Japan, aiming to achieve central control from a control room set up on the ground or inside a mine.

• Mineral dressing

With crushing and grinding processes, the adoption of SAG (Semi Autogenous) mills has become universal, thus saving energy and simplifying the processes. With the separation process, a move to larger flotation machines and the adoption of column flotation machines have made progress, while, with the dewatering process, the introduction of high-efficiency pressure filters has been under way accompanying energy saving and performance improvement effects. With process control, the control of the entire mineral dressing process is becoming a reality through progress in online analysis technology based on fluorescent X-ray analyzers and advances in fuzzy control technology.

• Leaching-SX-EX

Copper production based on the Leaching-SX-EX (leaching-solvent extraction-electrolytic extraction) method is widely used at mines in light rainfall areas in North and South America, as it can greatly reduce production costs compared to the conventional method that goes through mineral dressing and smelting processes. Although it was initially applicable to copper oxides only, its application to vitreous copper, which, among copper sulfides, is relatively amenable to leaching, is in progress, following recent advances in leaching technology through the use of bacteria etc.

• Solution mining

The use of solution mining — which injects a solvent from the surface into the ground, dissolves a desired metal in the solvent, and recovers it above ground — is being studied in the United States for possible use in copper recovery operations.

ii) Future outlook

In the resources and energy field, the results of the questionnaire survey showed a high level of interest in the recycling of resources as follows: “19: Practical use of economical methods for separating and recycling valuable substances in urban garbage” (degree of importance to Japan (index): 1st, contribution to socioeconomic development: 8th, resolution of global-scale problems: 3rd, and forecasted realization time: 2009) and “17. Practical use of technologies capable of separating useful metals from scrap cars etc. to a purity level of more than 99%” (degree of importance to Japan (index): 2nd, contribution to socioeconomic development: 6th, resolution of global-scale problems: 2nd, and forecasted realization time: 2011). Although recycling-related technological development is under way based on existing mineral dressing and smelting technologies, its progress is not quite satisfactory compared to advances in primary commodity production technologies mentioned above, and this partly explains why recycling costs are higher than primary commodity production costs.

In the future, there seems to be a need to facilitate technological development through greater government involvement in terms of bolstering the research framework and providing more funds, as questionnaire survey results show.

In related areas, a great interest in exploration technologies, such as the following, was noted: “14: Development of exploration technology capable of estimating the economic feasibility of mineral deposits with virtually no drilling” (degree of importance to Japan (index): 9th, resolution of global-scale problems: 4th, and forecasted realization time: 2017) and “12: Development of semiquantitative prospecting technology for mineral resources using artificial satellites” (degree of importance to Japan (index): 8th, resolution of global-scale problems: 8th, and forecasted realization time: 2013). In light of the fact that technological development in remote sensing, geophysical exploration and geochemical exploration has been progressing at a rapid rate, these forecasted realization times seem to be reasonable.

(Terumitsu Kawabata)

(2) Water utilization technologies that can address climate change and natural disasters

In areas such as the development of water resources, prevention of water-related disasters and improvement of water quality, making water use in daily lives and social activities more efficient and comfortable through the optimum control of the global hydrologic cycle is an important task. Advances in the natural sciences and industrial technologies have made Japan's technical standards and progress in the introduction of equipment/facilities in these areas among the best in the world, although they have not quite reached the level where all the problems have been overcome. The nationwide water shortages that gripped Japan in 1994 and 1995 and floods caused by torrential rain that struck Japan's Chubu and Hokuriku Regions in 1995, as well as subsequent debris flows, which occurred in 1996, are still vivid in our memories. It is hoped that research and technological development will be conducted aiming for higher standards in the future, so that such aberrations in natural phenomena can be adequately dealt with. In this regard, the realization times of some of the relevant technologies have been forecasted as follows: “21: Widespread use of accurate rain and precipitation water-balance forecasting” (2010) “34: Widespread use in Japan of seawater desalination to deal with water shortages” (2012) “25. Widespread practice of the recovery and reuse of treated effluent at housing complexes, small-scale industries, etc.” (2009) and “30: Significant reduction in the loss of human life in Japan through the improvement and widespread use of landslide and landslip prediction technologies” (2015).

From a global perspective, concerns about the outbreak of international conflicts over water because of serious water shortages in some regions in the future have been growing, while the threat of the Yellow River drying up is surfacing in China. With the impact of global-scale climate change attracting growing attention lately, the importance of such a global perspective will increase even more in the future. In this regard, the realization time of “22. Widespread introduction of measures to ensure adequate water resources based on elucidation of mechanism why climatic change causes abnormal rain phenomena” has been forecasted as 2013.

In the latest survey, 20 topics were set in the water resource area encompassing its three aspects — water use, disaster prevention/preparedness and water quality improvement — with water use being the main focus. This is the same number as the last survey. The 2011–15 range represents the most common forecasted realization times for these topics, accounting for 58% of the total, followed by 2006–10 (32%). Namely, most of the topics are forecasted to be realized within about 20 years. These results do seem to strongly reflect the hopes and enthusiasm of those involved in these areas.

The general trend of responses relating to these topics was such that, of the effects expected to be brought about by their realization, “response to people’s needs” was most common (65%), followed by the “resolution of global-scale problems” (56%) and the “contribution to socioeconomic development” (21%). Improvements in technologies relating to water use etc. were considered to greatly contribute to improvements in the standard of living. In this regard, the forecasted realization times of some of the topics in which great interest was shown were as follows: “38: Improvement in the water quality of closed water areas such as Tokyo Bay so that people can safely swim there” (2017) “39: Development of an accurate and precise environmental impact prediction technologies for trace water contaminants” (2013) and “37: Drastic improvements in water treatment technologies at water purification plants through the use of new materials and biotechnology” (2011). All of these topics scored around 90% for “response to people’s needs” as the expected effect.

However, in terms of the degree of importance index, even the highest “36. Widespread use of wastewater and sewage treatment technologies capable of removing a wide range of pollutants” did not score more than 69 (year 2011). This may mean that, in Japan, problems in the water resource area have generally been solved to an acceptable degree, so that topics to be included as issues of common interest for the near future have been in short supply.

Apart from this, Japan's leading country score was a very substantial 59%, which was greater than the U.S. or EU. This fact seems to partly reflect the region-specific nature of the water resource area.

“Measures the government should adopt” included greater research funding (54%), followed by an enhancement of the personnel exchange promotion system (43%) and human resource development (37%), and this underscores the fact that securing research funds has the highest priority.

(Shoichi Kunikane)

7.1.2. Forecast topic framework

In the course of compiling forecast topics, a framework representing the organization of technologies in tabulated matrix form was drawn up for each field, with objectives and technological domains defining the rows and columns of the table, respectively. The framework is designed to present an overall picture of technological development in each field in terms of future prospects, importance, etc. as seen from the present perspective, and is also used as a working framework for future reviews of forecast topics.

Table 7.1.2-1 Forecast Topic Framework for Mineral Resources Field

Objective \ Domain	Metal	Non-metal	Scarce resources	Common
Exploration, recovery and extraction	01 02 03 04		08 09	12 13 14 15 16 17
Application development/recycling			10 11	
Substitution	05	07		
Environmental protection and safety	06			18 19

* Figures appearing in the table represent topic numbers.

Table 7.1.2-2 Forecast Topic Framework for Water Resources Field

Objective \ Domain	Rainfall	Rivers, lakes and groundwater	Municipal water supply and sewage/drainage services	Seawater	Common
Water resource development technology	20 21 22	23 24	25 26		27 28 29
Flood prevention/preparedness technology	30 31	32	33	34	
Water quality improvement technology		35	36 37	38	39

* Figures appearing in the table represent topic numbers.

7.1.3. Topics with high degree of importance

Degree of importance index scores (Note 1) averaged at 60.6 for topics in the resources field as a whole, with topics in the mineral resources field and water resources field (which together comprised the resources field) scoring 61.2 and 60.0, respectively. The topic with the highest degree of importance index score was 19. Practical use of economical methods for separating and recycling valuable substances in urban garbage (88 points) in the mineral resources field and 36. Widespread use of wastewater and sewage treatment technologies capable of removing a wide range of pollutants (60 points) in the water resources field.

Topics considered of particular importance to Japan (top 10 topics in terms of degree of importance index score) are listed in the table below. In the mineral resources field, 3 topics scored more than 80 points.

Table 7.1.3-1 Top 10 Topics in Terms of Degree of Importance Index

Topic (Mineral resources)	Degree of importance index	Forecasted realization time (year)
19 Practical use of economical methods for separating and recycling valuable substances in urban garbage.	88	2009
17 Practical use of technologies capable of separating useful metals, such as iron, copper andaluminum, from metal-containing wastes, such as scrap cars, discarded electric appliances, to a purity level of more than 99%.	88	2011

06 Development of a steelmaking technology that requires fossil fuel consumption less than half of the present level.	83	2014
08 Practical use of economical techniques to recover deep ocean metal resources, such as manganese nodules, colloidal or hydrothermal deposits of heavy metals, and cobalt-rich crusts.	68	2017
13 Discovery and development of new mineral deposits through the accumulation of new geological knowledge which has replaced plate tectonics.	67	2017
09 Development of an economical refining process to extract valuable constituents from deep ocean resources such as manganese nodules.	67	2015
11 Availability of rare-earth materials at prices less than half of the present levels.	66	2014
12 Development of semiquantitative prospecting technology for mineral resources using artificial satellites.	62	2013
14 Development of exploration technology capable of estimating the economic feasibility of mineral deposits with virtually no drilling.	61	2017
03 Practical use of a new reduction method for aluminum melting instead of electrolysis.	61	2015
Topic (Water resources)	Degree of importance index	Forecasted realization time (year)
36 Widespread use of wastewater and sewage treatment technologies capable of removing a wide range of pollutants in addition to common pollutants such as phosphorus and nitrogen compounds.	69	2011
35 Practical use of water treatment technologies that contribute to improvement in the environmental quality of rivers and lakes and facilitate the use of water taken from them over a wide area.	68	2010
22 Elucidation of mechanism why climatic change causes abnormal rain phenomena (very heavy or very light rain), and widespread introduction of measures to ensure adequate water resources in response to changes in precipitation characteristics.	68	2013
24 Widespread of technologies for controlling sand inflows into dammed reservoirs to avoid the accumulation of sands or to remove accumulated sand efficiently, leading to extended service lives of dams and their rejuvenation.	67	2011
33 Practical use of water supply pipes made of new materials that are highly resistant to earthquakes and other disasters and their installation technologies.	66	2010
25 Advancement in sewage and wastewater treatment technologies and widespread practice of the recovery and reuse of treated effluent at housing complexes, small-scale industries, etc.	66	2009
29 Spread of a network interconnecting water systems throughout Japan, ensuring a stable supply of water.	65	2016
23 Advancement in artificial groundwater recharging technology and widespread practice of the conservation and the rationalized use of groundwater.	64	2014
21 Widespread use of accurate rain and precipitation water-balance forecast aiming at effective utilization of rainfall.	63	2010
37 Drastic improvements in water treatment technologies at water purification plants through the use of new materials and biotechnology, enabling people to enjoy safe and tasty tap water.	63	2011

* Unlike other fields, where the top 20 topics are listed, only the top 10 topics are shown here because of the fewer number of topics included.

Note 1: Degree of importance index = (number of “high” responses × 100 + number of “medium” responses × 50 + number of “low” responses × 25 + number of “unnecessary” responses × 0) ÷ total number of degree of importance responses

7.1.4. Forecasted realization times

Forecasted realization times were distributed as shown in the diagram below.

In the mineral resources field, forecasted realization times tended to be concentrated in a relatively narrow period, with no topic forecasted to be realized after 2025. In the water resources field, forecasted realization times were even more concentrated than in the mineral resources field, with the location of the peak coinciding with that of the general trend covering all topics.

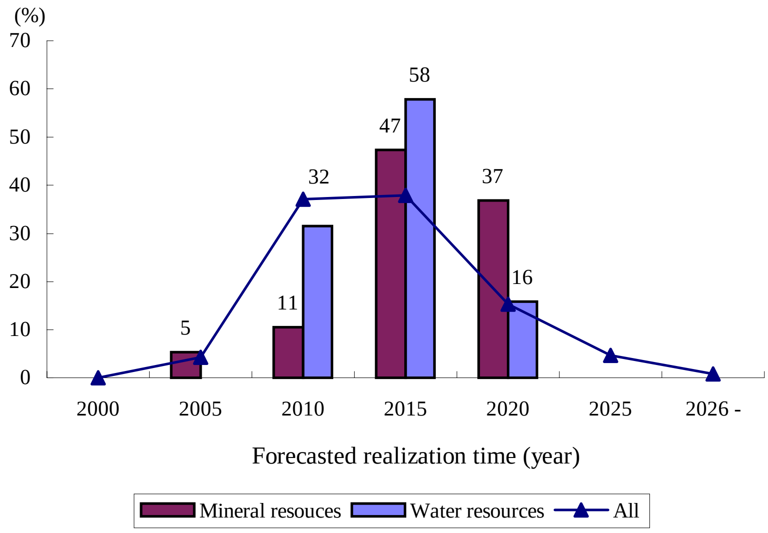


Fig. 7.1.4-1 Trends in Forecasted Realization Times

7.1.5. Current leading countries etc.

Responses to the question concerning current leading countries etc. were as shown in the diagram below. In the water resources field, Japan was named by the greatest number of respondents, followed by the U.S., while, in the mineral resources field, the U.S. ranked No. 1, followed by Japan. In both fields, the two countries were trailed by the EU, the former Soviet Union/Eastern Europe and other countries in that order, with do not know responses outstripping EU responses.

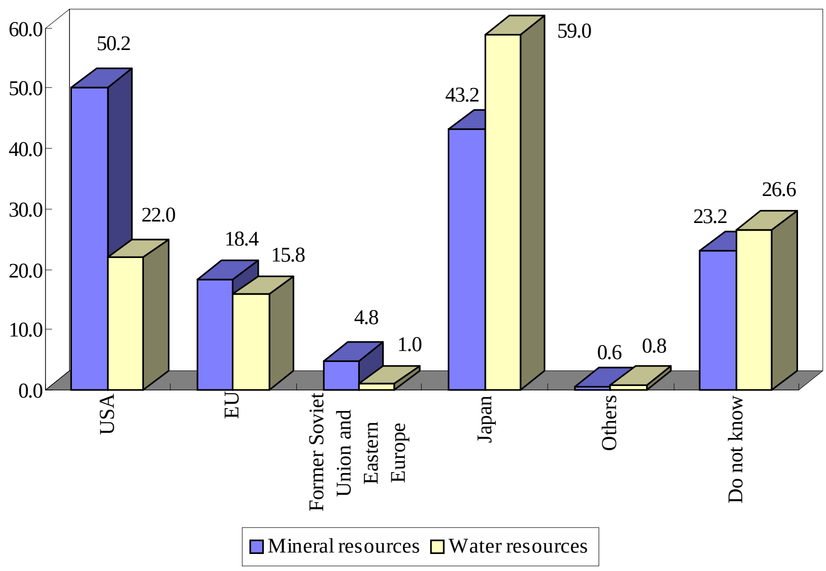


Fig. 7.1.5-1 Current Leading Countries etc. (%)

7.1.6. Comparison with the 5th Survey (previous survey)

In the latest survey, there were a total of 39 topics in the resources field (19 from the mineral resources field and 20 from the water resources field). In the mineral resources field, 10 topics (53%) were identical to the previous survey, 5 (26%) were modified, and 4 (21%) were newly introduced. In the water resources field, on the other hand, 14 (70%) were identical to the previous survey, 3 (15%) were modified, and 3 (15%) were newly introduced. For identical topics, the results of the latest survey were compared with those of the previous survey in terms of degree of importance index scores and forecasted realization times, as shown in the table below.

Degree of importance index scores rose for 3 topics, fell for 18 topics and remained the same for 3 topics. 21. Widespread use of accurate rain and precipitation water-balance forecast saw the greatest drop in importance index score, down 24 points.

Of the 39 topics included in the latest survey, forecasted realization times were pushed back for 22 topics, including 02. Widespread use of biotechnology for extraction and separation of metal elements, which saw its forecasted realization time pushed back most (13 years). Only 2 topics had their forecasted realization times brought forward. These were 14. Development of exploration technology capable of estimating the economic feasibility of mineral deposits with virtually no drilling and 20. Practical use of inducing artificial rain during droughts, by 3 years and 1 year, respectively.

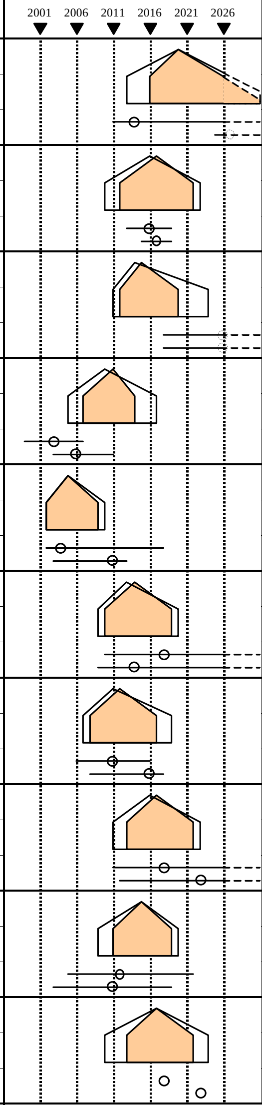
Table 7.1.6-1 Comparison with 5th Survey for Identical Topics

Topic	Degree of importance index / forecasted realization time	
	6th survey	5th survey
02 <u>Widespread use</u> of biotechnology for extraction and separation of metal elements.	49/2017	64/2004
03 <u>Practical use</u> of a new reduction method for aluminum melting <u>instead of electrolysis</u>.	61/2015	61/2014
04 <u>Practical use</u> of a process using apply magnetic force, as non-ferrous metal casting method.	47/2011	43/2008
05 Substantial shift in photography from silver chloride film and photographic paper to electronic cameras, resulting in <u>drastic reduction</u> of demand for silver in this field.	47/2005	47/2003
07 <u>Partial</u> replacement of copper and aluminum by organic electrical conductors such as polymers.	54/2012	65/2005
10 <u>Practical use</u> of method for <u>recovering</u> helium from air to cope with an increased helium demand and diminishing natural resources.	51/2017	50/2009
12 <u>Development</u> of <u>semiquantitative</u> prospecting technology for mineral resources using artificial satellites.	62/2013	69/2006
14 <u>Development</u> of exploration technology capable of estimating the economic feasibility of mineral deposits <u>with virtually no drilling</u>.	61/2017	56/2020
15 <u>Practical use</u> of ultra-deep drilling and excavating technologies applicable to severe condition of up to <u>400C</u> and a depth of <u>15 Km</u>.	56/2016	64/2006
19 <u>Practical use</u> of <u>economical</u> methods for separating and recycling valuable substances in urban garbage.	88/2009	93/2001
20 <u>Practical use</u> of inducing artificial rainmarking in event of drought.	57/2014	57/2015
21 <u>Widespread use</u> of accurate rain and precipitation water-balance forecast aiming at effective utilization of rainfall.	63/2010	87/2004
22 <u>Elucidation</u> of mechanism why climatic change causes abnormal rain phenomena (very heavy or very light rain), and <u>widespread</u> introduction of measures to ensure adequate water resources in response to changes in precipitation characteristics.	68/2013	82/2007
23 Advancement in artificial groundwater recharging technology and <u>widespread</u> practice of the conservation and the rationalized use of groundwater.	64/2014	72/2005

Topic	Degree of importance index / forecasted realization time	
	6th survey	5th survey
25 Advancement in sewage and wastewater treatment technologies and widespread practice of the recovery and reuse of treated effluent at housing complexes, small-scale industries, etc.	66/2009	74/2001
27 Widespread use of comprehensive water supply and food control management systems based on snow-melting control and long-term flood forecast.	57/2013	66/2008
28 Practical use of international water transfer systems to make stable supply of water.	29/2020	41/2015
30 Significant reduction in the loss of human life in Japan through the improvement and widespread use of landslide and landslip prediction technologies.	63/2015	84/2008
31 Establishment of technologies enabling accurate forecast of rainfall and practice of effective dam operation in the case of floods.	60/2010	81/2004
32 Widespread use of bankss designed not to break even if overflow happens through the utilization of super banks and new materials.	61/2015	80/2004
35 Practical use of water treatment technologies that contribute to improvement in the environmental quality of rivers and lakes and facilitate the use of water taken from them over a wide area.	68/2010	86/2005
36 Widespread use of wastewater and sewage treatment technologies capable of removing a wide range of pollutants in addition to common pollutants such as phosphorus and nitrogen compounds.	69/2011	85/2005
37 Drastic improvements in water treatment technologies at water purification plants through the use of new materials and biotechnology, enabling people to enjoy safe and tasty tap water.	63/2011	69/2004
38 Improvement in the water quality of closed water areas such as Tokyo Bay so that people can safely swim there.	52/2017	59/2013

Note: Up until the 5th Survey, realization meant realization in Japan unless otherwise specified. However, this was changed to mean realization somewhere in the world in the 6th Survey. Therefore, care should be taken when comparing forecasted realization times from the two surveys.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time			Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001 2006 2011 2016 2021 2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Metal	1	Practical use of solution mining, a technology to recover minerals from deep underground deposits by rendering ores such as chalcopyrite and sulfides of lead and zinc into solutions and pumping them up.	1	108	8	15	77	49	19	42	37	3	31	81	2	6		9	17	44	8	9	12	1	46	40	35	21	1	45	7	9	73	10	1	3
			2	90	7	14	79	43	7	55	38	1	32	86	0	6		11	14	48	1	4	9	0	48	48	36	20	0	60	4	4	84	12	0	1
			X	6	100	0	0	46	17	33	50	0	17	100	0	0		33	17	67	0	0	0	0	33	83	50	17	0	67	17	0	83	0	0	0
	2	Widespread use of biotechnology for extraction and separation of metal elements.	1	148	6	20	74	51	20	49	27	4	35	78	2	16		7	11	49	18	5	30	0	30	51	40	15	23	38	2	3	50	14	3	5
			2	120	4	17	79	49	13	60	26	2	31	79	1	16		6	10	60	11	3	33	0	27	55	45	10	22	43	3	2	64	10	1	3
			X	5	100	0	0	50	20	60	0	20	20	80	0	20		20	20	100	40	20	20	0	0	80	80	20	20	40	0	0	40	0	0	0
	3	Practical use of a new reduction method for aluminum melting instead of electrolysis.	1	131	4	24	73	60	34	43	17	6	47	72	0	12		15	16	34	13	5	31	2	36	37	44	13	4	40	2	5	32	3	2	6
			2	101	4	25	71	61	31	54	13	2	47	76	0	11		14	10	38	9	5	33	1	43	28	58	9	1	50	1	4	43	1	3	0
			X	4	100	0	0	56	25	50	25	0	50	75	0	25		50	0	50	25	0	50	0	25	50	50	0	0	50	0	0	50	0	0	0
	4	Practical use of a process using apply magnetic force, as non-ferrous metal casting method.	1	98	4	30	66	51	19	52	26	3	58	44	2	18		6	17	36	22	12	47	0	30	33	48	22	1	34	2	4	15	11	4	5
			2	78	5	26	69	47	8	66	25	1	63	42	3	14		8	9	29	22	13	51	0	27	37	60	15	0	44	3	0	23	14	3	1
			X	4	100	0	0	50	0	100	0	0	100	75	0	0		0	0	50	75	75	75	0	0	50	75	0	0	100	0	0	0	25	0	0
	5	Substantial shift in photography from silver chloride film and photographic paper to electronic cameras, resulting in drastic reduction of demand for silver in this field.	1	208	3	16	81	51	23	38	35	4	51	46	21	8		6	2	56	9	0	83	0	10	17	31	10	1	11	15	9	15	8	18	5
			2	170	1	15	84	47	15	46	37	2	58	46	14	6		4	1	49	3	0	88	0	7	16	45	6	1	10	14	8	15	5	21	2
			X	2	100	0	0	38	0	50	50	0	50	0	0	50		0	0	50	0	0	100	0	0	50	0	0	0	0	0	0	0	0	0	0
	6	Development of a steelmaking technology that requires fossil fuel consumption less than half of the present level.	1	198	10	22	68	80	62	35	3	1	47	88	2	10		8	11	19	19	4	77	1	14	34	51	15	2	47	5	3	30	12	4	3
			2	158	11	23	66	83	66	32	2	0	41	92	2	6		5	6	15	16	1	79	0	13	32	63	12	0	51	3	2	34	9	2	1
			X	17	100	0	0	84	71	24	6	0	35	88	6	18		18	0	35	35	0	88	0	0	59	59	12	0	65	6	0	41	12	0	0
Non-metal	7	Partial replacement of copper and aluminum by organic electrical conductors such as polymers.	1	160	3	22	76	58	26	55	17	3	61	48	10	24		5	8	59	27	2	53	0	24	46	48	14	7	31	6	3	16	10	4	6
			2	125	2	19	79	54	16	72	10	2	62	50	6	17		4	6	60	18	0	54	0	22	52	58	10	4	30	4	1	25	11	2	2
			X	2	100	0	0	75	50	50	0	0	100	0	0	0		0	0	100	50	0	100	0	0	100	100	0	0	50	0	0	50	0	0	0
Scarce resources	8	Practical use of economical techniques to recover deep ocean metal resources, such as manganese nodules, colloidal or hydrothermal deposits of heavy metals, and cobalt-rich crusts.	1	179	8	17	75	68	42	49	8	1	42	83	1	4		6	12	59	17	4	45	0	22	33	40	21	2	59	7	4	57	6	3	4
			2	143	6	17	77	68	39	58	3	1	38	85	1	1		6	9	63	13	0	49	0	22	32	46	16	1	63	6	1	64	2	1	1
			X	8	100	0	0	81	63	38	0	0	25	88	0	0		0	13	88	0	0	88	0	0	50	38	38	0	63	0	0	75	25	13	0
	9	Development of an economical refining process to extract valuable constituents from deep ocean resources such as manganese nodules.	1	148	10	19	71	66	39	47	13	1	45	76	2	5		5	10	54	16	3	50	0	25	36	45	20	3	51	4	3	43	3	1	3
			2	112	9	19	72	67	39	53	6	2	40	82	0	2		4	9	62	13	0	54	0	22	34	56	17	2	59	4	2	54	1	1	1
			X	10	100	0	0	85	70	30	0	0	40	90	0	10		0	0	80	20	0	70	0	0	50	30	30	0	50	0	0	40	10	10	0
	10	Practical use of method for recovering helium from air to cope with an increased helium demand and diminishing natural resources.	1	134	1	25	74	53	26	42	25	8	40	70	2	7		16	14	43	21	2	22	0	41	34	28	18	3	37	1	5	27	4	3	4
			2	109	1	21	78	51	18	56	22	5	37	78	3	2		12	10	50	17	2	20	0	38	39	31	14	1	42	2	4	37	3	2	3
			X	1	100	0	0	50	0	100	0	0	100	100	0	0		0	0	100	0	0	100	0	0	100	100	100	0	0	0	0	0	0	0	0



(Note) See page 7 for the interpretation of the graphs.

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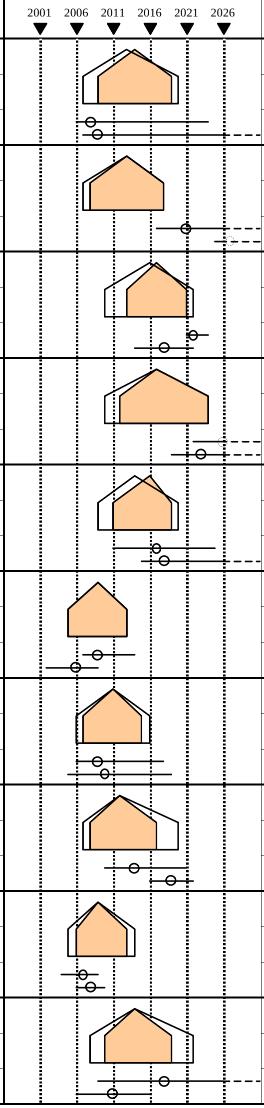

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary
Scarce resources	11	Availability of rare-earth materials at prices less than half of the present levels.	1	120	8	24	68	68	39	53	8	0
			2	97	5	25	70	66	34	62	4	0
			X	5	100	0	0	70	40	60	0	0
Common	12	Development of semiquantitative prospecting technology for mineral resources using artificial satellites.	1	159	6	11	82	63	33	54	11	1
			2	128	5	13	83	62	29	62	9	1
			X	6	100	0	0	67	50	33	0	17
	13	Discovery and development of new mineral deposits through the accumulation of new geological knowledge which has replaced plate tectonics.	1	108	7	13	80	68	42	45	13	0
			2	89	4	13	82	67	37	59	5	0
			X	4	100	0	0	100	100	0	0	0
	14	Development of exploration technology capable of estimating the economic feasibility of mineral deposits with virtually no drilling.	1	105	10	17	73	62	33	48	18	1
			2	85	8	16	75	61	29	58	12	1
			X	7	100	0	0	75	57	29	14	0
	15	Practical use of ultra-deep drilling and excavating technologies applicable to severe condition of up to 400ºC and a depth of 15 km.	1	109	9	16	75	58	28	48	23	1
			2	90	8	14	78	56	23	56	20	1
			X	7	100	0	0	46	14	43	43	0
	16	Practical use of a "hard-rock" tunnel drifting technique based on water jets.	1	144	6	14	80	52	17	57	25	1
			2	119	8	14	78	52	16	62	23	0
			X	9	100	0	0	69	38	63	0	0
	17	Practical use of technologies capable of separating useful metals, such as iron, copper and aluminum, from metal-containing wastes, such as scrap cars, discarded electric appliances, to a purity level of more than 99%.	1	254	11	20	69	82	66	30	3	1
			2	201	11	17	72	88	78	20	2	1
			X	22	100	0	0	93	86	14	0	0
	18	Practical use of a highly economical unmanned mining technique that combines robot technologies.	1	136	7	12	82	53	20	53	24	2
			2	108	6	12	82	50	13	64	23	0
			X	6	100	0	0	58	33	33	33	0
	19	Practical use of economical methods for separating and recycling valuable substances in urban garbage.	1	284	9	26	65	82	65	32	2	0
			2	236	8	23	68	88	77	22	1	0
			X	20	100	0	0	94	89	11	0	0
Water resource development	20	Practical use of inducing artificial rainmarking in event of drought.	1	177	5	10	85	58	30	45	22	3
			2	153	3	8	89	57	26	53	19	3
			X	5	100	0	0	55	20	60	20	0

Topic serial No.	Questionnaire round	Expected effect (%): Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Forecasted realization time: Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know
11	1	67	62	10	8	15	21	48	21	22	40	9	23
	2	66	65	6	4	16	14	56	19	15	38	5	25
	X	80	100	0	20	20	20	80	0	20	80	0	0
12	1	35	87	3	14	4	13	86	19	15	20	1	12
	2	29	84	2	12	5	9	85	15	12	17	1	10
	X	17	83	0	0	50	0	83	17	0	17	0	0
13	1	33	84	2	20	5	16	63	27	11	27	4	23
	2	24	87	0	17	8	10	69	17	7	22	0	19
	X	25	75	0	50	25	0	50	25	25	25	0	25
14	1	32	81	3	18	16	12	67	20	8	20	1	27
	2	27	87	0	12	14	9	66	14	6	15	1	27
	X	14	86	0	43	57	0	43	14	0	14	0	29
15	1	37	88	6	22	6	5	63	30	23	26	0	17
	2	32	82	1	22	6	4	69	27	18	27	0	14
	X	29	86	0	43	0	0	86	57	71	29	0	0
16	1	55	53	16	6	1	12	31	19	10	46	0	31
	2	60	50	10	3	1	8	38	12	4	61	0	21
	X	22	100	11	11	0	22	44	22	11	78	0	0
17	1	58	90	10	6	2	6	30	49	1	52	0	20
	2	55	91	6	3	1	3	29	55	1	56	0	17
	X	59	91	5	5	9	0	36	73	5	64	0	5
18	1	47	63	22	5	2	9	46	23	4	49	3	22
	2	52	62	16	3	1	7	54	15	0	53	2	21
	X	67	100	17	0	0	0	83	17	0	100	0	0
19	1	56	91	27	2	2	5	20	51	1	52	1	21
	2	50	89	21	1	3	2	16	55	0	61	0	16
	X	70	90	25	0	0	0	40	75	0	80	0	0
20	1	24	70	40	8	23	15	37	7	6	27	3	41
	2	19	78	41	5	20	12	43	5	5	27	1	43
	X	20	20	80	0	20	0	60	0	20	20	20	0

Topic serial No.	Questionnaire round	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
11	1	33	43	18	8	34	5	3	31	3	3	4
	2	36	53	14	4	36	4	5	45	1	2	2
	X	80	100	0	0	40	20	0	40	0	0	0
12	1	39	40	25	8	48	3	3	20	10	6	6
	2	36	46	23	6	55	2	1	25	8	2	2
	X	17	33	17	0	33	17	0	33	0	0	0
13	1	52	43	20	10	36	2	3	35	3	5	2
	2	64	44	16	3	42	2	1	42	1	0	0
	X	50	75	25	0	75	25	0	50	0	0	0
14	1	47	42	23	8	47	0	1	20	8	2	3
	2	53	48	16	2	51	2	0	27	6	0	0
	X	57	29	14	0	29	14	0	14	14	0	0
15	1	28	40	30	6	59	6	3	43	10	2	2
	2	24	52	24	2	63	6	1	50	6	1	0
	X	43	57	57	0	71	0	0	43	14	0	0
16	1	28	45	28	1	40	6	3	42	17	1	2
	2	26	57	20	0	43	5	3	52	13	1	0
	X	56	67	33	0	22	0	0	67	22	0	0
17	1	36	52	22	1	56	28	2	30	7	12	4
	2	32	60	16	1	66	24	2	39	4	7	0
	X	41	59	9	5	64	32	0	23	9	5	0
18	1	31	47	18	1	43	4	3	32	14	4	1
	2	31	56	11	0	49	6	1	40	9	4	1
	X	17	83	0	0	50	0	0	50	0	0	0
19	1	34	48	21	2	54	31	2	33	8	14	1
	2	25	60	13	0	61	31	1	40	6	11	0
	X	25	70	20	0	60	40	0	30	5	10	0
20	1	45	33	18	6	40	4	2	60	13	8	0
	2	52	32	11	3	47	3	2	74	9	5	0
	X	40	20	40	0	80	0	20	80	20	20	0

(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic development	Expected effect: Resolution of global problems	Expected effect: People's needs	Expected effect: Expansion of intellectual resources	Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	Leading countries: EU	Leading countries: Former Soviet Union and Eastern Europe	Leading countries: Japan	Leading countries: Other countries	Leading countries: Do not know	Measures the government should adopt (%): Foster human resources	Measures: Promote exchanges among industrial, academic and government sectors and different fields	Measures: Upgrade advanced facilities and equipment	Measures: Develop a research base	Measures: Increase government research funding	Measures: Adjust regulations (relax/toughen)	Measures: Others	Potential problems (%): Adverse effect on the natural environment	Potential problems: Adverse effect on safety	Potential problems: Adverse effect on morals, culture or society	Potential problems: Other adverse effects
Water resource development technology	21	Widespread use of accurate rain and precipitation water-balance forecast aiming at effective utilization of rainfall.	1	135	10	11	79	67	38	55	7	1	31	70	56	10		2	4	42	15	1	59	0	23	56	33	23	17	42	4	1	35	16	3	1
			2	125	6	14	80	63	28	69	3	0	21	72	55	5		1	6	47	13	0	64	0	22	65	27	14	7	53	3	0	45	12	2	0
			X	8	100	0	0	81	63	38	0	0	25	50	63	0		13	13	50	13	0	63	0	13	63	25	13	0	63	0	0	50	13	0	0
	22	Elucidation of mechanism why climatic change causes abnormal rain phenomena (very heavy or very light rain), and widespread introduction of measures to ensure adequate water resources in response to changes in precipitation characteristics.	1	137	7	13	80	70	44	50	6	0	27	81	51	20		4	9	48	19	1	46	1	28	59	35	23	16	50	5	1	42	19	3	1
			2	128	5	10	84	68	36	62	2	0	20	80	49	11		2	7	54	13	2	58	0	26	69	32	12	7	57	2	1	54	9	2	0
			X	7	100	0	0	93	86	14	0	0	29	71	57	14		14	14	57	0	0	57	0	14	57	57	0	14	43	0	0	57	14	0	0
	23	Advancement in artificial groundwater recharging technology and widespread practice of the conservation and the rationalized use of groundwater.	1	135	8	16	76	65	38	46	14	2	33	78	47	4		4	11	21	19	3	36	0	39	52	40	18	6	47	17	1	56	16	4	1
			2	116	5	16	78	64	31	61	8	0	19	81	44	2		3	9	22	16	1	47	2	36	57	43	13	3	50	10	2	66	11	3	1
			X	6	100	0	0	75	50	50	0	0	33	67	67	0		17	17	83	17	0	50	0	0	67	50	17	0	17	17	17	83	0	0	0
	24	Widespread of technologies for controlling sand inflows into dammed reservoirs to avoid the accumulation of sands or to remove accumulated sand efficiently, leading to extended service lives of dams and their rejuvenation.	1	128	9	20	70	66	40	46	13	1	35	73	39	4		3	6	15	8	1	59	0	28	31	44	20	2	53	16	2	55	15	2	0
			2	114	8	19	73	67	38	55	6	1	25	77	32	2		2	5	9	5	0	71	0	22	25	47	9	1	65	11	0	62	11	1	0
			X	9	100	0	0	81	63	38	0	0	22	67	44	0		0	0	0	11	0	78	0	0	44	44	11	0	67	0	0	44	11	0	0
	25	Advancement in sewage and wastewater treatment technologies and widespread practice of the recovery and reuse of treated effluent at housing complexes, small-scale industries, etc.	1	217	9	25	66	67	40	49	10	0	36	72	55	1		1	3	17	27	1	53	1	29	28	41	18	1	40	41	2	29	14	14	2
			2	191	6	22	72	66	35	59	6	0	28	74	57	1		1	2	12	29	1	58	2	26	24	48	10	1	50	43	1	35	16	7	1
			X	11	100	0	0	82	64	36	0	0	45	73	45	0		9	0	36	27	0	45	0	0	27	45	18	0	36	55	0	27	27	9	0
	26	Near elimination of leakage from water distribution networks, resulting in an efficient utilization of water resources.	1	154	6	15	79	55	26	44	28	1	21	60	49	1		13	6	6	12	1	44	0	38	17	37	18	3	26	18	7	17	13	5	3
			2	140	4	14	82	57	24	54	22	0	16	67	54	1		9	4	4	14	1	56	0	34	12	51	16	0	40	15	4	20	16	1	1
			X	6	100	0	0	71	50	33	17	0	33	50	83	0		17	0	0	0	17	50	0	33	33	33	67	0	50	17	0	33	0	0	0
	27	Widespread use of comprehensive water supply and food control management systems based on snow-melting control and long-term flood forecast.	1	129	10	13	77	62	33	52	14	1	34	71	53	6		8	4	19	18	5	52	2	34	36	42	19	13	42	9	0	47	16	5	0
			2	117	6	12	82	57	22	64	14	0	18	67	60	3		7	3	12	17	3	60	2	32	38	50	10	7	52	3	0	51	9	2	0
			X	7	100	0	0	71	43	57	0	0	29	43	71	0		14	0	29	0	0	43	0	57	86	43	14	14	71	0	0	29	14	0	0
	28	Practical use of international water transfer systems to make stable supply of water.	1	102	10	12	78	36	12	27	40	20	29	69	47	7		25	11	12	23	2	13	5	45	19	29	5	6	28	16	9	28	12	14	2
			2	88	6	13	82	29	6	20	53	20	18	72	43	3		27	10	7	27	1	11	3	53	18	35	5	1	34	13	6	40	7	6	1
			X	5	100	0	0	40	20	20	40	20	20	80	40	0		40	20	0	40	0	0	0	60	20	0	0	0	20	40	0	40	0	60	0
	29	Spread of a network interconnecting water systems throughout Japan, ensuring a stable supply of water.	1	134	10	17	73	66	42	42	11	5	37	54	60	4		12	8	19	17	1	38	1	30	22	30	13	4	37	40	8	37	14	11	3
			2	120	7	20	73	65	38	46	14	2	25	48	68	3		8	3	16	17	0	50	0	29	18	33	5	2	44	54	3	43	10	3	2
			X	8	100	0	0	84	75	13	13	0	50	63	75	0		0	13	63	13	0	25	0	13	38	13	13	0	38	63	0	38	0	38	0
Flood prevention technology	30	Significant reduction in the loss of human life in Japan through the improvement and widespread use of landslide and landslip prediction technologies.	1	127	6	17	76	63	35	46	18	1	19	19	82	6		9	8	12	9	0	59	2	25	49	39	18	11	52	12	1	26	24	3	1
			2	116	3	12	84	63	30	62	9	0	9	14	87	1		5	7	3	5	0	66	1	24	54	41	11	4	62	7	1	27	16	0	0
			X	4	100	0	0	88	75	25	0	0	25	25	100	0		50	0	25	25	0	100	0	0	25	100	25	0	75	0	0	75	50	0	0

(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time			Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001 2006 2011 2016 2021 2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Flood prevention technology	31	Establishment of technologies enabling accurate forecast of rainfall and practice of effective dam operation in the case of floods.	1	124	14	10	76	62	33	50	16	2	25	49	68	2		2	4	27	10	2	57	0	26	36	44	19	17	44	8	2	34	19	1	2
			2	108	12	10	78	60	26	62	12	0	18	45	75	0		2	1	27	9	1	67	0	21	43	46	14	10	58	3	0	39	15	0	0
			X	13	100	0	0	77	58	33	8	0	23	38	85	0		8	0	31	0	0	77	0	15	85	46	23	15	69	0	0	15	23	0	0
	32	Widespread use of banks designed not to break even if overflow happens through the utilization of super banks and new materials.	1	89	15	11	74	61	32	49	15	3	37	29	74	1		4	8	13	10	1	54	1	33	33	42	18	2	45	18	4	36	19	2	2
			2	76	12	11	78	61	26	69	5	0	28	16	87	0		4	4	5	11	0	68	0	28	26	53	11	0	62	12	3	41	14	0	3
			X	9	100	0	0	78	56	44	0	0	22	11	100	0		0	0	11	11	0	89	0	11	33	56	11	0	56	22	22	11	22	0	0
	33	Practical use of water supply pipes made of new materials that are highly resistant to earthquakes and other disasters and their installation technologies.	1	146	6	16	78	63	34	51	13	1	43	23	77	2		3	5	16	6	1	64	0	21	32	45	19	2	46	27	2	12	25	2	5
			2	127	3	15	82	66	35	59	6	0	41	14	83	2		2	3	12	4	1	72	0	22	29	52	13	1	60	25	1	8	31	0	2
			X	4	100	0	0	69	50	25	25	0	25	0	100	0		0	0	25	0	0	75	0	0	25	50	25	0	50	50	0	0	0	0	25
	34	Widespread use in Japan of seawater desalination to deal with water shortages due to drought, etc.	1	259	8	19	73	50	22	38	37	4	37	59	63	3		14	8	27	15	3	61	6	22	21	35	18	2	44	16	7	33	12	4	2
			2	228	5	19	76	47	15	46	36	3	24	57	70	2		11	5	27	9	2	67	5	19	18	40	14	0	55	16	4	37	10	2	2
			X	11	100	0	0	59	36	36	18	9	45	55	82	0		9	0	55	18	0	73	9	0	45	45	9	0	55	27	9	18	18	0	9
Water quality improvement technology	35	Practical use of water treatment technologies that contribute to improvement in the environmental quality of rivers and lakes and facilitate the use of water taken from them over a wide area.	1	230	11	25	64	70	44	49	6	0	32	70	60	2		2	4	23	28	2	66	0	21	34	47	23	7	56	26	2	37	7	7	2
			2	194	6	22	72	68	39	56	5	1	23	70	64	1		1	3	23	32	1	72	0	19	34	51	18	3	68	22	2	44	6	3	1
			X	12	100	0	0	92	83	17	0	0	42	67	75	0		0	0	42	50	0	75	0	17	50	67	25	0	50	17	0	58	8	8	0
	36	Widespread use of wastewater and sewage treatment technologies capable of removing a wide range of pollutants in addition to common pollutants such as phosphorus and nitrogen compounds.	1	199	8	25	67	69	43	48	8	1	25	70	61	3		3	6	21	30	2	61	1	23	38	45	24	6	51	29	1	33	8	6	3
			2	169	5	18	78	69	41	56	3	1	20	72	68	1		4	4	19	32	1	66	1	21	38	47	22	4	57	28	1	35	7	4	2
			X	8	100	0	0	94	88	13	0	0	50	75	75	0		0	0	38	50	0	75	0	0	38	63	25	0	38	38	0	38	0	13	0
	37	Drastic improvements in water treatment technologies at water purification plants through the use of new materials and biotechnology, enabling people to enjoy safe and tasty tap water.	1	192	8	19	72	65	38	48	13	1	33	45	79	2		4	4	29	22	1	64	2	22	40	44	27	11	48	20	1	25	11	9	2
			2	163	6	14	80	63	32	57	11	1	25	37	88	1		3	2	24	22	0	71	0	18	40	50	23	6	57	20	0	28	11	5	1
			X	9	100	0	0	78	56	44	0	0	22	33	89	0		0	0	44	56	0	78	0	0	56	44	56	0	56	22	0	11	22	11	0
	38	Improvement in the water quality of closed water areas such as Tokyo Bay so that people can safely swim there.	1	156	6	19	75	53	21	50	28	1	17	52	80	1		10	6	17	13	1	62	0	27	30	32	15	8	44	30	4	29	10	10	2
			2	130	3	12	85	52	16	58	26	0	9	45	90	1		8	2	13	10	0	68	0	22	26	31	11	5	59	31	3	34	8	4	2
			X	4	100	0	0	56	25	50	25	0	0	25	100	0		0	0	50	50	0	100	0	0	25	25	0	0	25	50	25	25	25	0	0
	39	Development of an accurate and precise environmental impact prediction technologies for carcinogenic or otherwise harmful trace water contaminants.	1	123	5	20	76	62	32	52	15	1	17	41	85	8		2	6	56	33	1	52	0	13	48	40	21	23	48	13	1	24	14	11	2
			2	107	3	14	83	60	23	69	7	0	9	38	89	4		2	4	61	27	0	59	0	15	59	47	14	17	55	14	0	26	11	6	0
			X	3	100	0	0	83	67	33	0	0	33	67	100	33		0	0	67	0	0	33	0	0	100	67	0	0	33	33	0	33	0	0	0

(Note) See page 7 for the interpretation of the graphs.

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7.2. Survey Results in “Energy”

7.2.1. Trends in noteworthy domains

The latest survey introduced topics relating to the outlook of the world in 30 years time. In order to determine future greenhouse gas emissions, IPCC has estimated various annual carbon dioxide emission levels using several scenarios on population and economic growth. Of these estimates, the following three were picked up as typical and used in a survey question: one in which greenhouse gas emissions will increase rapidly, one in which they will decrease, and one midway between them. Asked to provide their own forecasts by choosing one from these three, nearly 80% of respondents chose the intermediate case. Respondents were also asked to name the measure that they thought most effective in tackling global environmental problems (e.g. rising carbon dioxide emissions) from economic measures including regulatory controls, lifestyle changes and other moral measures, and various technological measures. The largest number of respondents, about half, chose economic measures, followed by technical measures, which were slightly ahead of moral measures. Significantly, expectations for technical measures were not as high as one might have hoped. In fact, this was a dismal result, which requires further study and analysis, given that technology was met with such a low level of confidence in a survey aimed at identifying technological topics which had promising developmental prospects or high developmental priority.

Against this backdrop seems to lie a sense of disappointment and powerlessness caused by the inability to find a clear solution in the face of challenges such as a finite supply of fossil fuel resources, rapid economic development in developing countries, diminishment of forests, and advancement in desertification. In this regard, we are very curious about what the results of the survey might have been, if it had been conducted in the United States, Europe and other developed countries, as well as developing countries in Asia.

Global-scale problems, such as the depletion of the ozone layer and diminishment of tropical rain forests, have been included in the questionnaire in the environment field since the previous survey, and, as this fact shows, problems caused by the heavy consumption of fossil fuel energy constitute important topics in the “energy” field. Therefore, the following two areas are discussed in overview below as future areas of attention:

(1) Introduction of clean energy and natural energy

(2) Resolution of energy problems on global scale

(1) Introduction of clean energy and natural energy

The Advisory Committee for Energy's recent Long-term Energy Supply-Demand Outlook reports, which have been the cornerstone of the Japanese Government's basic energy policy, have consistently been advocating a greater shift towards nonfossil energy, consisting of nuclear power and new energy sources, while pinning hopes on substantial energy conservation. This stance aims to ensure stability in Japan's energy supply structure by reducing oil dependence, as well as curbing greenhouse gas emissions from the global environmental conservation point of view. Future dependence on nuclear power is envisaged to be particularly high, with the nuclear share of electric power supply in 2010 projected as more than 40%.

Natural energy sources include solar energy, biomass, wind power and geotherm, and expectations for the widespread use of solar cells are high ó so much so that most of the growth in the use of new energy sources projected in the Long-term Energy Supply-Demand Outlook is said to be attributable to solar cells.

The results of the latest survey vividly reflect the present reality and future outlook of energy and environmental problems. Of the 20 topics with high degree of importance index scores in the “energy” field, “nuclear power” accounted for five, including the top three. “Solar cells”, on the other hand, claimed the following three topics: the practical use of high-efficiency large-area solar cells; widespread residential use of solar cells; and practical use of electric vehicles (powered by solar cells). The fact that electric vehicles will likely be carrying secondary batteries and/or fuel cells means that battery-related topics accounted for as many as 8 of the top 20 topics.

Of the remaining topics, the following two belonged to the energy conservation/clean energy development technology category: “88. Widespread use of energy-efficient houses” and “72. Practical use of high-efficiency gas turbines”. This brings the clean energy/natural energy share of the top 20 topics to 10.

(2) Resolution of energy problems on global scale

Global warming caused by the emission of greenhouse gases such as carbon dioxide is not a problem that can be solved by Japan or any other single country. As the United Nations Framework Convention on Climate Change is ratified across the world, serious efforts are being made to reduce carbon dioxide emissions to 1990 levels.

Against this background, the “resolution of global-scale problems” was by far the greatest expected effect for topics in the “energy” field.

Concrete examples included “46: Practical use of photovoltaic power generation system in desert areas”, “47: MW-class ocean photovoltaic power generation system”, “45: Development of space photovoltaic power generating system” and “53: Practical use of an international energy supply system to transport hydrogen etc.”

Although the scope did not cover the entire world or extend to outer space, expectations for the following were also great: “71: Widespread use of solid-electrolyte fuel cells for district cogeneration and distributed small-scale power generation” and “69: Widespread use of efficient bottoming cycle power generation utilizing low temperature waste heat recovered from turbines etc.”. In this regard, the systems approach towards energy problems is attracting more interest than the development of individual technologies.

Another marked trend with topics in the energy field is the general backward shift of their forecasted realization times from the 5th survey.

It is particularly noteworthy that the “will not be realized” and “do not know” options were chosen relatively frequently in the “energy” field.

Topics that respondents thought would not be realized were “86: Development of antimatter production and storage technology and energy sources based on it”, “59: Development of fusion reactors”, “55: Widespread use of solar hot-water supply systems”, “49: Power generation by ocean thermal energy conversion”, and “44: Production of liquid fuels from carbon dioxide and hydrogen”. This is ironic because they all relate to the introduction of nuclear and natural energy and response to global-scale energy problems ó areas named important in the latest survey.

Topics whose realization times were pushed back include “58. Practical use of fast breeder reactors”, “59: Development of fusion reactors”, “43: Direct coal liquefaction”, “50: Practical use of MW-class wind power generation system”, “56: Practical use of hot dry rock power-generating technologies”, “64: Practical use of thermochemical decomposition hydrogen production”, “68: Widespread use of hydrogen cars”, “70: Practical use of molten salt fuel cells based on coal gas” and “80: Widespread use of power equipment utilizing high-temperature superconductivity, including generators”. These results clearly show that respondents were not very optimistic about the current progress of technological development.

(Kunio Yoshida)

7.2.2. Forecast topic framework

In the course of compiling forecast topics, a framework representing the organization of technologies in tabulated matrix form was drawn up for each field, with objectives and technological domains defining the rows and columns of the table, respectively. The framework is designed to present an overall picture of technological development in each field in terms of future prospects, importance, etc. as seen from the present perspective, and is also used as a working framework for future reviews of forecast topics.

Table 7.2.2-1 Forecast Topic Framework for Energy Field

Domain / Objective	Primary energy: Oil, coal and natural gas	Primary energy: Solar, wind power, ocean energy, biomass and geotherm	Primary energy: Nuclear	Second energy: Processed energy sources (hydrogen, methanol, etc.)	Second energy: Electricity	Second energy: Heat and mechanical energy	Energy-related systems (energy conservation, combined-cycle systems, etc.)
Exploration, recovery and extraction	40 41				69		
Production	42	45 46 47 48 49 50 51 52	58 59 60	64 65	70 71 72 73 74		86
Storage and transportation		53			75 76 77 78 79		
Utilization	43	54 55 56	61	66 67 68	80 81 82 83	84	87 88
Environmental measures/safety (recovery and disposal)	44	57	62 63			85	

* Figures appearing in the table represent topic numbers.

7.2.3. Topics with high degree of importance

Degree of importance index scores (Note 1) averaged at 60.2 for topics in the energy field as a whole. Topics considered of particular importance to Japan (top 20 topics in terms of degree of importance index score) are listed in the table below. In this field, 63. Practical use of technology for the safe disposal of highly radioactive solid waste was rated most important (89 points). The top 20 topics included six which were forecasted to be realized in or after 2021.

Table 7.2.3-1 Top 20 Topics in Terms of Degree of Importance Index

Topic	Degree of importance index	Forecasted realization time (year)
63 Practical use of technology for the safe disposal of highly radioactives solid waste.	89	2019
58 Practical use of fast breeder reactor systems including nuclear fuel cycle.	80	2025
59 Development of fusion reactors.	80	2026 or later
81 Widespread use of electric vehicles with driving performance equal to that of gasoline motorcars.	79	2013
88 Widespread use of energy-efficient houses that consume less than half as much power for air conditioning as the current average house.	78	2012
62 Practical use of sophisticated reprocessing technologies capable of group separation. *The separation of nuclides from high-level radioactive wastes according to half-life or the like (e.g., the separation of TRU elements, ^{137}Cs, ^{90}Sr, and elements of the platinum group).	77	2022
48 Practical use of large-area thin-film solar cells with a cell conversion factor over 20%.	77	2013
74 Widespread use of high energy density (200 Wh/kg: 5 times the energy density of a conventional lead acid battery) secondary batteries (Ni-MH, Li, etc.).	71	2010
54 Widespread use of solar cells for residential power supply.	71	2010

Topic	Degree of importance index	Forecasted realization time (year)
72 Practical use of large-scale combined-cycle power generation using high-efficient gas turbines (inlet temperature over 1,500°C).	69	2010
40 Practical use of methane hydrate mining.	69	2019
53 Practical use of an international energy supply system in which energy recovered from clean energy sources is transported after being converted into transportable forms, such as hydrogen.	68	2023
76 Practical use of electric power storage equipment using secondary batteries for load leveling.	67	2014
83 Practical use of electric vehicles powered by fuel cells and secondary batteries.	66	2013
42 Practical use of power generation by coal gasification.	66	2011
82 Practical use of electric vehicles powered by solar cells and secondary batteries.	65	2013
87 Realization of heat industrial complexes aiming at the rationalized utilization of energy.	64	2015
60 Development of high-safety small to medium-scale nuclear reactors designed for cogeneration of heat and power.	62	2022
77 Practical use of power networks utilizing superconducting cables.	61	2025
70 Practical use of molten salt fuel-cell power generation with the 200,000 to 300,000 MW class, using coal gas.	61	2017

Note 1: Degree of importance index = (number of "high" responses × 100 + number of "medium" responses × 50 + number of "low" responses × 25 + number of "unnecessary" responses × 0) ÷ total number of degree of importance responses

7.2.4. Forecasted realization times

Forecasted realization times were distributed as shown in the diagram below.

Compared to the general trend covering all topics, forecasted realization times tend to lie in a more distant future, with the peak of their distribution located between 2016 and 2020. This tendency is characteristic to this field, and can be seen in the results of the 5th Survey as well.

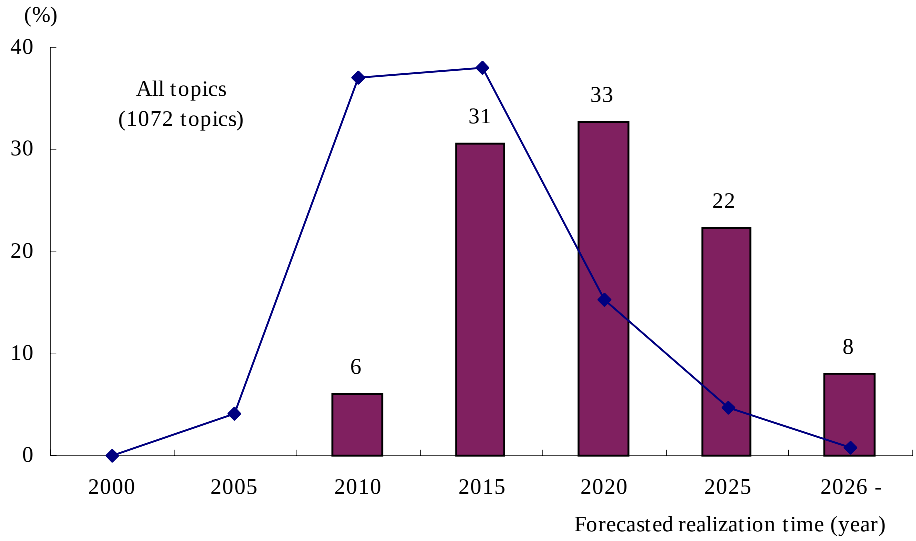

Fig. 7.2.4-1 Trends in Forecasted Realization Times

7.2.5. Current leading countries etc.

Responses to the question concerning current leading countries etc. were as shown in the diagram below. Japan was named by the greatest number of respondents, followed by the U.S., the EU and the former Soviet Union/Eastern Europe in that order.

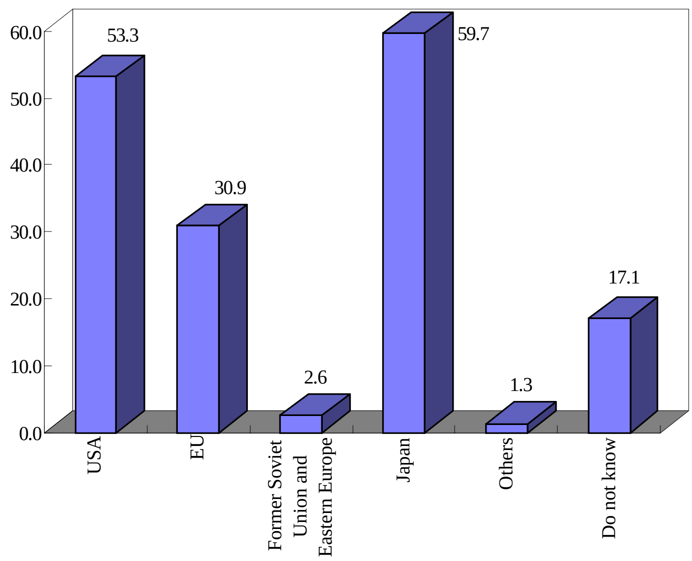

Fig. 7.2.5-1 Current Leading Countries etc. (%)

7.2.6. Comparison with the 5th Survey (previous survey)

Of the 49 topics included in the latest survey, 28 (57%) were identical to the previous survey, 6 (12%) were modified, and 15 (31%) were newly introduced. For identical topics, the results of the latest survey were compared with those of the previous survey in terms of degree of importance index scores and forecasted realization times, as shown in the table below.

Degree of importance index scores rose for 6 topics, fell for 20 topics and remained the same for 2 topics. 44. Practical use of production of liquid fuels such as methanol from carbon dioxide recovered from flue gas and hydrogen saw the greatest drop, down 17, while 53. Practical use of an international energy supply system in which energy recovered from clean energy sources is transported after being converted into hydrogen etc. saw the greatest drop, up 9 points.

From the 4th to the 5th Survey, forecasted realization times were pushed back for all topics. Likewise, from the 5th to the 6th Survey, all 29 topics saw their forecasted realization times pushed further into the future. As many as 7 topics saw their forecasted realization times pushed back 10 or more years, including ì49. Practical use of power generation by ocean thermal energy conversion (12 years).

Table 7.2.6-1 Comparison with 5th Survey for Identical Topics

Topic	Degree of importance index/forecasted realization time (year)	
	6th survey	5th survey
43 Practical use of direct coal liquefaction.	56/2017	69/2007
44 Practical use of production of liquid fuels such as methanol from carbon dioxide recovered from flue gases of large boilers at thermal power plants etc., by use of hydrogen.	54/2019	71/2008
45 Development of space photovoltaic power generating system.	53/2026 or later	52/2017
48 Practical use of large-area thin-film solar cells with a cell conversion factor over 20%.	77/2013	84/2004
49 Practical use of power generation by ocean thermal energy conversion.	41/2020	42/2008
50 Practical use of MW-class wind power generation system in Japan.	44/2011	39/2004
53 Practical use of an international energy supply system in which energy recovered from clean energy sources is transported after being converted into transportable forms, such as hydrogen.	68/2023	59/2013
54 Widespread use of solar cells for residential power supply.	71/2010	73/2007
56 Practical use of hot dry rock power-generating technologies.	50/2021	50/2011
57 Widespread use of technologies that make it possible to treat and reuse wastes and to obtain energies such as methane at low cost using biotechnology.	57/2016	60/2007
58 Practical use of fast breeder reactor systems including nuclear fuel cycle.	80/2025	85/2017
59 Development of fusion reactors.	80/2026 or later	89/2020 or later
61 Realization of nuclear power facilities (reactors, nuclear fuel cycle facilities) with a high degree of full automation by application of remote monitoring and robot system.	60/2019	70/2009
62 Practical use of sophisticated reprocessing technologies capable of group separation. *The separation of nuclides from high-level radioactive wastes according to half-life or the like (e.g., the separation of TRU elements, ^{137}Cs, ^{90}Sr, and elements of the platinum group).	77/2022	83/2014
63 Practical use of technology for the safe disposal of highly radioactives solid waste.	89/2019	92/2009
64 Practical use of thermochemical decomposition processes for hydrogen production.	59/2019	64/2010
65 Practical use of production methane and methanol from coal and biomass by use of hydrogen obtained from non-fossil sources.	55/2018	55/2012
66 Widespread use of fuel cells using as highly efficient, environmentally safe, and portable power sources, e.g., for electric vehicles.	60/2015	63/2006
68 Widespread use of hydrogen cars.	56/2021	55/2013

Topic	Degree of importance index/forecasted realization time (year)	
	6th survey	5th survey
69 Widespread use of efficient bottoming cycle power generation utilizing low temperature waste heat recovered from turbine or factor (e.g. kalina cycle).	56/2014	57/2008
70 Practical use of molten salt fuel-cell power generation with the 200,000 to 300,000 MW class, using coal gas.	61/2017	62/2010
72 Practical use of large-scale combined-cycle power generation using high-efficient gas turbines (inlet temperature over 1,500ºC).	69/2010	78/2006
75 Practical use of superconductive energy storage systems with a capacity (1000 MWh) as large as that of pumped hydro storage.	60/2024	69/2019
76 Practical use of electric power storage equipment using secondary batteries for load leveling.	67/2014	65/2007
78 Practical use of DC power transmission in the 1,000 KV class.	55/2015	61/2008
80 Widespread use of power equipments utilizing high-temperature superconductivity, including generators in industry.	56/2022	66/2013
81 Widespread use of electric vehicles with driving performance equal to that of gasoline motorcars.	79/2013	76/2008
86 Development of antimatter production and storage technology and energy sources based on it.	45/2026 or later	47/2020 or later

Note: Up until the 5th Survey, realization meant realization in Japan unless otherwise specified. However, this was changed to mean realization somewhere in the world in the 6th Survey. Therefore, care should be taken when comparing forecasted realization times from the two surveys.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time			Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001 2006 2011 2016 2021 2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Oil, coal and natural gas	40	Practical use of methane hydrate mining.	1	161	9	19	71	69	44	42	13	1	33	92	2	7		4	8	50	17	18	22	2	29	50	42	14	2	63	6	4	60	9	3	3
			2	134	10	19	72	69	43	49	9	0	34	93	2	4		3	6	59	10	14	22	2	24	53	43	12	1	72	2	2	65	8	1	1
			X	13	100	0	0	92	85	15	0	0	62	92	0	0		0	0	69	8	46	31	0	0	62	62	15	0	85	8	15	54	8	0	0
	41	Practical use of large-scale underground coal gasification.	1	186	7	28	65	47	20	35	37	8	31	90	6	6		16	12	51	22	18	20	3	24	44	35	14	1	44	6	6	60	25	1	1
			2	159	7	27	66	45	15	40	39	6	28	89	4	2		16	10	58	23	11	16	3	25	52	37	9	3	54	4	5	71	22	1	1
			X	11	100	0	0	57	27	45	27	0	36	82	18	0		18	18	64	27	36	27	0	0	73	36	9	0	64	0	0	55	18	0	0
	42	Practical use of power generation by coal gasification.	1	262	14	29	58	64	38	44	16	2	40	91	5	4		3	7	51	42	8	56	2	14	34	47	18	2	59	8	3	46	11	3	2
			2	223	14	26	60	66	37	53	9	1	39	89	4	1		1	6	52	42	4	60	0	12	34	52	13	1	68	6	2	53	10	1	1
			X	31	100	0	0	95	90	10	0	0	71	84	13	0		0	0	74	68	3	68	3	0	42	58	19	3	84	16	0	26	13	0	3
	43	Practical use of direct coal liquefaction.	1	235	12	21	67	55	25	50	21	4	35	88	6	5		10	11	52	34	9	54	6	15	43	42	17	2	58	4	4	39	9	2	4
			2	197	10	22	68	56	23	58	17	3	32	86	4	3		10	9	55	30	3	59	6	14	43	47	12	1	67	3	3	44	7	1	3
			X	20	100	0	0	69	45	40	15	0	40	80	5	5		25	0	65	25	0	85	5	5	50	50	20	5	55	0	10	35	5	5	5
	44	Practical use of production of liquid fuels such as methanol from carbon dioxide recovered from flue gases of large boilers at thermal power plants etc., by use of hydrogen.	1	254	15	22	63	54	30	36	25	9	30	90	4	4		18	13	32	23	3	51	2	27	40	41	17	2	50	6	2	29	9	2	4
			2	217	14	22	64	54	25	46	24	5	27	91	2	3		18	9	31	20	2	57	1	28	42	41	14	1	59	5	3	32	7	1	2
			X	30	100	0	0	58	33	37	27	3	40	80	0	3		27	7	27	13	0	87	3	10	37	53	17	0	47	0	3	20	3	3	3
Solar, wind power, ocean energy, biomass and geotherm	45	Development of space photovoltaic power generating system.	1	272	10	22	68	54	29	35	28	7	41	90	3	12		16	16	73	13	10	32	0	16	47	35	18	1	56	4	5	46	19	6	5
			2	225	10	24	66	53	25	42	27	6	36	90	2	10		17	12	77	8	6	30	0	14	53	35	14	1	64	3	5	52	20	4	2
			X	22	100	0	0	66	45	36	9	9	59	86	0	14		18	0	91	14	9	59	0	5	55	45	23	0	82	0	0	68	32	0	0
	46	Practical use of 100 MW-capacity photovoltaic power generation system in desert areas.	1	304	14	28	58	43	16	35	38	11	41	94	8	6		6	8	65	29	3	54	2	13	36	38	14	1	53	8	7	38	6	4	5
			2	259	14	27	59	41	12	38	40	10	37	95	3	2		5	6	70	24	1	58	2	12	42	44	8	1	61	6	5	47	3	3	2
			X	36	100	0	0	60	33	47	11	8	53	97	3	6		3	8	86	39	0	83	6	0	50	64	8	0	75	3	6	47	0	8	3
	47	Practical use of MW-class ocean photovoltaic power generation system.	1	283	14	28	58	55	27	44	23	5	41	90	8	4		10	12	42	21	2	57	0	23	33	40	14	1	57	10	4	48	7	2	4
			2	245	13	28	58	53	22	50	24	5	38	93	4	3		12	8	48	18	0	65	0	21	37	46	9	1	70	8	4	58	5	2	2
			X	33	100	0	0	57	30	39	27	3	48	91	3	6		9	3	67	21	0	94	3	0	36	67	6	0	85	6	6	64	3	0	6
	48	Practical use of large-area thin-film solar cells with a cell conversion factor over 20%.	1	284	17	28	56	75	53	39	6	1	54	95	13	11		2	5	61	30	1	85	1	7	48	47	24	1	67	9	1	24	5	3	4
			2	245	16	25	60	77	57	37	5	1	54	92	10	6		2	4	56	22	0	86	1	7	53	49	18	0	74	8	1	32	4	1	1
			X	38	100	0	0	92	84	16	0	0	68	95	5	8		3	0	79	34	0	97	5	0	66	55	24	0	89	3	3	21	5	3	0
	49	Practical use of power generation by ocean thermal energy conversion.	1	262	5	21	74	41	12	36	44	8	31	90	5	4		22	14	37	18	1	47	0	26	39	32	15	2	47	8	5	46	3	2	4
			2	230	5	22	73	41	10	39	46	5	27	92	3	2		24	9	40	13	0	56	0	25	43	34	9	1	59	6	3	57	2	1	2
			X	12	100	0	0	52	33	17	42	8	33	83	0	0		17	0	50	33	0	100	0	0	67	67	25	0	83	0	0	67	0	0	0

(Note) See page 7 for the interpretation of the graphs.

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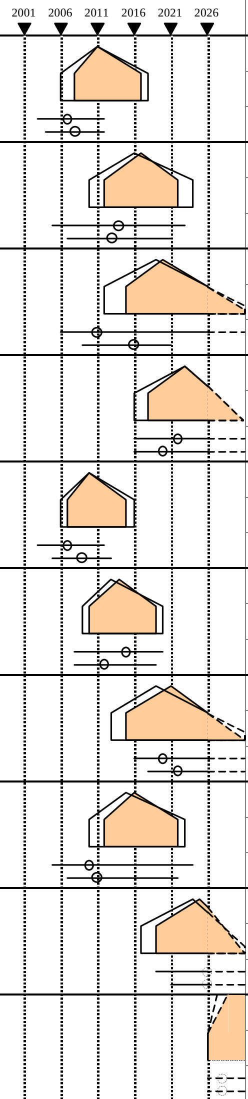
Solar, wind power, ocean energy, biomass and geotherm	50	Practical use of MW-class wind power generation system in Japan.	1	284	8	23	69	46	19	34	41	6	27	89	7	2	17	12	74	45	2	36	0	7	29	32	14	3	48	21	5	46	12	2	5
			2	245	9	22	69	44	16	35	44	5	23	93	5	2	16	8	76	44	1	34	0	8	30	36	8	2	59	20	3	52	9	2	4
			X	22	100	0	0	73	55	32	9	5	36	95	5	5	0	5	82	68	0	45	0	0	41	45	5	5	73	27	0	68	9	5	9
	51	Widespread use of high-efficient energy production processes using biomass as raw material.	1	230	7	23	70	50	22	39	33	5	39	92	6	7	13	10	49	34	3	28	6	26	47	38	17	12	49	8	4	47	5	7	4
			2	199	8	22	71	48	16	48	33	4	33	91	6	4	13	8	56	36	3	27	5	22	54	42	11	10	53	6	4	57	4	4	2
			X	15	100	0	0	73	53	33	13	0	60	93	13	0	7	0	80	80	7	40	0	0	60	60	20	0	60	0	7	73	0	0	7
	52	Practical use of energy plantation.	1	167	8	19	73	48	17	43	36	4	39	90	10	5	11	14	47	25	1	22	4	29	38	42	11	11	43	7	5	44	8	4	5
			2	147	10	16	75	43	8	53	34	4	33	93	6	1	13	7	54	26	0	22	4	28	42	50	10	6	52	7	3	55	6	1	1
			X	14	100	0	0	59	29	50	21	0	43	93	14	0	14	0	71	36	0	36	7	7	36	57	7	0	57	7	14	64	0	0	0
	53	Practical use of an international energy supply system in which energy recovered from clean energy sources is transported after being converted into transportable forms, such as hydrogen.	1	279	14	28	58	67	44	38	14	3	51	94	5	6	10	14	46	38	3	46	1	24	44	43	18	3	53	13	2	27	27	4	3
			2	247	12	30	58	68	44	43	11	2	46	94	3	2	11	11	50	37	0	53	1	23	52	45	13	1	63	11	2	30	32	2	3
			X	30	100	0	0	87	77	20	0	3	47	100	3	7	7	0	57	60	0	80	3	3	50	47	27	0	73	10	7	40	27	3	3
	54	Widespread use of solar cells for residential power supply.	1	354	18	30	52	70	48	36	15	1	50	90	34	2	3	6	47	39	1	76	1	10	22	35	12	2	47	47	10	19	14	7	5
			2	298	18	30	52	71	48	41	10	1	46	90	29	1	2	3	50	38	0	83	1	6	18	41	7	1	55	54	6	22	12	3	4
			X	55	100	0	0	83	70	22	7	0	55	98	27	0	0	0	60	64	0	91	2	0	20	40	7	2	53	55	11	27	18	2	4
	55	Widespread use of solar hot-water supply systems in most Japanese households (current rate 20%).	1	334	12	23	64	56	28	41	29	2	28	82	37	1	24	12	18	15	1	69	2	17	12	25	7	2	29	32	10	15	8	4	6
			2	290	11	22	67	53	21	51	27	1	21	84	36	0	24	8	18	12	0	81	2	12	11	28	3	1	33	41	8	16	6	2	4
			X	32	100	0	0	81	68	19	13	0	31	97	41	0	13	3	28	28	0	94	9	0	19	44	6	0	50	44	13	34	9	3	13
	56	Practical use of hot dry rock power-generating technologies.	1	210	7	22	71	51	21	43	33	3	22	90	4	6	9	13	42	21	4	56	2	20	33	36	14	1	58	14	0	60	10	0	1
			2	176	6	27	68	50	18	45	36	1	19	94	2	5	7	7	50	27	2	64	2	17	39	43	7	0	67	9	1	69	8	0	0
			X	10	100	0	0	73	50	40	10	0	30	100	0	0	20	0	70	40	0	70	0	0	40	70	0	0	70	0	0	90	20	0	0
	57	Widespread use of technologies that make it possible to treat and reuse wastes and to obtain energies such as methane at low cost using biotechnology.	1	248	8	21	71	59	28	55	16	2	40	90	22	4	6	9	30	33	0	41	2	29	39	39	13	10	49	19	2	33	8	7	3
			2	215	7	18	74	57	22	64	13	1	35	93	19	2	3	6	33	37	0	50	1	26	45	47	5	5	58	16	1	39	8	4	0
			X	16	100	0	0	72	44	56	0	0	44	94	13	0	0	0	50	56	0	75	0	0	50	44	0	6	56	38	0	50	6	0	0
Nuclear	58	Practical use of fast breeder reactor systems including nuclear fuel cycle.	1	230	17	24	60	76	62	22	10	6	34	91	7	12	16	14	27	60	17	77	1	6	45	40	22	2	58	10	8	41	43	15	3
			2	191	17	21	62	80	69	18	7	5	36	89	5	7	16	8	24	71	12	80	1	5	51	42	17	1	68	8	8	47	55	10	2
			X	33	100	0	0	95	91	6	3	0	42	91	9	12	3	3	9	73	36	97	3	0	67	58	12	0	82	9	9	30	33	9	6
	59	Development of fusion reactors.	1	217	15	25	59	73	58	23	13	6	38	91	6	23	25	19	71	61	27	66	1	11	47	32	23	3	58	3	6	39	33	12	1
			2	183	13	29	58	80	67	20	9	4	37	91	3	14	28	17	79	64	17	75	0	8	61	34	21	2	67	2	6	44	45	8	0
			X	23	100	0	0	89	82	9	9	0	61	87	9	30	22	9	83	83	26	96	0	4	65	48	22	9	74	0	17	30	39	13	0



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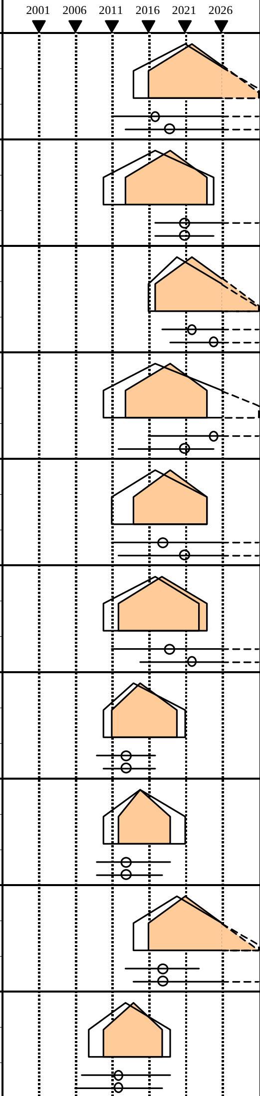
Nuclear	60	Development of high-safety small to medium-scale nuclear reactors designed for cogeneration of heat and power.	1	195	16	23	61	61	37	38	20	5	37	89	10	6	14	13	39	38	17	39	3	24	36	30	19	2	45	18	5	39	35	15	3
			2	167	17	20	63	62	37	42	16	5	33	89	8	3	15	7	50	49	11	53	3	17	43	34	13	0	56	19	5	46	50	9	2
			X	28	100	0	0	75	56	33	11	0	32	82	11	7	4	0	50	54	36	71	4	4	43	39	14	0	79	25	11	43	43	4	11
	61	Realization of nuclear power facilities (reactors, nuclear fuel cycle facilities) with a high degree of full automation by application of remote monitoring and robot system.	1	174	11	20	69	58	33	39	21	7	38	67	20	7	12	11	40	33	3	58	0	23	30	43	21	2	46	13	3	24	40	10	2
			2	147	11	19	70	60	32	48	17	3	35	77	18	4	10	8	47	34	1	65	1	19	33	50	17	1	55	13	2	24	47	9	1
			X	16	100	0	0	69	44	44	13	0	44	75	13	6	19	0	56	63	6	69	0	13	19	63	19	0	50	25	0	44	44	6	0
	62	Practical use of sophisticated reprocessing technologies capable of group separation. *The separation of nuclides from high-level radioactive wastes according to half-life or the like (e.g., the separation of TRU elements, $^{137}C_{s}$, $^{90}S_{r}$, and elements of the platinum group).	1	131	19	24	57	72	53	32	12	3	30	84	11	13	8	15	41	49	11	56	1	18	51	43	23	4	60	6	3	39	30	11	1
			2	109	18	19	62	77	60	30	8	2	25	92	6	7	8	11	44	57	8	69	1	15	52	41	20	4	70	6	3	44	34	10	1
			X	20	100	0	0	88	79	16	5	0	20	85	5	5	15	0	45	85	15	85	0	5	65	45	35	5	80	10	0	40	30	5	5
	63	Practical use of technology for the safe disposal of highly radioactives solid waste.	1	185	15	28	57	83	69	27	3	1	24	88	17	5	5	9	58	69	8	58	2	14	42	46	28	1	55	18	4	49	34	15	2
			2	151	15	27	58	89	80	17	2	1	19	95	12	3	6	5	62	71	3	63	2	11	45	49	22	1	66	15	3	54	37	9	3
			X	23	100	0	0	91	83	17	0	0	13	87	13	4	0	4	83	91	0	78	4	4	61	39	35	0	74	17	9	48	26	13	4
Processed energy sources (hydrogen, methanol, etc.)	64	Practical use of thermochemical decomposition processes for hydrogen production.	1	197	11	26	63	60	34	42	21	3	38	90	4	9	9	15	45	30	4	51	1	22	46	44	17	2	52	8	3	24	16	2	5
			2	166	13	25	62	59	30	50	16	4	33	89	1	5	10	11	51	28	1	55	0	20	49	43	13	2	58	5	2	27	16	1	3
			X	21	100	0	0	71	52	38	0	10	48	81	0	10	10	5	43	14	0	90	0	0	57	48	19	5	67	5	0	29	24	0	5
	65	Practical use of production methane and methanol from coal and biomass by use of hydrogen obtained from non-fossil sources.	1	197	13	29	58	57	28	47	22	3	34	92	5	5	9	13	45	31	4	47	1	25	46	46	15	4	50	8	2	28	9	2	4
			2	170	14	28	59	55	23	50	26	1	28	95	2	4	8	8	55	29	0	53	1	21	48	51	7	2	60	7	2	34	8	0	2
			X	23	100	0	0	68	45	36	18	0	39	87	0	13	4	0	57	30	0	70	4	9	43	48	17	4	57	9	9	35	17	0	9
	66	Widespread use of fuel cells using as highly efficient, environmentally safe, and portable power sources, e.g., for electric vehicles.	1	247	15	22	63	61	31	50	18	1	43	89	23	4	6	9	57	29	0	55	2	18	40	43	13	1	52	23	2	27	18	4	4
			2	207	15	20	64	60	28	56	15	0	42	91	15	2	5	7	66	27	0	63	3	14	39	46	6	0	61	23	2	31	16	2	2
			X	32	100	0	0	77	58	35	6	0	50	88	28	6	6	0	84	38	0	81	6	3	41	53	19	0	69	31	3	34	22	3	3
	67	Widespread use of methanol as fuel.	1	248	11	25	64	53	20	53	26	1	33	88	11	2	8	12	44	26	2	37	14	23	31	36	9	2	34	29	4	28	15	2	4
			2	211	11	21	68	52	16	61	21	1	30	92	7	1	7	8	54	26	0	41	15	19	29	41	6	1	44	31	4	33	14	1	1
			X	23	100	0	0	69	45	41	14	0	26	96	0	4	4	0	78	22	0	52	22	4	26	39	17	0	39	43	9	30	17	4	0
	68	Widespread use of hydrogen cars.	1	264	9	19	72	54	26	42	29	3	41	87	16	4	11	17	40	34	0	44	1	28	39	41	14	2	45	28	3	21	31	3	2
			2	224	10	15	75	56	26	47	24	3	38	92	10	3	11	11	49	37	0	57	1	23	38	44	9	0	53	28	2	18	37	0	1
			X	22	100	0	0	71	52	29	19	0	32	100	9	5	9	0	55	68	0	77	0	0	36	45	18	0	55	27	0	23	36	0	0
Electricity	69	Widespread use of efficient bottoming cycle power generation utilizing low temperature waste heat recovered from turbine or factor (e.g. kalina cycle).	1	180	9	29	62	58	27	53	19	1	33	90	7	3	4	8	39	30	2	48	0	24	34	41	14	2	44	18	2	26	11	1	3
			2	161	9	28	63	56	19	69	13	0	29	94	3	2	2	6	42	32	2	61	0	22	34	44	11	1	57	17	1	29	7	0	2
			X	14	100	0	0	73	50	43	7	0	29	93	0	7	7	0	57	43	0	100	0	0	36	43	14	0	57	21	0	29	0	0	0



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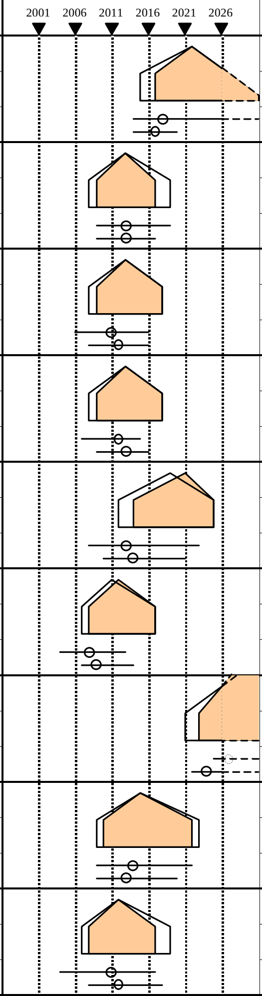
Electricity	70	Practical use of molten salt fuel-cell power generation with the 200,000 to 300,000 KW class, using coal gas.	1	197	19	25	56	62	34	47	17	2	34	92	6	6		6	13	62	18	2	64	0	15	41	46	13	2	59	15	3	23	12	1	3
			2	179	17	22	61	61	30	56	13	2	32	93	3	3		7	11	68	14	0	72	0	12	45	52	10	1	66	12	3	30	9	0	2
			X	31	100	0	0	77	61	29	6	3	23	94	3	3		10	6	87	19	0	94	0	0	39	48	16	0	81	19	6	23	13	0	0
	71	Widespread use of solid-electrolyte fuel cells with tens of MW for district cogeneration and diversified small-scale power generation.	1	232	16	29	55	63	33	53	13	0	48	93	14	6		3	9	64	23	1	63	0	14	39	46	17	1	53	25	3	16	14	4	4
			2	203	16	25	60	60	25	66	9	1	45	94	8	4		3	9	71	22	0	68	0	12	40	52	9	0	63	24	2	22	14	1	2
			X	32	100	0	0	71	50	41	3	6	38	91	13	9		6	6	94	34	0	72	0	0	53	41	13	0	78	16	6	13	16	3	0
	72	Practical use of large-scale combined-cycle power generation using high-efficient gas turbines (inlet temperature over 1,500ºC).	1	228	14	32	54	70	44	48	8	0	43	91	5	3		2	9	64	32	2	69	0	13	31	44	22	2	51	10	4	19	11	0	3
			2	196	15	29	56	69	41	55	5	0	42	92	3	1		2	5	72	30	1	79	0	7	32	52	21	2	60	9	2	22	10	0	2
			X	30	100	0	0	92	83	17	0	0	50	97	7	3		3	0	77	30	3	83	0	0	20	57	27	0	53	3	3	27	27	0	3
	73	Practical use of hydrogen-fueled turbines for power generation.	1	166	13	23	64	58	27	54	17	2	37	89	4	5		7	17	47	25	1	45	0	27	43	40	24	3	53	8	3	19	27	2	1
			2	147	14	20	66	56	21	62	14	2	28	93	1	3		6	14	54	27	1	53	0	22	47	48	21	1	60	6	1	20	27	1	1
			X	20	100	0	0	76	60	30	5	5	35	95	10	5		10	5	55	40	5	95	0	0	40	60	40	0	65	10	0	30	20	0	0
	74	Widespread use of high energy density (200 Wh/kg: 5 times the energy density of a conventional lead acid battery) secondary batteries (Ni-MH, Li, etc.).	1	201	16	26	58	70	44	48	8	0	59	77	30	5		1	4	58	23	1	79	0	12	44	49	14	3	54	11	1	25	18	3	2
			2	166	16	25	58	71	44	51	5	0	61	80	17	2		1	2	59	19	0	82	0	11	45	63	9	1	60	9	2	29	16	0	1
			X	27	100	0	0	91	81	19	0	0	74	93	30	4		0	4	67	19	0	100	0	0	48	70	7	4	52	19	4	30	30	0	0
	75	Practical use of superconductive energy storage systems with a capacity (1000 MWh) as large as that of pumped hydro storage.	1	193	9	22	68	62	37	43	16	4	42	84	4	10		12	17	54	20	2	59	0	21	42	44	24	3	58	7	3	26	23	2	2
			2	165	10	24	67	60	30	52	15	2	38	88	1	7		13	13	59	18	2	63	0	18	47	47	19	0	66	7	1	30	25	1	1
			X	16	100	0	0	77	53	47	0	0	44	94	0	0		13	13	75	6	0	88	0	0	38	56	25	0	81	6	0	38	13	6	6
	76	Practical use of electric power storage equipment using secondary batteries for load leveling.	1	212	15	28	57	65	37	52	10	1	40	85	12	3		2	8	46	24	1	67	0	19	28	44	17	1	49	19	2	16	18	3	2
			2	178	16	27	57	67	37	56	6	1	39	90	7	2		3	4	51	24	0	76	0	14	32	52	8	1	60	17	3	16	20	0	1
			X	29	100	0	0	83	67	33	0	0	45	93	3	3		3	0	59	21	0	93	0	0	38	45	7	0	52	31	3	24	17	0	3
	77	Practical use of power networks utilizing superconducting cables.	1	181	9	24	66	62	36	42	18	3	48	81	6	12		17	15	55	28	2	57	1	22	34	40	21	3	50	8	2	17	18	3	3
			2	157	8	24	68	61	32	51	14	3	49	87	4	6		15	9	60	26	0	68	0	18	32	46	16	1	61	6	3	24	23	1	1
			X	13	100	0	0	87	77	15	8	0	62	92	0	0		8	15	92	46	0	92	0	0	54	46	15	0	77	23	8	23	31	0	8
	78	Practical use of DC power transmission in the 1,000 KV class.	1	143	12	24	64	57	26	53	18	3	39	73	4	3		2	13	43	28	13	50	1	22	29	38	19	2	45	8	4	24	20	0	3
			2	125	12	24	64	55	20	62	17	2	33	81	5	0		1	9	48	23	10	60	2	19	27	45	12	2	55	10	4	26	23	0	1
			X	15	100	0	0	67	40	47	13	0	33	93	0	0		0	0	53	47	27	67	7	0	33	20	13	0	47	7	7	33	13	0	0
	79	Practical use of electricity storage using hydrogen produced by electrolysis.	1	205	10	24	66	56	28	43	27	3	40	84	6	5		9	11	42	30	3	44	1	30	35	39	16	2	47	15	2	14	30	2	3
			2	176	9	26	65	56	25	51	22	2	35	89	3	3		10	9	49	30	1	55	1	27	38	48	11	2	56	13	2	15	36	1	2
			X	16	100	0	0	63	44	25	25	6	31	94	0	0		19	0	75	44	0	81	0	6	44	50	13	6	63	19	0	25	25	0	0

(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic development	Expected effect: Resolution of global problems	Expected effect: People's needs	Expected effect: Expansion of intellectual resources	Forecasted realization time: Will not be realized (%)	Forecasted realization time: Do not know (%)	Leading countries (%): USA	Leading countries: EU	Leading countries: Former Soviet Union and Eastern Europe	Leading countries: Japan	Leading countries: Other countries	Leading countries: Do not know	Measures the government should adopt (%): Foster human resources	Measures: Promote exchanges among industrial, academic and government sectors and different fields	Measures: Upgrade advanced facilities and equipment	Measures: Develop a research base	Measures: Increase government research funding	Measures: Adjust regulations (relax/toughen)	Measures: Others	Potential problems (%): Adverse effect on the natural environment	Potential problems: Adverse effect on safety	Potential problems: Adverse effect on morals, culture or society	Potential problems: Other adverse effects
Electricity	80	Widespread use of power equipments utilizing high-temperature superconductivity, including generators in industry.	1	193	8	20	72	59	29	51	18	2	60	70	8	13	9	18	56	30	4	66	0	18	45	38	18	3	57	3	3	13	16	3	2
			2	163	8	20	72	56	21	62	15	2	59	80	4	7	10	14	64	28	2	72	0	15	51	42	16	2	69	1	1	13	21	1	0
			X	13	100	0	0	75	54	38	8	0	62	92	0	8	8	15	92	31	0	100	0	0	54	69	31	8	85	0	0	15	15	0	0
	81	Widespread use of electric vehicles with driving performance equal to that of gasoline motorcars.	1	306	12	21	68	74	53	41	6	1	60	89	38	4	4	7	70	43	0	74	0	9	31	49	14	1	49	35	4	21	12	8	5
			2	254	11	20	69	79	60	36	4	0	57	89	32	2	5	5	74	40	0	83	0	4	28	57	11	0	58	37	3	23	12	4	2
			X	28	100	0	0	84	71	21	7	0	64	96	39	4	11	0	93	46	0	100	0	0	29	61	18	0	71	46	0	36	14	7	4
	82	Practical use of electric vehicles powered by solar cells and secondary batteries.	1	293	14	24	63	65	40	42	16	2	51	89	29	3	7	10	63	37	1	69	0	13	31	47	15	1	45	29	2	20	13	6	5
			2	249	13	23	64	65	38	47	13	2	49	88	22	2	4	7	73	35	0	82	1	6	33	53	10	0	57	30	2	24	12	2	2
			X	33	100	0	0	69	45	39	15	0	61	94	33	3	6	0	88	48	0	100	0	0	33	48	6	0	76	45	0	33	15	6	3
	83	Practical use of electric vehicles powered by fuel cells and secondary batteries.	1	269	16	21	63	66	40	44	15	2	55	88	26	3	5	11	67	36	0	60	0	14	35	43	13	1	45	29	3	20	17	5	4
			2	235	14	20	66	66	38	52	10	1	51	91	20	0	4	8	73	36	0	71	0	10	37	53	8	0	59	30	3	23	18	2	3
			X	34	100	0	0	72	50	38	12	0	53	94	29	0	6	0	88	56	0	82	0	3	35	53	12	0	76	41	3	21	24	3	3
Heat and mechanical energy	84	Widespread use of household solid polymer electrolyte fuel cells for cogeneration.	1	204	18	21	62	53	24	44	30	2	43	78	31	5	11	12	51	21	0	55	3	21	33	35	14	1	47	28	1	15	17	6	3
			2	181	17	18	65	51	19	49	30	2	42	85	26	3	8	9	59	20	0	70	2	16	39	51	10	0	61	28	2	18	18	3	2
			X	31	100	0	0	65	39	45	16	0	48	90	23	3	16	6	87	39	0	90	6	3	39	52	16	0	65	48	3	19	23	0	3
	85	Widespread use of highefficient heat pumps utilizing untapped energy held by river water, groundwater, etc. (COP for cooling 6 or more)	1	241	16	24	61	54	23	51	22	3	38	88	22	3	6	13	25	22	1	65	0	22	27	43	15	2	45	24	5	35	8	5	2
			2	211	16	24	60	55	22	57	18	2	36	91	15	3	3	9	26	22	0	75	0	18	27	56	11	1	52	26	3	41	8	2	0
			X	34	100	0	0	73	47	50	3	0	53	100	6	6	3	12	32	26	0	94	0	6	35	56	9	0	53	38	0	53	6	0	0
Energy systems (energy conservation, combined-cycle, etc.)	86	Development of antimatter production and storage technology and energy sources based on it.	1	93	9	15	76	45	22	33	26	19	19	63	5	44	46	25	37	20	5	16	0	44	45	20	18	1	33	3	4	32	19	10	2
			2	75	8	16	76	45	21	33	32	14	15	68	3	44	47	19	43	21	3	13	0	48	60	21	17	1	35	4	7	43	25	7	0
			X	6	100	0	0	63	50	17	17	17	17	100	0	0	50	0	83	33	0	33	0	0	50	33	17	0	33	0	0	50	33	0	0
	87	Realization of heat industrial complexes aiming at the rationalized utilization of energy.	1	217	12	27	60	66	40	46	14	1	53	88	12	3	7	12	28	38	6	47	0	30	29	49	13	0	37	39	4	25	17	7	4
			2	190	11	28	61	64	35	51	13	0	46	89	5	3	5	10	26	42	2	57	0	24	31	59	9	1	41	45	3	32	16	2	2
			X	21	100	0	0	76	57	33	10	0	52	100	5	10	14	5	29	38	5	62	0	14	38	57	5	0	43	48	5	29	14	5	0
	88	Widespread use of energy-efficient houses that consume less than half as much power for air conditioning as the current average house.	1	281	15	28	58	73	50	44	5	1	43	87	47	3	3	6	28	46	1	56	1	18	25	50	16	2	39	42	7	14	14	9	4
			2	242	16	24	60	78	58	38	3	1	40	89	42	2	2	4	24	45	0	67	1	16	21	58	11	1	43	51	5	16	13	4	2
			X	39	100	0	0	89	79	21	0	0	46	95	56	3	0	3	33	67	0	69	5	10	26	64	8	0	51	51	10	28	26	3	5



(Note) See page 7 for the interpretation of the graphs.

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8. Survey Results in "Environment"

8.1. Trends in areas of attention

With the United Nations Framework Convention on Climate Change (FCCC), which was signed in 1992, as the catalyst, international consensus for global environmental problems has been established, and we are at the stage where serious efforts must be made to find a solution. Global-scale climate change has been dubbed the ultimate environmental problem because of the extreme difficulty in addressing it. Although discussions have so far been focusing on the stabilization of greenhouse gas emissions in the year 2000, which is a relatively short-term target, the achievement of the ultimate goal of the FCCC would require long-term targets as well. Namely, rather than merely stabilizing emissions, there is a need to go a step further and actually reduce them, and this highlights the inadequacy of Band-Aid measures. Indeed, with the Third Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP3) scheduled to be held in Japan in 1997, awareness of global environmental problems has been steadily increasing.

In the latest survey, there were 39 questions, which were roughly divided into two groups: global environment and local environment. Of the 10 topics ranked high in terms of the degree of importance index, six were from the global environment area, and this should be interpreted as an expression of the view that, to conserve the global environment, effective global environmental conservation measures should be given priority. However, the global environment is far more complex an issue than conventional local industrial pollution. Notably, the "waste" area accounted for as many as two topics. For these problems, there are no simple solutions. Rather, they require complete rethinking in terms of urban structure and product design concepts.

By purpose, nine out of the 10 topics regarded most important were in the "countermeasures, control and management" category, and this points to a shift in people's perspective from the traditional heavy emphasis on the "prediction/elucidation of phenomena and impacts" to greater importance attached to environmental management techniques and prevention/control measures.

Global environmental problems have also reached the stage where the "think globally and act locally" approach, which has become a favorite catchword in recent years, must be put into practice. As areas of attention regarding the latest survey, we have chosen the (1) introduction of design technologies for the realization of a recycling society (LCA) and (2) establishment of environmental management techniques, and will discuss their trends below:

8.1.1. Introduction of design technologies for the realization of a recycling society (LCA)

Any realistic and meaningful investigation into a social system that gives the environment priority must address city concepts and corporate philosophy as well. At the city level, it is, as a matter of course, desirable to minimize energy or resource input. While demand reduction through demand side management (DSM) is a prerequisite, the ultimate goal for future cities should be to build energy/resource recycling societies based on the idea of environmental load reduction.

The hitherto-prevalent people's propensity to mass energy consumption and environmental problems are consequences of a rapid expansion of a "one-way-traffic" society based on the mass production, consumption and disposal of energy and resources, and the findings of the latest survey are testimony to the importance of a switch to an energy/resource recycling society structure as soon as possible.

There are basic models in realizing an energy/resource recycling society. The ultimate type is a zero-emission society, which requires a city structure that allows the concentration of companies that form the core of an industrial food chain amenable to the total "digestion" of input (no waste) or total reuse of byproduct output (waste) as an input (raw material). In this regard, it is interesting to note that topics relating to technologies that bring existing cities closer to the zero-emission level, such as RDF-based wide-area waste power generation and biotechnology-based wastewater treatment systems were considered important. Namely, while technological development tended to focus on the "arterial side" in the past, the perspective is shifting to the development of "veinal side" technologies from the environmental load reduction point of view.

For the large-scale implementation of global-scale environmental measures, the establishment of assessment techniques for increasingly diverse technologies will be indispensable. In doing so, life cycle assessment (LCA) involving energy requirements and environmental impacts will be effective, apart from economic merits. From this viewpoint, the introduction of an LCA approach geared towards recycling and reuse will be a crucial element of product design that gives priority to the environment. In the past, the concept of manufacturing was to produce brand-new goods at factories by pouring in raw materials. However, as recycling-oriented societies take off, manufacturing will have to be redefined as a closed-loop process in which byproduct output (waste) is fed back to the same subprocess or reused as the input (raw material) to another subprocess to ensure sustainable corporate activities. This gives rise to the concept of "a reverse factory". It is interesting to note that, of all the topics, the one that was ranked highest in terms of the degree of importance index was "32: Wide acceptance of LCA-style product design concepts that encourage recycling and reuse", with its realization time forecasted to be 2007.

8.1.2. Establishment of environmental management techniques

Against the background of the above is the effectuation of the ISO 14000 series of environmental management and auditing system standards, which began in 1996. The foreword of ISO 14001 states that an environmental management system is a tool devised in search of compatibility between the environment and the economy. The introduction of an LCA approach is essential for the development of a sustainable society, and this is becoming a basic condition for international competition.

This means that 21st century-style production and manufacturing processes represent an all-out change, and we are now at a new stage of industrial development not seen since the Industrial Revolution. Namely, it is very important to scrutinize industrial processes associated with high environmental loads and establish thorough environmental management techniques, such as process rationalization, from an LCA viewpoint.

According to the results of the latest survey, a new perspective is needed, if an environment-conserving economy and society are to be realized. In this regard, in addition to the participation of the general public through lifestyle changes etc., the participation of businesses as powerful members of society is very important, and their role crucial. Ultimately, it is important to facilitate the transition to an environment-conserving society by making the best use of the vitality of the private sector, and, to this end, the implementation of measures based on the following three basic policies is considered effective: i) active utilization of the market mechanism premised on the internationalization of environmental costs; ii) setting of clear goals for future social and technological environmental management; iii) active inducement of continued investment into the future.

The most important thing about conducting corporate activities in a sustainable manner in the future is thorough environmental management shown in ii) above, and, as a noteworthy recent trend, the importance of the introduction of product design concepts with an LCA perspective has been recognized, according to the results of the latest survey.

(Takao Kashiwagi)

8.2. Forecast topic framework

In the course of compiling forecast topics, a framework representing the organization of technologies in tabulated matrix form was drawn up for each field, with objectives and technological domains defining the rows and columns of the table, respectively. The framework is designed to present an overall picture of technological development in each field in terms of future prospects, importance, etc. as seen from the present perspective, and is also used as a working framework for future reviews of forecast topics.

Table 8.2-1 Forecast Topic Framework for Environment Field

Objective \ Domain	Global environment						
	Depletion of ozone layer	Global warming	Acid rain	Marine pollution	Diminishment of tropical rainforests	Desertification	Common
Elucidation, prediction and observation of phenomena	01 02	05 06	12	14			22
Elucidation, prediction and observation of impacts	03	07 08	13	15	17 18	20	
Prevention, control and management	04	09 10 11		16	19	21	23

* Figures appearing in the table represent topic numbers.

Objective \ Domain	Local environment					
	Air quality	Water quality	Noise/ vibration	Waste	Nature/ecosystems	Cross-sectional
Elucidation, prediction and observation of phenomena		25				35
Elucidation, prediction and observation of impacts						36
Prevention, control and management	24	26 27 28	29	30 31 32 33	34	37 38 39

* Figures appearing in the table represent topic numbers.

8.3. Topics with high degree of importance

Degree of importance index scores (Note 1) averaged at 72.0 for topics in the environment field as a whole. Topics considered of particular importance to Japan (top 20 topics in terms of degree of importance index score) are listed in the table below. 32. Wide acceptance of LCA-style product design concepts that encourage recycling and reuse was rated most important (91 points), while 18. Elucidation of the impact of diminishing tropical rain forests on wildlife ecosystems was rated least important (49 points).

Table 8.3-1 Top 20 Topics in Terms of Degree of Importance Index

Topic	Degree of importance index	Forecasted realization time (year)
32 Wide acceptance of LCA-style product design concepts that encourage recycling and reuse.	91	2007
24 Widespread use of control technologies in virtually all types of automobiles, capable of meeting the emission control standard for nitric oxide at the order of 0.1 to 0.2 g/Km. (The current level for heavy diesel motorcars is on the order of 4 to 5 g/Km, and the standard control value for gasoline passenger cars in 1978 is 0.25 g/Km.)	89	2007
34 Establishment of assessing socio-economic damage/loss because of the destruction of natural environment by soil contamination and land subsidence (e.g., loss of natural beaches, forests, or fields) and incorporation of its countermeasures in regulatory system.	87	2012
38 Widespread use more than 10% in the world of automobiles as urban transportation system (electric vehicles) which do or noise pollution. not cause air	86	2013
23 Introduction of environment tax aiming at global environmental conservation.	85	2006

Topic	Degree of importance index	Forecasted realization time (year)
08 Determination and general understanding of the impact of global warming on world agricultural production.	84	2012
31 Widespread use of power generation using refuse derived fuel (RDF).	82	2006
04 Practical use of materials that replace fluorocarbons and halons, that do not damage the ozone layer and cause global warning problem.	82	2007
27 Widespread use, including use at home, of compact waste-water treatment systems based on biotechnology for the highly efficient treatment of persistent substances and hazardous materials.	82	2010
09 Reduction of global carbon dioxide emissions to 20% below the 1990 level.	81	2022
25 Progress of investigation of mechanisms for both concentration of heavy metals and other pollutants in ecosystems and occurrence of eutrophication, and realization of prediction and forecasting of the impact of water pollution in closed water bodies, such as lakes and semi-closed bays, on their ecosystems.	81	2010
35 Elucidation of a long-term exposure effects of quantities of most of the harmful chemical substances in ordinary environment, on human beings.	80	2016
12 Elucidation of the worldwide long-distance migration mechanisms of acid-rain-causing substances, such as SO_x and NO_x, considering regional characteristics.	79	2010
36 Establishment of a technique to predict the fate of newly discovered chemical substances through the accumulation of knowledge on matters such as the behavior of persistent chemical substances in the environment.	79	2015
26 Widespread use of formulation methods for water environment plan based on quantitative understanding of natural purification functions of paddy fields, reservoirs, rivers, water channels and water permeating into the ground.	79	2010
15 Elucidation of impacts exerted by marine pollutants upon marine ecosystem.	79	2016
30 Widespread use of biodegradable plastics that can be fully decomposed by anaerobic microorganisms as a means of properly handling containers and packaging materials with short intended service lives.	78	2009
29 Development of low-noise engines and tires, and sound-absorbing construction materials, leading to the reduction of automobile noise within the environmental standard for the area specified to be for resident.	76	2011
13 Elucidation of the mechanism of the impact caused by acid rain to animals and plants.	76	2009
22 Generalization of global-scale monitoring of various factors causing air and water pollution and other forms of pollution, and realization of a system for centralizing all environmental information.	75	2013

Note 1: Degree of importance index = (number of “high” responses ×100 + number of “medium” responses × 50 + number of “low” responses × 25 + number of “unnecessary” responses × 0) ÷ total number of degree of importance responses

8.4. Forecasted realization times

Forecasted realization times were distributed as shown in the diagram below. About 90% of the topics saw their forecasted realization times concentrated in the 2006 - 2015 range, and the overall distribution was similar to the general trend covering all topics.

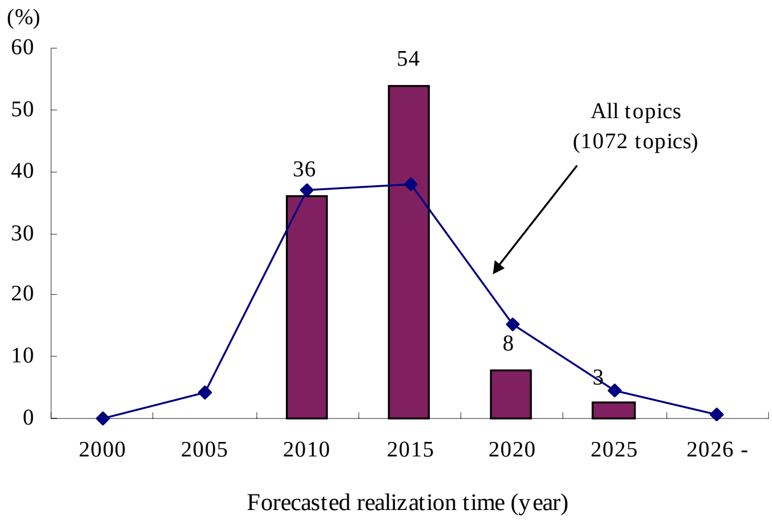


Fig. 8.4-1 Trends in Forecasted Realization Times

8.5. Current leading countries etc.

Responses to the question concerning current leading countries etc. were as shown in the diagram below. For almost all topics, the U.S. was named by the greatest number of respondents, followed by Japan and the EU with similar scores. The rating of the former Soviet Union/Eastern Europe was extremely low.

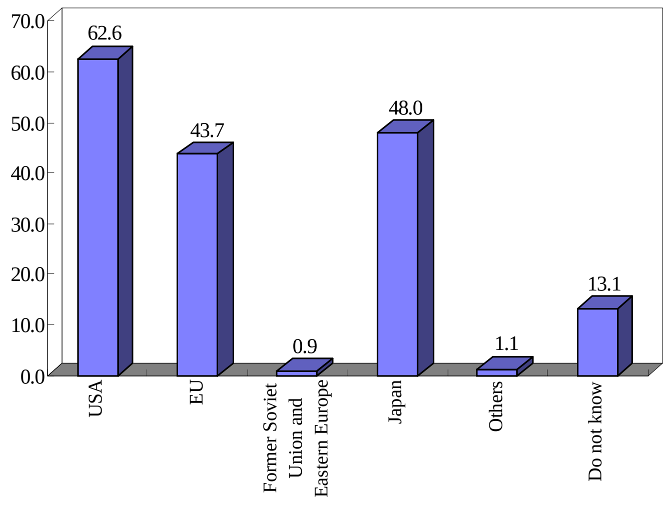


Fig. 8.5-1 Current Leading Countries etc. (%)

8.6. Comparison with the 5th Survey (previous survey)

Of the 39 topics included in the latest survey, 23 (59%) were identical to the previous survey, 9 (23%) were modified, and 7 (18%) were newly introduced. For identical topics, the results of the latest survey were compared with those of the previous survey in terms of degree of importance index scores and forecasted realization times, as shown in the table below.

Degree of importance index scores rose for 5 topics, fell for 17 topics and remained the same for 1 topic. 29. Reduction of automobile noise to satisfy environmental quality standards in Japanese urban areas designated as exclusively residential saw the greatest jump, up 15 points, while 20. Elucidation of impact of desertification on climate and weather saw the greatest drop, down 28 points.

From the 4th to the 5th Survey, forecasted realization times were pushed back for all topics. Likewise, from the 5th to the 6th Survey, forecasted realization times were pushed back for all topics, with 37. Application of useful organisms created through gene manipulation etc. in environmental clean-up having its forecasted realization time pushed back most (10 years).

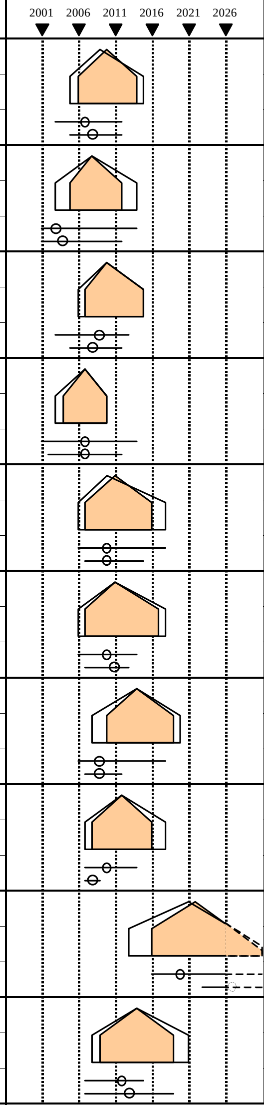
Table 8.6-1 Comparison with 5th Survey for Identical Topics

Topic	Degree of importance index / forecasted realization time	
	6th survey	5th survey
01 Completion of high-accuracy, high-density observation system capable of determining global trends in the change of stratosphere ozone for each altitude.	57/2010	68/2002
02 Quantitative grasp of effect of fluorocarbon and the like on change in the ozone layer.	60/2008	77/1999
04 Practical use of materials that replace fluorocarbons and halons, that do not damage the ozone layer and cause global warning problem.	82/2007	91/1998
06 Availability of accurate forecasting the extent of climate change to a 50 Km-mesh square level throughout the world.	63/2011	73/2008
08 Determination and general understanding of the impact of global warming on world agricultural production.	83/2012	91/2004
09 Reduction of global carbon dioxide emissions to 20% below the 1990 level.	81/2022	91/2015
12 Elucidation of the worldwide long-distance migration mechanisms of acid-rain-causing substances, such as SO_x and NO_x, considering regional characteristics.	79/2010	79/2001
13 Elucidation of the mechanism of the impact caused by acid rain to animals and plants.	76/2009	82/2001
14 Completion of global automatic and remote sensing networks for monitering marine pollution and marine ecosystem.	67/2015	73/2009
15 Elucidation of impacts exerted by marine pollutants upon marine ecosystem.	79/2016	76/2009
16 Practical use of effective technologies for restoring ocean areas contaminated by tanker accidents, etc. (e.g., oil pollution control technologies utilizing marine microorganisms).	72/2011	73/2004
17 Elucidation of impacts of destruction of tropical forests upon climate and weather.	58/2012	80/2004
18 Elucidation of the impact of diminishing tropical rain forests on wildlife ecosystems.	49/2014	71/2009
19 Development of a technology effective for regenerating damaged tropical rain forest ecosystems.	61/2014	85/2007
20 Elucidation of effect of desertation on climate and water.	51/2013	79/2005
22 Generalization of global-scale monitoring of various factors causing air and water pollution and other forms of pollution, and realization of a system for centralizing all environmental information.	75/2013	77/2006
24 Widespread use of control technologies in virtually all types of automobiles, capable of meeting the emission control standard for nitric oxide at the order of 0.1 to 0.2 g/Km. (The current level for heavy diesel motorcars is on the order of 4 to 5 g/Km, and the standard control value for gasoline passenger cars in 1978 is 0.25 g/Km.)	89/2007	90/2003

Topic	Degree of importance index / forecasted realization time	
	6th survey	5th survey
29 Development of low-noise engines and tires, and sound-absorbing construction materials, leading to the reduction of automobile noise within the environmental standard for the area specified to be for resident.	76/2011	61/2006
33 Widespread use of household trash cans which are capable of automatically classifying whatever wastes are thrown into them and also easy to move.	58/2012	61/2005
34 Establishment of assessing socio-economic damage/loss because of the destruction of natural environment by soil contamination and land subsidence (e.g., loss of natural beaches, forests, or fields) and incorporation of its countermeasures in regulatory system.	87/2012	80/2005
35 Elucidation of a long-term exposure effects of quantities of most of the harmful chemical substances in ordinary environment, on human beings.	80/2016	81/2009
37 Establishment of assessment and safeguarding standards for the utilization of useful organisms created through gene manipulation etc. in open system environments, leading to their application in environmental clean-up.	61/2016	53/2006
38 Widespread use more than 10% in the world of automobiles as urban transportation system (e.g., electric vehicles) which do not cause air or noise pollution.	86/2013	81/2006

Note: Up until the 5th Survey, realization meant realization in Japan unless otherwise specified. However, this was changed to mean realization somewhere in the world in the 6th Survey. Therefore, care should be taken when comparing forecasted realization times from the two surveys.

Forecasted realization time:



Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic development	Expected effect: Resolution of global problems	Expected effect: People's needs	Expected effect: Expansion of intellectual resources	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Depletion of ozone layer	1	Completion of high-accuracy, high-density observation system capable of determining global trends in the change of stratosphere ozone for each altitude.	1	190	6	26	68	58	24	58	17	0	13	83	20	21	3	9	75	34	0	25	2	17	61	32	36	11	57	6	2	41	5	8	1
			2	169	5	21	73	57	20	67	13	0	7	92	14	14	2	6	82	31	0	25	1	11	63	27	35	8	66	4	1	47	5	5	1
			X	9	100	0	0	67	33	67	0	0	22	89	11	11	0	0	100	11	0	11	0	0	56	22	33	0	67	11	0	67	0	0	0
	2	Quantitative grasp of effect of fluorocarbon and the like on change in the ozone layer.	1	213	7	22	72	62	33	51	15	0	15	87	21	16	2	5	73	35	1	28	0	16	68	32	30	8	58	5	1	38	6	8	2
			2	185	6	19	75	60	25	62	12	0	7	95	16	12	2	4	78	34	1	24	0	13	70	28	26	6	64	3	0	45	6	3	1
			X	12	100	0	0	67	42	42	17	0	8	92	0	17	0	0	92	33	0	25	0	0	67	33	42	0	67	0	0	58	0	8	0
	3	Elucidation of the impact of increased UV radiation as a result of depletion of the ozone layer on humans as well as plants and animals, including its interaction with other environmental impact factors and accumulated exposure effect.	1	220	5	21	73	63	33	53	14	0	11	73	51	18	4	5	64	43	0	21	4	23	65	36	25	19	55	3	1	38	9	11	2
			2	196	4	19	77	61	28	59	13	0	8	81	49	12	3	5	71	45	1	20	3	17	68	35	23	15	61	1	0	40	8	7	1
			X	8	100	0	0	81	63	38	0	0	13	75	25	25	0	0	88	38	0	25	13	0	50	63	38	25	25	0	0	63	0	25	0
	4	Practical use of materials that replace fluorocarbons and halons, that do not damage the ozone layer and cause global warning problem.	1	217	6	22	71	79	60	36	3	1	62	84	26	7	1	4	71	35	1	56	0	15	45	56	26	4	49	25	2	47	9	9	4
			2	190	4	21	75	82	66	30	3	1	57	88	19	3	1	2	77	31	0	62	0	11	42	64	20	2	53	25	1	56	8	6	2
			X	8	100	0	0	94	88	13	0	0	75	100	13	13	0	0	88	38	0	50	0	0	50	88	13	0	50	38	0	75	0	0	0
Global warming	5	Elucidation of the accurate mechanism of carbon dioxide generation and absorption.	1	287	12	35	53	72	49	41	9	1	20	91	8	36	5	6	73	44	0	42	0	15	68	31	32	14	57	5	2	40	5	12	2
			2	244	9	37	54	72	47	46	6	0	16	92	3	28	3	3	81	43	1	44	0	9	75	25	28	10	66	4	1	41	2	8	2
			X	22	100	0	0	81	62	38	0	0	9	100	9	9	0	5	91	41	0	55	0	0	59	45	27	5	50	5	0	36	0	9	5
	6	Availability of accurate forecasting the extent of climate change to a 50 Km-mesh square level throughout the world.	1	205	6	26	68	67	40	47	12	1	27	82	33	25	12	3	79	35	3	41	0	14	60	26	34	19	53	2	4	36	14	11	2
			2	177	4	27	69	63	32	57	10	1	16	88	25	18	10	2	82	30	2	42	0	11	66	19	35	17	57	2	2	41	9	8	1
			X	7	100	0	0	82	71	14	14	0	14	86	29	0	0	0	86	86	14	71	0	0	71	29	29	29	57	0	0	43	29	0	0
	7	Elucidation of the impact of global warming on forests and other natural vegetation quantitatively on a global scale.	1	270	8	32	60	72	50	41	8	1	24	93	14	24	9	7	64	46	3	25	0	22	66	33	25	23	53	4	2	41	6	12	1
			2	232	6	29	65	74	52	42	6	0	19	95	5	17	8	3	72	50	0	25	0	16	72	31	22	20	60	3	0	42	4	11	0
			X	14	100	0	0	89	79	21	0	0	7	100	7	7	0	0	93	71	0	64	0	0	86	29	36	36	57	7	0	50	0	7	0
	8	Determination and general understanding of the impact of global warming on world agricultural production.	1	245	4	32	64	78	59	35	6	0	40	90	16	11	6	7	71	40	6	28	0	20	60	39	22	27	49	5	2	41	7	18	2
			2	223	2	27	71	83	69	27	4	0	35	88	9	6	3	5	78	43	6	30	0	15	67	38	16	23	52	5	2	43	4	16	0
			X	4	100	0	0	100	100	0	0	0	50	75	0	0	0	0	100	75	25	75	0	0	50	50	50	50	50	0	0	75	0	0	0
	9	Reduction of global carbon dioxide emissions to 20% below the 1990 level.	1	267	13	31	55	77	59	33	7	1	39	90	17	11	34	12	41	49	1	56	0	16	43	41	19	9	42	42	4	40	6	22	1
			2	230	8	33	59	81	65	30	4	1	30	92	11	5	32	6	45	54	1	67	0	10	44	40	15	7	46	47	3	45	4	20	0
			X	19	100	0	0	87	79	16	0	5	32	95	5	5	32	5	47	74	5	84	5	0	26	37	0	5	37	42	11	42	5	11	0
	10	Development of storage methods of carbon dioxide at deep sea levels of more than 3,000 m below surface.	1	234	8	29	64	53	28	40	22	10	28	85	3	16	18	12	41	17	0	50	1	28	38	40	21	4	47	14	6	70	9	5	2
			2	199	7	27	66	56	29	45	20	7	25	85	3	11	19	6	44	16	0	60	0	21	38	47	17	3	57	12	6	75	10	6	2
			X	14	100	0	0	86	71	29	0	0	21	93	7	0	7	7	57	36	0	79	0	0	57	36	21	0	57	7	0	71	0	7	0

(Note) See page 7 for the interpretation of the graphs.

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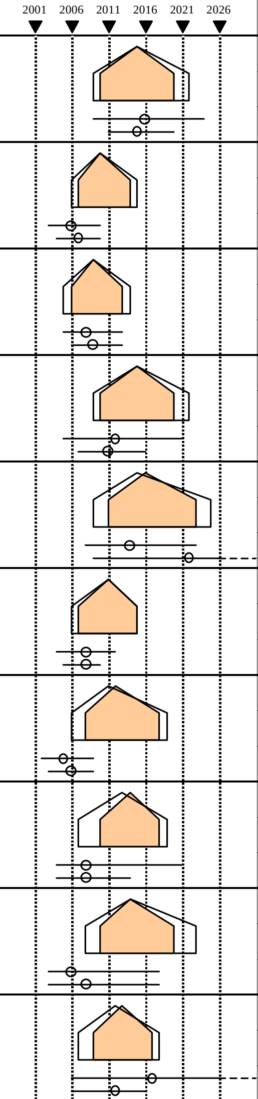
Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%) High	Medium	Low	Importance (index, %) Index	High	Medium	Low	Unnecessary	Expected effect (%) Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Will not be realized (%)	Do not know (%)	Leading countries (%) USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%) Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%) Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Global warming	11	Practical use of carbon dioxide fixing technologies using marine organisms such as microscopic algae.	1	246	18	31	51	62	36	44	18	2	39	89	8	15	16	9	54	27	2	54	1	22	52	45	25	15	58	7	3	60	5	7	3
			2	209	16	30	54	63	36	46	16	2	35	92	4	13	16	6	62	20	1	63	1	18	56	46	20	12	64	5	1	65	4	5	2
			X	34	100	0	0	75	55	36	9	0	35	100	6	3	12	3	59	24	0	85	3	0	50	35	15	12	68	18	0	62	6	3	3
Acid rain	12	Elucidation of the worldwide long-distance migration mechanisms of acid-rain-causing substances, such as SOx and NOx, considering regional characteristics.	1	267	12	24	64	76	56	37	8	0	21	94	23	14	2	5	54	61	4	46	1	12	59	38	29	18	56	6	2	43	7	10	1
			2	234	11	24	65	79	61	33	6	0	18	94	18	12	2	3	58	70	2	51	2	9	69	37	24	15	65	3	2	50	5	9	1
			X	25	100	0	0	96	92	8	0	0	16	88	32	16	0	0	68	88	0	64	8	0	68	52	20	8	76	8	8	60	8	8	4
	13	Elucidation of the mechanism of the impact caused by acid rain to animals and plants.	1	256	11	27	62	72	49	43	9	0	18	91	24	17	1	4	45	70	6	41	0	12	67	34	25	20	59	5	2	46	8	9	0
			2	227	10	29	62	76	54	40	6	0	14	93	23	11	0	3	45	82	4	42	1	7	72	31	23	17	67	2	1	49	5	6	0
			X	22	100	0	0	93	86	14	0	0	14	95	23	5	5	0	64	95	5	45	5	0	91	41	27	9	77	5	0	59	9	18	0
Marine pollution	14	Completion of global automatic and remote sensing networks for monitering marine pollution and marine ecosystem.	1	194	11	24	65	70	44	46	10	0	24	89	9	21	10	10	67	37	2	42	1	21	57	38	24	13	63	5	3	40	9	9	2
			2	173	8	22	71	67	38	55	8	0	21	95	5	17	11	4	79	32	3	50	1	14	64	40	21	10	71	1	2	47	8	3	2
			X	13	100	0	0	83	67	33	0	0	31	85	23	23	8	0	92	62	15	62	0	0	54	69	23	8	62	0	0	31	8	15	0
	15	Elucidation of impacts exerted by marine pollutants upon marine ecosystem.	1	212	11	25	65	74	52	41	6	1	19	91	17	26	9	8	69	42	1	43	3	16	66	36	18	21	60	4	3	39	6	8	1
			2	183	5	26	68	79	61	34	4	1	19	93	13	20	8	4	81	42	1	49	2	11	76	38	13	19	67	3	2	48	6	4	1
			X	10	100	0	0	100	100	0	0	0	10	100	30	40	10	0	90	60	0	70	0	10	60	40	20	20	50	0	10	30	10	10	0
	16	Practical use of effective technologies for restoring ocean areas contaminated by tanker accidents, etc. (e.g., oil pollution control technologies utilizing marine microorganisms).	1	215	11	28	61	70	44	46	10	0	39	84	20	9	6	7	69	42	0	45	1	18	50	51	21	11	53	11	1	52	14	4	1
			2	187	9	26	65	72	46	50	4	0	39	88	13	6	4	5	78	43	0	48	0	10	52	56	15	9	64	10	0	61	12	3	2
			X	17	100	0	0	88	76	24	0	0	35	100	6	18	6	6	100	41	0	47	0	0	59	41	24	12	59	0	0	41	6	0	0
Diminishment of tropical rainforests	17	Elucidation of impacts of destruction of tropical forests upon climate and weather.	1	208	5	20	75	59	26	58	15	1	21	95	12	24	2	10	68	41	3	27	3	21	67	37	15	19	57	5	4	44	5	11	1
			2	187	4	20	76	58	21	69	10	1	17	97	5	18	2	6	76	43	1	27	3	16	76	38	12	17	61	3	2	48	3	10	2
			X	7	100	0	0	68	43	43	14	0	14	100	14	0	0	0	100	29	0	14	14	0	57	71	14	14	57	0	0	57	0	0	0
	18	Elucidation of the impact of diminishing tropical rain forests on wildlife ecosystems.	1	177	5	16	80	52	19	54	27	0	11	90	8	28	3	9	67	45	2	26	5	23	66	31	14	25	56	2	3	43	5	11	0
			2	173	3	12	85	49	12	62	26	0	7	92	3	26	4	6	74	48	1	21	3	18	76	29	10	23	61	1	2	51	3	9	1
			X	5	100	0	0	90	80	20	0	0	20	100	20	0	0	0	80	80	0	60	0	20	60	40	0	40	100	0	0	60	0	0	0
	19	Development of a technology effective for regenerating damaged tropical rain forest ecosystems.	1	200	6	19	75	63	34	50	15	0	44	94	11	13	8	10	55	33	1	37	4	29	60	40	16	19	60	7	5	46	7	11	2
			2	181	4	19	77	61	28	60	12	0	41	92	6	10	8	7	69	35	1	39	4	20	64	39	11	18	66	4	3	56	6	9	1
			X	8	100	0	0	88	75	25	0	0	75	100	25	25	0	0	88	63	0	63	13	0	88	38	0	38	88	0	0	50	13	13	0
Desertification	20	Elucidation of effect of desertation on climate and water.	1	194	5	20	76	50	16	54	30	1	19	94	8	22	4	6	61	40	3	25	4	26	62	34	18	19	54	2	3	43	5	9	1
			2	177	5	18	77	51	15	59	26	0	18	98	6	16	3	5	71	44	2	24	5	21	74	34	12	15	58	1	2	50	5	7	1
			X	8	100	0	0	56	25	50	25	0	25	100	13	38	0	0	88	88	13	50	13	0	63	50	0	25	50	0	0	50	0	13	0

Forecasted realization time



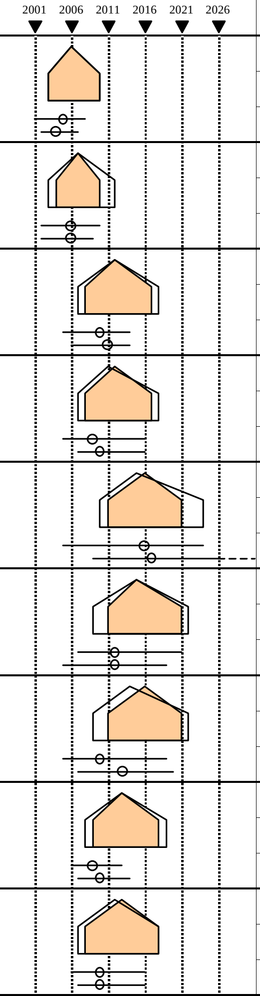
(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic development	Expected effect: Resolution of global problems	Expected effect: People's needs	Expected effect: Expansion of intellectual resources	Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Desertification	21	Development of plants that are resistant to dry and saline conditions via biotechnology with the aim of greening deserts.	1	193	8	20	72	49	18	48	29	6	37	89	7	22		8	10	61	30	2	44	7	21	54	35	20	35	48	3	4	54	5	10	1
			2	177	8	18	73	50	15	55	28	2	36	92	5	17		6	8	70	32	2	51	7	18	63	32	16	34	53	3	2	66	3	7	1
			X	15	100	0	0	67	40	47	13	0	33	87	7	20		7	7	80	40	7	73	13	0	73	47	7	47	67	0	0	67	7	20	0
Common	22	Generalization of global-scale monitoring of various factors causing air and water pollution and other forms of pollution, and realization of a system for centralizing all environmental information.	1	273	13	26	60	73	49	44	7	0	27	93	21	23		4	6	71	47	3	44	1	15	49	37	29	26	58	7	3	35	10	10	1
			2	234	12	28	60	75	51	46	3	0	25	95	18	18		2	3	82	53	3	48	3	10	57	38	25	23	65	3	2	39	9	7	2
			X	29	100	0	0	84	69	31	0	0	17	97	21	24		0	0	86	72	3	69	7	0	41	55	21	21	66	3	0	31	10	14	0
	23	Introduction of environment tax aiming at global environmental conservation.	1	262	9	24	67	80	65	27	7	1	52	84	33	6		3	9	27	67	1	21	2	16	14	26	5	8	15	65	5	23	8	50	4
			2	232	8	21	71	85	72	24	3	0	53	88	25	4		3	6	22	81	0	22	1	11	14	28	2	6	13	77	4	22	3	57	5
			X	18	100	0	0	88	78	17	6	0	56	83	39	6		0	0	44	94	0	39	11	0	22	39	0	11	33	67	0	28	6	67	0
Air quality	24	Widespread use of control technologies in virtually all types of automobiles, capable of meeting the emission control standard for nitric oxide at the order of 0.1 to 0.2 g/Km. (The current level for heavy diesel motorcars is on the order of 4 to 5 g/Km, and the standard control value for gasoline passenger cars in 1978 is 0.25 g/Km.)	1	189	15	23	62	86	73	24	2	1	49	78	52	6		2	4	44	39	0	81	1	5	30	49	19	3	33	49	3	37	13	16	3
			2	163	10	23	66	89	78	21	1	0	48	80	51	4		0	3	46	40	0	89	0	3	29	63	12	1	36	59	1	47	10	17	1
			X	17	100	0	0	94	88	12	0	0	59	88	59	6		0	0	47	47	0	100	0	0	41	65	12	0	59	35	0	53	6	12	0
Water quality	25	Progress of investigation of mechanisms for both concentration of heavy metals and other pollutants in ecosystems and occurrence of eutrophication, and realization of prediction and forecasting of the impact of water pollution in closed water bodies, such as lakes and semi-closed bays, on their ecosystems.	1	263	23	37	40	77	57	38	4	1	28	71	44	23		4	6	59	54	2	67	2	10	59	41	24	22	55	14	1	41	6	14	0
			2	225	22	39	40	81	64	34	2	0	23	79	44	17		1	2	64	58	2	78	2	6	65	46	19	19	62	12	1	46	4	11	0
			X	49	100	0	0	90	80	20	0	0	20	88	39	24		0	0	71	65	4	80	4	0	67	55	14	10	69	12	2	49	8	12	0
	26	Widespread use of formulation methods for water environment plan based on quantitative understanding of natural purification functions of paddy fields, reservoirs, rivers, water channels and water permeating into the ground.	1	249	18	31	51	75	54	39	6	1	32	64	54	11		3	5	42	43	1	54	0	18	51	42	20	17	44	28	2	41	10	12	0
			2	212	17	29	53	79	60	35	4	0	28	71	59	8		2	2	44	49	0	68	0	12	54	47	16	12	52	28	0	48	6	10	0
			X	37	100	0	0	86	73	24	3	0	35	68	73	8		0	3	41	57	0	81	0	3	57	62	11	14	68	38	0	57	8	8	0
	27	Widespread use, including use at home, of compact waste-water treatment systems based on biotechnology for the highly efficient treatment of persistent substances and hazardous materials.	1	247	23	31	46	79	59	37	3	0	52	64	53	10		4	4	57	40	0	67	1	9	47	49	27	12	43	21	1	46	7	11	1
			2	218	24	30	46	82	64	33	2	0	49	65	57	6		2	4	61	39	0	82	0	4	51	64	14	6	50	22	1	59	4	11	0
			X	52	100	0	0	86	73	25	2	0	60	71	60	6		4	4	63	42	0	94	0	0	50	69	12	6	52	33	0	52	4	10	0
	28	Development of bioreactor systems utilizing bacteria and animalcules that ingest/decompose the algae responsible for water blooms or red tides for the purpose of improving aquatic environment.	1	237	17	34	49	69	45	41	12	2	40	68	38	11		7	5	38	24	1	65	0	19	47	46	25	17	48	11	1	49	5	9	1
			2	207	14	34	52	72	50	42	8	1	40	71	31	6		5	4	42	25	0	76	0	14	52	52	24	14	54	8	0	59	4	8	1
			X	29	100	0	0	84	69	28	3	0	34	79	41	3		7	0	48	31	0	93	0	0	52	59	21	14	86	10	0	52	3	7	0
Noise/vibration	29	Development of low-noise engines and tires, and sound-absorbing construction materials, leading to the reduction of automobile noise within the environmental standard for the area specified to be for resident.	1	137	9	17	74	73	54	33	12	2	43	32	74	5		12	6	30	29	0	61	0	23	25	50	18	2	34	45	3	26	20	19	1
			2	118	8	19	74	76	59	27	13	1	44	24	80	3		13	3	31	31	0	72	0	14	23	61	12	1	37	49	1	35	18	20	2
			X	9	100	0	0	88	75	25	0	0	56	22	89	0		11	0	33	44	0	67	0	22	33	78	11	11	56	44	0	33	33	22	0
Waste	30	Widespread use of biodegradable plastics that can be fully decomposed by anaerobic microorganisms as a means of properly handling containers and packaging materials with short intended service lives.	1	249	13	29	59	75	57	33	8	3	61	69	46	7		6	8	49	41	1	56	2	18	40	51	18	8	41	30	2	46	10	18	2
			2	221	13	26	61	78	61	31	6	2	61	71	42	3		5	4	55	38	0	74	0	9	42	56	12	5	51	29	1	54	7	17	1
			X	28	100	0	0	74	54	36	11	0	75	68	39	7		4	0	64	46	0	79	0	4	32	54	14	7	57	43	0	54	7	14	0

(Note) See page 7 for the interpretation of the graphs.

Environment

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic development	Expected effect: Resolution of global problems	Expected effect: People's needs	Expected effect: Expansion of intellectual resources	Forecasted realization time: Will not be realized (%)	Forecasted realization time: Do not know (%)	Leading countries (%): USA	Leading countries: EU	Leading countries: Former Soviet Union and Eastern Europe	Leading countries: Japan	Leading countries: Other countries	Leading countries: Do not know	Measures the government should adopt (%): Foster human resources	Measures: Promote exchanges among industrial, academic and government sectors and different fields	Measures: Upgrade advanced facilities and equipment	Measures: Develop a research base	Measures: Increase government research funding	Measures: Adjust regulations (relax/toughen)	Measures: Others	Potential problems (%): Adverse effect on the natural environment	Potential problems: Adverse effect on safety	Potential problems: Adverse effect on morals, culture or society	Potential problems: Other adverse effects
Waste	31	Widespread use of power generation using refuse derived fuel (RDF).	1	208	17	25	58	75	54	38	6	1	67	76	35	4	1	2	32	37	1	63	0	16	26	45	20	1	40	50	3	45	7	18	2
			2	186	15	22	63	82	67	29	4	0	70	76	34	1	1	1	29	36	0	79	0	10	23	53	16	1	42	58	1	56	4	18	1
			X	28	100	0	0	86	71	29	0	0	79	79	29	0	0	0	39	46	0	82	0	4	7	61	14	0	32	68	4	61	7	29	4
	32	Wide acceptance of LCA-style product design concepts that encourage recycling and reuse.	1	223	17	30	53	86	75	23	2	1	70	78	37	12	1	5	39	74	0	39	0	8	37	50	11	9	30	57	4	28	7	33	3
			2	195	13	27	59	91	82	16	1	1	74	78	34	6	1	3	39	83	1	42	0	5	31	58	6	5	32	66	2	30	5	39	2
			X	26	100	0	0	98	96	4	0	0	85	85	23	8	0	0	42	96	0	38	0	0	31	69	12	15	27	65	0	31	4	27	4
	33	Widespread use of household trash cans which are capable of automatically classifying whatever wastes are thrown into them and also easy to move.	1	208	13	23	64	57	37	29	21	13	47	50	55	4	39	10	11	20	0	25	0	47	22	39	11	1	29	26	6	26	7	30	2
			2	183	11	17	72	58	36	34	20	10	42	49	67	1	36	7	7	25	0	34	0	45	17	50	8	1	32	28	4	30	4	39	2
			X	20	100	0	0	54	30	40	15	15	45	65	70	0	55	5	10	45	0	50	0	30	5	50	15	5	35	35	0	35	15	30	5
Nature/ecosystems	34	Establishment of assessing socio-economic damage/loss because of the destruction of natural environment by soil contamination and land subsidence (e.g., loss of natural beaches, forests, or fields) and incorporation of its countermeasures in regulatory system.	1	233	17	25	58	82	65	33	2	0	50	70	48	10	4	8	48	48	0	27	0	23	44	42	9	12	36	45	2	33	12	25	1
			2	206	14	23	63	87	74	26	0	0	48	75	45	7	2	3	61	59	0	27	1	18	48	44	6	8	39	51	0	36	7	28	0
			X	29	100	0	0	100	100	0	0	0	66	83	59	14	3	0	76	62	0	28	3	7	59	59	7	14	48	66	3	41	14	45	0
Cross-sectional	35	Elucidation of a long-term exposure effects of quantities of most of the harmful chemical substances in ordinary environment, on human beings.	1	203	14	22	64	74	52	39	8	1	17	39	81	24	9	10	67	44	1	35	0	19	57	31	20	31	51	12	1	27	19	19	2
			2	180	12	21	67	80	63	32	5	0	12	41	82	17	7	6	76	50	1	36	0	13	67	31	16	32	61	8	1	28	22	15	0
			X	21	100	0	0	93	86	14	0	0	14	48	90	14	0	5	76	52	5	62	0	0	76	33	19	33	52	5	0	38	33	19	0
	36	Establishment of a technique to predict the fate of newly discovered chemical substances through the accumulation of knowledge on matters such as the behavior of persistent chemical substances in the environment.	1	205	15	27	58	74	52	42	5	1	35	61	56	25	10	14	65	41	0	32	0	21	60	37	19	31	51	9	1	37	17	12	2
			2	183	16	22	62	79	60	38	3	0	31	68	59	19	10	6	75	49	0	37	1	12	69	33	13	29	58	5	1	39	15	10	1
			X	29	100	0	0	91	83	17	0	0	34	83	52	24	7	0	83	62	0	52	0	0	69	28	17	28	66	7	0	48	14	21	3
	37	Establishment of assessment and safeguarding standards for the utilization of useful organisms created through gene manipulation etc. in open system environments, leading to their application in environmental clean-up.	1	195	13	20	67	62	34	50	14	2	47	72	29	22	9	12	79	35	1	29	1	17	49	34	21	37	42	26	3	59	13	26	2
			2	171	12	15	73	61	31	56	11	2	41	81	25	17	8	8	88	38	0	30	1	10	57	35	19	37	47	23	2	64	19	24	1
			X	21	100	0	0	75	57	33	5	5	48	95	33	14	14	0	100	52	0	33	5	0	57	19	24	38	52	29	5	67	5	24	0
	38	Widespread use more than 10% in the world of automobiles as urban transportation system (e.g., electric vehicles) which do not cause air or noise pollution.	1	209	10	25	65	81	65	29	6	0	66	78	52	5	3	4	68	44	0	60	0	11	27	48	17	1	45	50	4	32	13	18	1
			2	184	9	20	71	86	73	24	3	0	68	80	51	1	2	2	72	45	0	67	0	7	24	55	12	1	45	63	3	40	13	16	1
			X	17	100	0	0	91	82	18	0	0	82	88	59	6	0	0	82	65	0	65	0	0	18	53	6	0	35	65	0	35	24	18	0
	39	Practical use of in-situ detoxification of soil contaminated with heavy metals or chemical substances (e.g., residue of agricultural chemicals).	1	241	20	31	50	70	46	44	8	1	41	68	56	8	12	8	61	38	0	41	0	20	45	48	19	13	42	31	1	45	12	10	1
			2	218	18	28	55	74	51	44	4	1	37	71	60	3	11	6	73	39	0	47	0	12	51	60	14	8	50	30	0	50	13	8	0
			X	39	100	0	0	74	51	46	0	3	38	69	44	8	10	5	74	49	3	51	0	3	56	62	15	13	41	23	0	41	15	10	0



(Note) See page 7 for the interpretation of the graphs.

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9. Survey Results in “Agriculture, Forestry and Fisheries”

9.1. Trends in areas of attention

In the “agriculture, forestry and fisheries” field, the following were selected as future areas of attention commonly applicable to agricultural, forestry and fisheries industries, and their present state and future outlook are examined in outline below:

1. Production activities harmonious with environment and sustainable
2. Stable supply of healthy and safe food and protection of living environment
3. Utilization of biological functions and new industrial uses

Since the last survey, the “agriculture, technological development in forestry and fisheries” field has undergone another major conceptual change. Namely, a switch from narrowly-focused food production to the provision of safe and healthy food and a quality living environment has been under way, and, amid progress in research on biotechnology and biological functions, a shift to programs that would contribute to the creation of biology-based industries has been occurring.

Agriculture, forestry and fisheries used to be industries that thrived in harmony with the environment. However, due to the single-minded pursuit of productivity and efficiency, techniques using large amounts of chemical fertilizers, pesticides, etc. have been favored in recent years, and this excess has undeniably caused water pollution and the disruption of biota. This has given rise to calls for technological development that would bring these industries back in harmony with the environment.

On the other hand, amid concerns over deterioration in the global environment due to rapid population growth towards the 10 billion mark and phenomena caused by excessive human activities, such as desertification and the depletion of the ozone layer, hopes are mounting for the potential of agricultural, forestry and fisheries industries to play a part in overcoming these problems. Future technological development in this field will focus more on technologies that support industries that ensure a comfortable living environment for humanity and promote the biological richness of the earth, instead of overemphasizing food production. Amid progress in internationalization and diversification in people's dietary life, interest in healthy and safe food is growing, making technological development in this area essential.

“Agriculture, forestry and fisheries” represents one of the research fields in which biotechnology have brought about a dramatic change. While hopes are pinned on the creation of new crops and varieties via genetic recombination, interest in their impact on ecosystems is also growing. Progress in the research aimed at elucidating biological functions, such as those of insects, is leading to the development of new materials, not restricted to the traditional boundary of the agriculture, forestry and fisheries field, thus foreshadowing the birth of a new industry in the near future.

Topics scoring high in terms of the degree of importance index in the “agriculture, forestry and fisheries” field concentrated in the area of “management and assessment of the environment and biological resources” (70.3 compared to the field average 60.5), and, regarding effective measures the government should adopt in Japan “, expectations for “human resource development” and “personnel exchanges among the industrial, academic and government sectors” scored high. This seems to illustrate the fact that researchers interest in this field has been gradually shifting to the above topics.

9.1.1. Sustainable production activities harmonious with environment

As is symbolized by the “United Nations Conference on the Environment and Development” held in Brazil in June 1992, the importance of global environmental problems has won widespread recognition. In agriculture, forestry and fisheries, too, there are concerns such as the contribution to global warming of the rise in methane emissions from paddy fields and farm animals and fall in carbon dioxide absorption due to deforestation, and hopes are high for the development of technologies that can address these problems while maintaining productivity (topics 21 and 81). In response to the decline in forest area, international conventions on the conservation of genetic resources, such as rare species, and biological diversity have been strengthened, and the elucidation of the environmental conservation function of forest ecosystems and establishment of their efficient management techniques have emerged as important tasks (topics 42, 80 and 82).

On the other hand, as a measure of stemming the advancement of desertification, hopes are pinned on the "Development of new plants and a cultivation system which enables the growing of plants in water-limited regions" (topic 71). There are also expectations for monitoring systems based on remote sensing etc. designed to monitor the impact of global-scale environmental changes on the agricultural, forestry and fisheries industries over a wide area with high accuracy (topics 50 and 78).

Calls for the advancement of science and technology aimed at sustainable productive activities and harmony with the local/global environment are increasing from the viewpoint of keeping up food production with population growth as well. The development of microorganisms that have a high nitrogen-fixing efficiency and symbiotic relationship with rice and those that enable crop plants to absorb phosphorus fixed in the soil efficiently based on biotechnology and other cutting-edge technologies are important as an environment protection measure aimed at preventing/controlling the eutrophication of the hydrosphere and pollution of groundwater through reduced fertilizer use, as well as from a viewpoint of tackling the depletion of natural resources (topics 04 and 07). The establishment of utilization technologies for waste originating in farm products and livestock as part of recycling efforts is also attracting attention (topic 35). Progress is desired in the "Practical use of resource management systems using artificial intelligence and computer simulation technologies aimed at environmental conservation and harmonization of the agricultural-forestry ecosystem" (topic 79) as well. In fisheries, the "Practical use of environmental restoration technologies and a pollution load removal system for polluted lakes, bays and other closed water bodies" is also eagerly awaited (topic 84).

These technologies are essential to make sustainable productive activities harmonious with the global environment possible, and their effects will hopefully spread across the globe. International research cooperation is indispensable for the development of these technologies, and the bolstering of research funding is strongly desired.

Against a background of increased consumer awareness of the environment and food safety, environmental quality standards and monitoring activities were strengthened for agricultural chemicals and other synthetic organic compounds, and the establishment of biological control, allelopathic control or integrated control based on the self-preservation functions of ecosystems, which do not depend on chemicals, is awaited (topics 08, 09 and 43).

As discussed above, the importance of the development of agricultural, forestry and fisheries technologies leading to harmony between production and the protection of the local/global environment will further increase in the future.

9.1.2. Stable supply of healthy and safe food and protection of living environment

While the primary goal of agricultural, forestry and fisheries industries is the stable supply of healthy and safe food to the public, the conservation and provision of sound living environments is also important. In fact the two go hand in hand as goals these industries always strive to achieve.

However, food requirements are becoming increasingly complex. Firstly there has been a rapid increase in people's health-awareness. Rather than expecting a mere nutrient supply from food, people are demanding that food intake offer active health effects, such as the maintenance of health. Against this backdrop is the progress made in research on the impact of food ingredients on physiological functions. As a result, a specified health-food certification system has been introduced as a world first. The more advanced "67: Practical use of functional foods which help prevent diseases according to individual body characteristics" is forecasted to become reality by 2011, along with "34: Widespread use of allergy-free livestock product manufacturing techniques". Namely, a major advance in health promotion is forecasted in a little more than 10 years. Secondly there is a diet-conscious trend, centering on young women. While this accompanies potential health problems, the supply of low-calorie food has become an important task for the food industry. The realization time for “68: Practical use of artificial sugar substitutes with the same cooking characteristics as sucrose” is forecasted as 2007. Thirdly there is the importance of elderly-oriented food due to a rapid increase in the old-age population. New types of foods that take into consideration senior citizens' reduced taste, smell and mastication ability are required, and this necessitates taste measuring equipment (sensors). The realization time of “75: Practical use of general-purpose taste measuring equipment provided with a taste sensor and a texture sensor” is forecasted as 2010. Fourthly there is an expansion in the demand for convenience. As people's lives become busier, cutting the time and effort needed for food preparation at home has become a major requirement for processed foods. For example, “18. Widespread use of a technology that keeps starch-based foods with a high water content from deteriorating for a prolonged period” has been forecasted to be realized by 2007, which is fairly soon. The respondent group with high levels of expertise unanimously thought that Japan was the leading country in this area, with great expectations expressed. The forecasted realization time for “77: Practical use of containers and packaging with in-built temperature control technology that obviates the need for refrigeration for processed foods aimed at the outdoor lifestyle” was 2008, along with 76: Development of household food testers capable of instantaneously determining freshness and microorganic contamination levels of foods. In addition to technological innovations that would benefit consumers (demand side), there are calls for a number of those involving the production and distribution area (supply side). Firstly there is the development of new technologies that offer high added-value. While technologies such as extrusion cooking and the use of membranes, ultrahigh voltage and supercritical fluids having given birth to new types of foods, hopes are also pinned on the development of other technologies, such as the use of strong electric fields, strong magnetic fields and functional water. The realization time for “17: Widespread use of a full-sterilization continuous food processing technology involving high pressures of around 3,000 atm.” has been forecasted as 2006. Secondly there is the development of new ingredients that satisfy consumer taste. The development of low-calorie food ingredients, high water retention food ingredients, high quality preserving ingredients, etc. is under way. This makes the search for new microorganisms and the development of a new enzyme utilization technology indispensable. In this area, Japan has led the world with numerous achievements based on its time-weathered fermentation technologies, with the realization time for “16. Practical use of a technology capable of producing fermented foods within short periods of time through the use of artificial modified enzymes with high reaction rate” forecasted as 2005.

These forecasts show that respondents thought that many of the technological topics in the food area would be put to practical use by around 2010, with some in widespread use implying that the realization of these topics is fairly easy. Moreover, Japan was considered to be the world leader with regard to most topics, and this may be interpreted as reflecting Japan's relative advantage in applied technology areas.

The protection of living environments requires a comprehensive system. The realization time for “79: Practical use of environmental conservation and agricultural-forestry ecosystem harmonious management systems based on artificial intelligence, etc.” was forecasted as 2013. Along with farm villages, forests are important for the quality of life. The forecasted realization time for “83: Elucidation of the mechanism involved in the relationship between the environment and human physiology and psychology in 'forest bathing' etc.” was 2011.

9.1.3. Utilization of biological functions and new industrial uses

The creation of biologically derived new materials and development of new technologies to mimic biological functions are attracting attention as important breakthroughs in dealing with unfolding global-scale environmental problems as well as population and food supply problems. Against this background, things like insects, the largest untapped resources on earth, and so-far-unexploited marine organisms are attracting attention, and the elucidation of their functions and development of utilization technologies have great significance with regard to the creation of new industries and new technologies in the 21st century. The advances in genetic engineering technologies and sophistication in analysis technologies for trace substances in recent years have been breath-taking, and have made the elucidation of complex cranial nerve mechanisms and the isolation of trace substances and genes possible.

With insects, R&D on the utilization of silk proteins as ingredients for contact lens materials, blood anticoagulants and leather-touch coating materials is making progress, taking advantage of accumulated past research experience in silk, and hopes are pinned on the development of “58. Artificial skin utilizing biomaterials from insects”. Lately, promising antibacterial agents with different action mechanisms from existing antibiotics have been discovered from a wide variety of insects such as Oryctes rhinoceros and silkworms, and some of them exhibit remarkable effectiveness against bacteria resistant to antibiotics. In addition, blood anticoagulants have been discovered in the saliva of blood sucking insects such as assassin bugs, which attack mammals, with relevant genes isolated. In the future, the elucidation of the biosynthesis mechanisms and functions involved in “57: Antibacterial proteins and blood anticoagulants obtained from insects” will make progress, giving rise to hopes for their practical application as new antibacterial drugs, food preservatives, environmentally-friendly agricultural chemicals, and myocardial infarction and cerebral infarction prevention/treatment drugs, after the establishment of artificial synthesis and volume production technologies.

Societies requirement for technological development in marine-organism production, which until recently merely dealt with conventional food production, has expanded to include tackling various other topics. Along these lines, hopes have been pinned on “61: Development of new materials for common daily life items, such as glues and fibers from marine organisms”, as well as “62: Development of a new material production technology based on the utilization of the physiological functions of deep-sea organisms” through an analysis of physiological functions of organisms living in deep seas, which have been outside the scope of traditional fisheries production.

Moreover, based on advances in gene engineering technology, the development of “64: Transgenic animals that make cross-species organ transplants possible” is desired by society as a new role for technological development in animal husbandry, while there are hopes for the establishment of other new technologies such as “63: Livestock feed intake management techniques based on the understanding of the brain-nervous system of livestock animals” and “59: Production technology for useful materials based on insect cultured cells”, which allows external control.

As a basic research area that supports the development of such new materials and technologies, the importance of the study of genomes has been recognized.

From the next section onwards, trends in individual technology areas will be examined in overview.

9.1.4. Agriculture Biotechnology/crop production

With crops developed using genetic recombination technology by overseas companies being imported, the use of biotechnology, which was until recently considered a 21st century technology, is starting to sweep through the community. Japans biotechnological development in agriculture has fallen behind a little in terms of final product development due to factors such as a relatively slow entry and the existence of few major agriculture-oriented companies in the country. In this area, a large market is expected to develop in the future, and, in light of the fierce worldwide competition for development through patent acquisition etc., Japan is faced with an urgent need to step up its R&D efforts.

Rice farming is starting to be exposed to fierce competition with imported rice as a result of the conclusion of the GATT Uruguay Round of negotiations, introduction of the Food Law, etc., and competition between domestic production centers is also intensifying. Securing stable production against weather changes, such as the cold weather that caused major crop damage in FY 1993, has become an important task.

Against this background, the establishment of low-cost, upward-stable rice farming through larger-scale farm operation based on new enterprise units is strongly desired. For this purpose, the development of technologies such as those which support the sophistication of a paddy farming system combining rice and other crops, new varieties of paddy rice with multiple disease and pest resistance, fostering of varieties suitable for Japanese-style direct sowing, innovative paddy rice growing techniques, and efficient and pleasant farming techniques will be important research areas in the future.

In the latest survey, the importance of “10: Development of cold-weather crop damage prevention systems that respond to weather forecasts” and “14: Development of multi-purpose agricultural robots, which can be easily operated by aged people” was highly rated.

Dry-field crop farming represents intensive agriculture involving large quantities of labor input and a concentrated use of chemical fertilizers, agricultural chemicals and other materials within small plots. As a result, stunting in vegetative growth due to the excessive accumulation of nutrients in the field soil and plant injury caused by continuous cropping, as well as environmental loading due to groundwater pollution by fertilizer ingredients, etc., are posing a problem. On the other hand, safety and quality, apart from price, have become important criteria in the production of farm products, as consumer interest in and requirements for them intensify.

Against this back ground, the establishment of high-profit and sustainable dry-field crop farming is strongly desired. For this reason, R&D activities such as the following will become important future technological tasks: fostering of varieties highly amenable to mechanization and resistant to disease, pests and weather stress; elucidation of the development mechanisms for production-disrupting disease and pest infestation; development of new pest control techniques that do not depend on agricultural chemicals; development of a system of mechanized farm work for open-field vegetable farming; and development of a technology to optimize the cultivation environment without causing environmental pollution through the sophistication of diagnostic techniques for dry-field soils and crops.

The results of the latest survey clearly underscored the importance of agricultural technologies utilizing the functions of living organisms and ecosystems, such as “08: Allelopathy”, “09: Microbes, pheromones, etc.” and techniques utilizing “15: Weather and soil information” in a sophisticated manner ó rather than that of the widespread use of “11: Vegetable processing plants”.

9.1.5. Livestock farming and grasslands

In livestock farming, imported livestock industry products increased rapidly following the conclusion of the GATT Uruguay Round of negotiations, with hog raising and cattle fattening particularly severely affected. For this reason, cutting production costs has become the utmost task, and ever greater hopes are pinned on the development of cutting-edge technologies, centering on biotechnology. With health-conscious attitudes towards livestock products becoming entrenched, technological development to raise the quality of these products has also become important. In addition, great hopes are pinned on labor-saving technologies to help establish less demanding livestock farming operations in terms of time and effort. Environmental problems stemming from livestock animal waste have been increasing in seriousness every year, necessitating innovative technological development, encompassing, among other things, greenhouse gas reduction technologies aimed at the methane released from the rumens of ruminating animals.

Against this background, progress in biotechnology research centers on livestock reproduction technologies, with topics such as the following recognized as particularly important: “22: Genetic improvement of domestic animals through the introduction of genes into fertilized ova or embryos”, “23: Production of copies of superior cattle by nuclear transplantation”, “24: Livestock production technology that utilizes embryonic stem (ES) cells” and “29: Establishment of a sperm sex identification technique”. Many of these topics are forecasted to be realized within 10 years, with the fostering of human resources etc. identified as effective measures that the government should adopt in this regard. On the other hand, just as the advent of a cloned sheep* has led to stringent restrictions on the application of the results of such research, the proportion of respondents citing “adverse effect on morals, culture or society” has increased. In pursuing research, adequate consideration sho*uld been given to this aspect.

In feeding management, topics such as “30: Labor-saving grazing livestock management based on computers, mechatronics devices, etc.” and “31: Advanced sustainable grazing techniques that take advantage

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* The successful cloning of a sheep by a group of researchers led by Dr. Ian Wilmut at Roslin Institute, U.K., was reported in the science journal “Nature” (February 27, 1997).

of the functions of living organisms” were recognized as relatively important, with the remaining question being whether cost reductions can be achieved. Hopes are also pinned on “27: Development of a technology to control milk and beef qualitatively and quantitatively through gene manipulation on rumen microorganisms” as a means of extracting maximum performance from superior livestock animals.

In livestock disease prevention, “73: Development of rapid disease diagnostic systems based on the PCR technique etc.” and “28: Practical use of synthetic vaccines for livestock based on molecular designs” have emerged as important topics, with a contribution to production cost reductions as their expected benefit.

Regarding worsening livestock-related environmental problems, “35: Utilization of animal waste through decomposition into constituents” was identified as an important research topic, although it was indicated that its success depended on integration with cultivation-related technologies, etc.

9.1.6. Forests and forestry industry

Due to an economic downturn in the fisheries industry in Japan, there has not been any significant technological progress over the last 10 years. As interest in environmental problems grew following the Rio Declaration, hopes mounted in the forestry area, and the introduction of new technologies was believed to be a certainty. Nevertheless, the degree of importance index of the elucidation of the functions of forest ecosystems in tropical regions and practical use of their efficient management and utilization technologies (topic 80) fell sharply from 69% in the last survey to 18% in the latest survey. However, this seems to be more a consequence of the realization of the enormity of the associated socioeconomic problems, which cannot be overcome with progress in science and technology, than a drop in their perceived importance. Alternatively, it may be interpreted as “resignation” over the realization that technological innovation was too slow to stop the rapid progress in the destruction of tropical rain forests. The development of forest tree breeding technologies based on cell fusion etc. (topic 36) has further increased the value of tropical rainforests as the treasure-trove of genetic resources (topic 82).

Present political and social circumstances place an enormous demand on forests and the forestry industry, and conditions are rife for the field application of individually developed technologies. Namely, many critical problems such as diminishing forestry resources worldwide (topics 37 and 39), excessive dependence on fossil fuels and global warming demand technological innovation in the forests and forestry industry field. Nevertheless, against a background of people's general tendency to prefer cheaper petrochemical products over timber, and virgin pulp over recycled paper, in Japan, the supply of cheap imported timber has been continuing, thus hindering the practical use and spread of new technologies (topics 40 and 41). The same applies to reforestation technologies for tropical regions and developing countries. Large-scale afforestation utilizing new technologies (topic 38) may not be able to catch up with the overgrazing by livestock and ravaging by residents looking for firewood (topics 42 and 71). Rather, Japanese conventional technologies, after being adapted to the specific conditions of each local community, would be more effective. The fact that many new technologies presuppose the existence and availability of high-tech equipment, such as computers, (topics 44 and 79) and plenty of energy is also a problem. While energy conservation technologies are important in developed countries, they are meaningless in regions where energy consumption is very low in the first place. Technologies that should be applied to such areas may be somewhat old-fashioned Japanese conventional technologies that were developed before the country's high economic growth era.

In Japan, despite the fact that domestically-grown timber is in over supply, the inflow of imported timber looks set to continue. This is quite a peculiar phenomenon by international standards. Timber imports from tropical countries at least must be reduced, and technological development must be undertaken on the premise that the time will come when domestically-grown timber will be needed. For this to happen, forestry workers must be able to obtain similar levels of incomes to those of urban salaried workers for similar amounts of work. Mechanization at felling sites means liberation from harsh labor and danger. In fact, the introduction of chain saws at such job sites dramatically reduced serious labor accidents involving axes and saws. However, they were also used as a means of increasing labor productivity, and this gave rise to tragic incidents of Raynaud's syndrome. The level of mechanization achieved in Scandinavian countries is not applicable to Japan. This is not only because of the existence of numerous steep slopes, one of the countries typical topographic features, but is also due to the absence of a system that secures a year-round work load that justifies the investment. It should therefore be noted that technologies can only be applied where suitable social conditions exist. Cries voicing the importance of the natural environment and warnings issued against the danger of chemical substances in the living environment have not translated into the use of timber resources. However, this may be interpreted as a consequence of the inadequacy of Japans economic infrastructure, which has failed to make people feel secure enough to pursue greater comfort in their lives. It must be stressed again that new technologies should promote safety and comfort, rather than pursuing cost reductions. It is hoped that the fostering of consumer preference for recycled paper despite its price disadvantage will become the catalyst for true technological innovation.

9.1.7. Fisheries industry

In November 1994, the United Nations Convention on the Law of the Sea came to force after a marathon discussion spanning a quarter of a century, and Japan signed the convention in July 1996, giving rise to the need for it to develop a new order for its fisheries industry. According to the convention, the sea area within 200 nautical miles of the shore of a coastal nation is designated as an exclusive economic zone, over which the nation is entitled to undertake, among other things, economic development involving natural resources etc. as its sovereign right, while there is an obligation to take responsibility for the conservation and management of fisheries resources by setting a total allowable catch (TAC) for each fish species every year. On this basis, the Japanese Government has set TACs for six fish species including Pacific saury, walleye pollack, horse mackerel, Sardinops melanosticta (kind of sardine) and mackerel in 1997. The convention also obligates each coastal nation to conserve the sea environment within 200 nautical miles of its shores.

While the available resources of Sardinops melanosticta, of which up to 4.5 million tons used to be caught, have declined significantly, international controls over fisheries resources have become more stringent, and Japan's TAC fell dramatically, from a one-time 12 million to 7 million ton level, for the first time in 30 years. International interest in the status of fisheries resources as food sources is high, and 95 countries and 11 international organizations took part in the “International Conference on the Sustainable Contribution of Fisheries to Food Security”, held in December 1995 in Kyoto, Japan.

Against this background, the establishment by Japan of a sustainable fisheries industry based on fisheries resources within its 200 nautical economic zone is becoming ever more important, and the promotion of fish-farm or resource-management-type fisheries operations must continue to be the backbone of future policy measures.

Even today, when TACs are set, “54. Development of an estimation technique for an optimum fisheries production level” and “55. Development of production regulation systems based on the prediction of long term (10 to 20 years) changes in major fishery resources” within the 200 nautical-mile economic zone take a long time, with their realization times forecasted as 2014 and 2016, respectively.

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9.2. Forecast topic framework

In the course of compiling forecast topics, a framework representing the organization of technologies in tabulated matrix form was drawn up for each field, with objectives and technological domains defining the rows and columns of the table, respectively. The framework is designed to present an overall picture of technological development in each field in terms of future prospects, importance, etc. as seen from the present perspective, and is also used as a working framework for future reviews of forecast topics.

Table 9.2-1 Forecast Topic Framework for Agriculture, Forestry and Fisheries Field

Domain / Objective	Agriculture		Forests/forestry industry	Fisheries industry	Other new industries based on living organisms	Common
	Crop production	Animal husbandry/grazing				
Breeding and development of biological functions	01 02 03 04 05 06	22 23 24 25 26	36	45	57 58 59 60 61 62 63 64 65	69 70 71
Cultivation and feeding management	07 08 09 10 11 12 13 14 15	27 28 29 30 31 32 33	37 38	46 47 48 49 50 51 52	66	72 73
Storage, distribution and processing	16 17 18 19 20	34	39 40 41		67 68	74 75 76 77
Management and assessment of environment and biological resources	21	35	42 43 44	53 54 55 56		78 79 80 81 82 83 84

* Figures appearing in the table represent topic numbers.

9.3. Topics with high degree of importance

Degree of importance index scores (Note 1) averaged at 60.5 for topics in the agriculture, forestry and fisheries field as a whole. Topics considered of particular importance to Japan (top 20 topics in terms of degree of importance index score) are listed in the table below. Ten of the top 20 topics (50%) related to management and assessment of the environment and biological resources.

Table 9.3-1 Top 20 Topics in Terms of Degree of Importance Index

Topic	Degree of importance index	Forecasted realization time (year)
84 Practical use of a system of removing almost the entire pollution load on lakes, bays and other closed water bodies that are suffering from water quality degradation by developing environmental restoration technology that utilizes ecosystems and biological functions.	88	2018
02 Practical use in Japan of crop varieties having the characteristics (higher yield and more disease- and cold-resistance) improved by gene manipulation.	87	2004
01 Elucidation of the whole DNA sequences of crops (e.g. Rice) to isolate useful genes.	87	2009
20 Widespread use of biodegradable containers and wrapping materials that use bio-oriented materials.	86	2005

55 Development of production regulation systems as a step toward management of resources and fisheries once it becomes possible to predict the long term (10 to 20 years) changes major fishery resources.	84	2016
42 Establishment of a quantitative assessment technique for the environmental conservation functions of forest ecosystems, and widespread use of a forest management technique that makes the exploitation of timber resources, while still maintaining such functions.	83	2014
54 Development of an estimation technique for an optimum fisheries production level for each fishing area based on simulation techniques for the propagation of marine organisms of all forms, from primitive to advanced, inhabiting the coastal to offshore fishing zone.	80	2014
73 Widespread use of rapid disease diagnostic systems based on the PCR technique etc.	79	2004
09 Widespread use of the pest control method based mainly on the biological insecticides (natural microbial enemies, pheromones, etc.).	78	2008
43 Elucidation of the mechanism whereby organisms belonging to forest ecosystems turn into pests, and development of a prediction technique for the outbreak of major pests and an integrated pest control technique that takes advantage of the self-maintanance functions of forests.	75	2014
81 Development of a forest management method that realizes the advanced use of forests, while maintaining sustainable forest operation, on a global scale.	75	2016
78 Practical use of global monitoring systems that keep watch on the resource and environment of agriculture, forestry and fisheries using the next-generation remote sensing technologies with high-resolution ability.	75	2010
07 Widespread use of microbial mediated techniques to facilitate crop plant uptake of phosphorus fixed in the soil.	72	2011
51 Practical use of selective fishing methods for catching desired size and species of fish, and of inductive fishing for catching in desirable area through the development of technologies that are able to control the behavior of a shoal of fish.	72	2013
79 Practical use of resource management systems using artificial intelligence and computer simulation technologies to conserve forest, water, soil, and other natural environments and harmonize the agricultural-forestry ecosystem.	72	2013
39 Extension of the service lives of wood resources and improvement of their recycling rates through advancements in their weatherability and recycling techniques, resulting in a halving of new tree requirements.	70	2015
65 Development of a bio-micromachining technology aiming for a drug delivery system to cancer tissue etc. featuring biodegradation after drug discharge.	70	2010
53 Practical use of a management technique for migratory fisheries-resource organisms with great traveling distances, based on a prediction system for the relationship between ocean-wide environmental changes and marine organism propagation.	70	2018
47 Practical use of technology to develop an algae-covered area to maximize the productivity potential of fisheries resources, targeting unutilized intertidal zones and shoal zones, centering on sand beaches.	69	2010
35 Widespread use of animal waste utilization techniques via decomposition into constituents.	68	2010

Note 1: Degree of importance index = (number of “high” responses × 100 + number of “medium” responses × 50 + number of “low” responses × 25 + number of “unnecessary” responses × 0) ÷ total number of degree of importance responses

9.4. Forecasted realization times

Forecasted realization times were distributed as shown in the diagram below. The distribution peaked earlier than the general trend covering all topics, with about 90% of the topics forecasted to be realized by 2015.

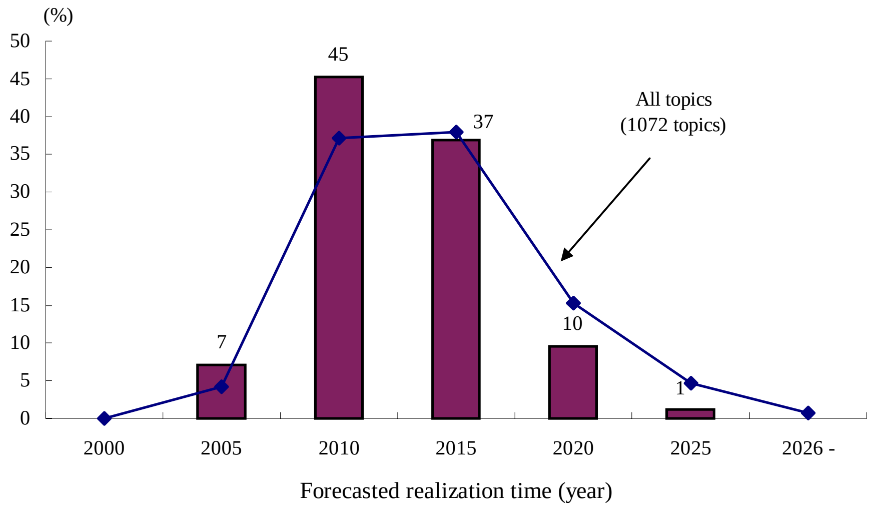


Fig. 9.4-1 Trends in Forecasted Realization Times

9.5. Current leading countries etc.

Responses to the question concerning current leading countries etc. were as shown in the diagram below.

Unlike other fields, the pattern of overwhelming dominance by the U.S. is absent in the agriculture, forestry and fisheries field, with Japan closely behind, followed by the EU.

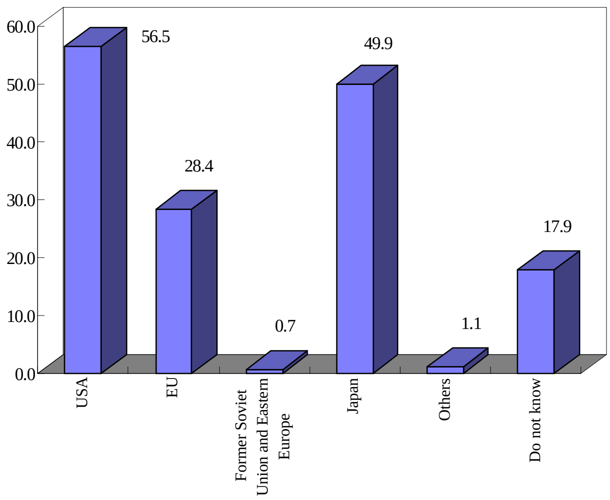


Fig. 9.5-1 Current Leading Countries etc. (%)

9.6. Comparison with the 5th Survey (previous survey)

Of the 84 topics included in the latest survey, 27 (32%) were identical to the previous survey, 16 (19%) were modified, and 41 (49%) were newly introduced. For identical topics, the results of the latest survey were compared with those of the previous survey in terms of degree of importance index scores and forecasted realization times, as shown in the table below.

Degree of importance index scores rose for 7 topics, fell for 19 topics and remained the same for 1 topic. ì51. Practical use of selective fishing methods and of inductive fishing based on technologies that are able to control the behavior of a shoal of fish saw the greatest jump, up 12 points, while ì80. Practical use of technologies for efficient management and use of tropical forest and the organisms living there saw the greatest drop, down 29 points.

From the 4th to the 5th Survey, forecasted realization times were pushed back for all but one topic. However, from the 5th to the 6th Survey, forecasted realization times were brought forward for 3 topics and remained the same for one, with ì10. Development of prevention systems against crop damage by cold-weather, such as localized climate control having its forecasted realization time brought forward by 5 years. Four topics saw their forecasted realization times pushed back 7 years.

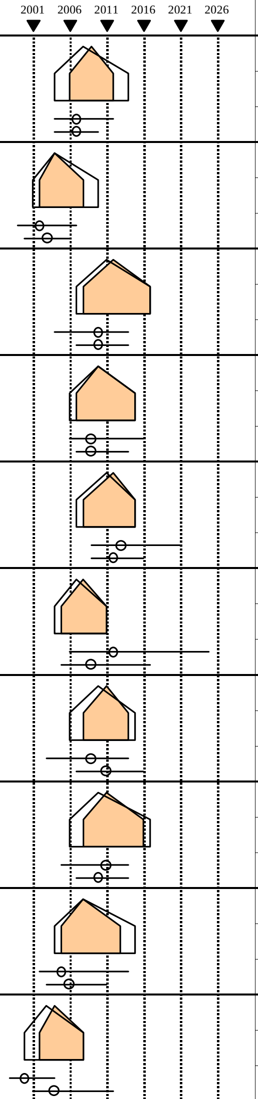
Table 9.6-1 Comparison with 5th Survey for Identical Topics

Topic	Importance index / forecasted realization time	
	6th survey	5th survey
01 Elucidation of the whole DNA sequences of crops (e.g. Rice) to isolate useful genes.	87/2009	84/2004
02 Practical use in Japan of crop varieties having the characteristics (higher yield and more disease- and cold-resistance) improved by gene manipulation.	87/2004	93/2002
06 Development of a new variety of the silkworm, *Bombyx mori*, that secretes silk fibroin proteins introduced of the characteristics of the silk fibroin proteins of the wild silkworm, *Antheraea yamamai*, through the introduction of fibroin gene of *A. Yamamai* into *B. mori* by the gene manupilation.	42/2008	49/2004
08 Practical use of technologies evading grouth retardation by continuous cropping by treating the soil with microorganisms or allelopathic substances.	66/2011	67/2007
09 Widespread use of the pest control method based mainly on the biological insecticides (natural microbial enemies, pheromones, etc.).	78/2008	82/2001
10 Development of prevention systems against crop damage by cold-weather, such as localized climate control, that respond to weather forecasts.	63/2004	75/2009
12 Practical use of agricultural robots capable of harvesting and simultaneous sorting of fruits according to quality.	53/2007	57/2002
14 Development of remote-controlled, multi-purpose agricultural robots with artificial intelligence, that can make even aged people self-reliant in cultivation and harvesting of crops.	61/2011	62/2004
19 Practical use of a technology capable of cutting, isolating and utilizing nutritious sections in food proteins, through the use of proteases etc.	47/2009	71/2004
22 Practical use of techniques for genetic improvement of domestic animals whose disease resistance and fecundity are enhanced by introduction of genes with desirable traits into the fertilized ovum or embryo.	63/2009	81/2005
23 Practical use of production of copies of superior cattle by nuclear transplantation.	61/2007	77/2003
28 Practical use of synthetic vaccines for preventing diseases of livestock utilizing molecular designs by gene engineering and protein engineering.	63/2010	79/2005
36 Development of useful tree varieties with desirable characteristics using gene manipulation, cell fusion and other similar technologies in forest tree breeding.	56/2010	67/2008
37 Realization in Japan of systems enabling forest biomass to be used in a balanced manner in terms of energy and economic considerations through the practical use of technologies for efficiency raising and collecting broad-leaved trees, bamboo grass, slash and other yet-unused resources that are presently of relatively little economic importance.	65/2014	64/2008
41 Practical use of technologies for manufacturing paper and pulp by using the enzyme of wood decaying fungi.	57/2010	63/2006

Topic	Importance index / forecasted realization time	
	6th survey	5th survey
45 Realization of the creation of varieties of fisheries-resource aquatic organisms with traits advantageous for cultivation, such as high resistance to changes in water temperature and diseases, through cell fusion, gene manipulation, etc.	62/2010	65/2005
46 Widespread use of a management system for the reproduction of coastal fisheries resources based on an environmental control technology designed to guide fry from the nursery to an area more suitable for their growth, while preventing their destruction or scattering of eggs.	62/2015	63/2013
47 Practical use of technology to develop an algae-covered area to maximize the productivity potential of fisheries resources, targeting unutilized intertidal zones and shoal zones, centering on sand beaches.	69/2010	66/2004
48 Practical use of technologies for using a large volume of deep sea water for new fishing grounds in the open sea.	57/2013	51/2013
49 Development of a technology to utilize physiologically active substances derived from algae etc. to encourage the preferential propagation of useful algae in reef zones, while preventing the growth of miscellaneous algae and algae-eating organisms.	54/2013	54/2011
51 Practical use of selective fishing methods for catching desired size and species of fish, and of inductive fishing for catching in desirable area through the development of technologies that are able to control the behavior of a shoal of fish.	72/2013	60/2015
52 Widespread use of super labor-saving fishing boats designed to automate a series of operations from searching for shoals of fish, dragging and lifting nets. to sorting fish by size and storing them consequently allowing the crew to devote only to monitoring.	58/2014	57/2009
55 Development of production regulation systems as a step toward management of resources and fisheries once it becomes possible to predict the long term (10 to 20 years) changes major fishery resources.	84/2016	81/2018
69 Elucidation of the mechanisms of totipotency of plant cells.	66/2021	87/2014
75 Practical use of general-purpose taste measuring equipment provided with a taste sensor capable of sensing taste ingredients and a texture sensor capable of sensing.	44/2010	51/2003
79 Practical use of resource management systems using artificial intelligence and computer simulation technologies to conserve forest, water, soil, and other natural environments and harmonize the agricultural-forestry ecosystem.	72/2013	82/2011
80 Practical use of technologies for efficient management and use of tropical forest and the organisms living there through elucidation of the mechanisms of structure and functions of forest ecosystems in tropical regions.	55/2016	84/2014

Note: Up until the 5th Survey, realization meant realization in Japan unless otherwise specified. However, this was changed to mean realization somewhere in the world in the 6th Survey. Therefore, care should be taken when comparing forecasted realization times from the two surveys.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time			Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources		Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Agriculture (crop production)	1	Elucidation of the whole DNA sequences of crops (e.g. Rice) to isolate useful genes.	1	235	18	26	56	86	73	25	2	0	39	85	10	46		0	6	67	18	0	75	1	6	66	26	24	57	56	7	1	29	6	15	4
			2	202	17	27	55	87	74	24	1	0	37	87	6	45		0	2	70	11	0	81	0	5	74	19	16	67	64	3	0	38	4	16	4
			X	35	100	0	0	96	91	9	0	0	51	86	6	54		3	0	80	14	3	97	0	0	86	20	17	46	83	3	0	26	0	14	6
	2	Practical use in Japan of crop varieties having the characteristics (higher yield and more disease- and cold-resistance) improved by gene manipulation.	1	242	25	23	52	84	71	25	4	0	43	93	14	11		1	2	86	35	0	38	2	7	54	41	22	45	41	28	2	54	8	28	3
			2	213	25	22	53	87	75	22	3	0	44	92	11	10		1	1	92	33	0	45	2	3	69	37	14	47	48	22	1	60	6	23	2
			X	53	100	0	0	96	92	8	0	0	51	98	9	6		0	0	98	47	0	43	4	0	74	40	25	32	55	28	2	43	6	26	4
	3	Development of C_3 plants with modified photosynthesis systems through the techniques of biological/biochemical control or gene manipulation, etc.	1	191	14	32	54	67	42	46	12	1	23	93	4	25		3	11	75	28	1	25	2	20	67	28	25	25	53	8	2	42	8	12	3
			2	169	12	32	56	64	35	53	12	1	18	88	2	22		2	7	84	27	1	25	0	13	81	23	17	21	65	2	1	50	4	9	2
			X	21	100	0	0	81	67	24	10	0	24	95	0	24		0	0	95	33	5	33	0	0	86	19	29	10	71	0	0	43	0	0	5
	4	Development of new rice cultivation techniques based on the development/utilization of highly efficient symbiotic N_2-fixing microorganisms.	1	199	10	35	55	66	41	40	17	2	26	91	5	14		3	8	50	20	1	47	6	21	65	37	21	26	53	6	1	47	4	7	1
			2	175	9	33	58	66	37	52	10	1	22	94	3	7		2	5	66	18	1	54	6	14	79	33	14	21	61	3	1	50	0	5	1
			X	16	100	0	0	81	63	38	0	0	31	100	0	6		0	0	81	44	6	50	13	0	81	25	31	25	81	0	0	38	0	6	0
	5	Practical use of uniform seeds of F1 varieties of crops such as maize through the introduction of apomixis genes via gene manipulation.	1	138	20	27	54	55	24	48	26	2	23	88	3	14		1	15	80	15	3	11	2	11	59	25	15	33	41	7	1	30	6	11	1
			2	117	21	23	56	53	17	62	21	0	18	89	3	10		1	9	87	17	2	10	3	9	79	17	9	38	50	4	1	33	2	8	0
			X	24	100	0	0	71	46	46	8	0	25	92	0	0		4	4	88	21	4	8	8	0	79	4	13	38	75	0	0	33	0	4	0
	6	Development of a new variety of the silkworm, Bombyx mori, that secretes silk fibroin proteins introduced of the characteristics of the silk fibroin proteins of the wild silkworm, Antheraea yamamai, through the introduction of fibroin gene of A. Yamamai into B. mori by the gene manupilation.	1	123	9	18	73	43	10	46	39	5	64	20	20	16		1	9	11	9	2	69	0	22	48	40	12	22	46	9	0	33	5	10	2
			2	109	7	19	73	42	7	49	40	4	71	13	17	13		0	6	14	8	1	78	0	13	59	43	7	19	50	3	0	32	2	7	2
			X	8	100	0	0	53	13	75	13	0	88	0	13	13		0	13	25	25	0	75	0	13	50	63	0	0	75	0	0	38	13	0	0
	7	Widespread use of microbial mediated techniques to facilitate crop plant uptake of phosphorus fixed in the soil.	1	188	18	22	61	70	47	39	14	1	23	95	6	9		0	12	46	28	1	35	3	31	65	41	19	10	50	6	1	46	3	4	3
			2	170	16	20	64	72	49	43	8	0	22	94	4	6		0	8	55	25	1	46	2	24	74	39	10	6	57	2	1	49	1	3	2
			X	27	100	0	0	87	74	26	0	0	30	93	7	7		0	4	70	52	4	70	7	0	89	30	22	4	63	0	0	41	0	0	0
	8	Practical use of technologies evading grouth retardation by continuous cropping by treating the soil with microorganisms or allelopathic substances.	1	187	14	28	58	67	41	45	13	1	25	89	10	9		2	12	50	34	1	34	2	26	62	42	18	10	49	7	1	51	4	3	2
			2	162	12	31	57	66	35	59	5	0	20	94	4	6		1	7	68	35	1	45	2	18	77	40	10	8	60	4	1	51	1	2	1
			X	19	100	0	0	76	58	32	11	0	37	100	0	5		0	5	74	42	0	47	5	5	84	37	11	0	63	0	0	47	0	0	5
	9	Widespread use of the pest control method based mainly on the biological insecticides (natural microbial enemies, pheromones, etc.).	1	223	14	26	60	74	53	37	9	0	29	89	25	7		3	6	62	52	2	37	5	14	52	48	14	13	43	22	0	66	7	3	1
			2	191	14	24	62	78	59	36	5	0	26	90	20	4		3	4	70	57	2	45	3	8	66	55	8	7	50	14	1	68	4	2	1
			X	27	100	0	0	81	65	27	8	0	30	93	19	4		7	4	85	78	4	52	4	0	63	70	4	7	52	15	0	63	4	0	0
	10	Development of prevention systems against crop damage by cold-weather, such as localized climate control, that respond to weather forecasts.	1	150	10	37	53	65	40	43	15	1	25	84	12	1		1	4	12	3	1	75	1	17	38	55	19	3	49	1	2	21	9	1	4
			2	132	8	32	61	63	33	57	10	1	23	85	10	3		3	5	12	2	0	84	0	11	39	67	9	2	57	0	2	30	4	2	2
			X	10	100	0	0	80	60	40	0	0	40	90	0	0		0	0	10	0	0	80	0	10	40	80	0	0	40	0	0	30	0	0	0



(Note) See page 7 for the interpretation of the graphs.

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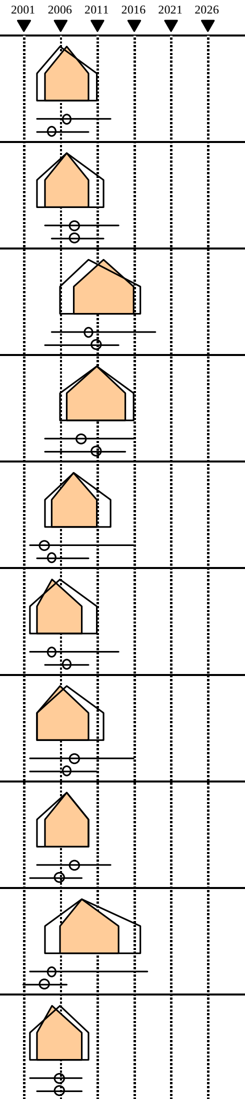
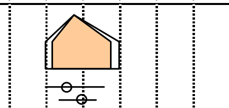
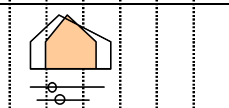
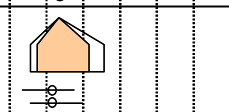
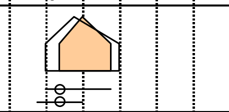
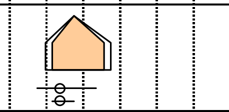
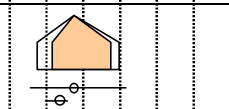
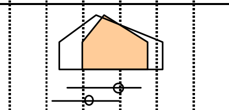
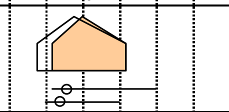
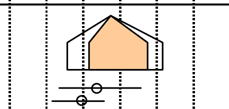
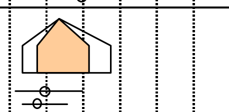
Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time		Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Agriculture (crop production)	11	Spread of vegetable processing plants, in which growth rates and maturity of crops such as tomato are automatically controlled and automated harvesting and packaging facilities are available.	1	203	12	29	59	48	17	45	33	5	54	49	22	1	11	5	45	35	0	52	1	16	26	61	22	4	31	6	1	22	5	13	6
			2	187	10	28	63	47	14	48	35	3	62	43	24	1	9	5	56	35	0	66	0	10	27	71	17	1	30	3	1	21	4	13	4
			X	18	100	0	0	67	39	50	11	0	83	56	11	0	6	0	56	61	0	78	0	0	56	83	6	0	39	0	6	22	6	17	11
	12	Practical use of agricultural robots capable of harvesting and simultaneous sorting of fruits according to quality.	1	189	15	23	61	54	22	51	26	1	55	40	28	1	3	5	46	21	1	56	0	22	31	70	16	0	40	1	1	10	6	9	5
			2	170	13	23	64	53	20	53	27	1	71	34	25	1	2	3	54	20	0	65	0	16	28	78	12	0	40	1	0	8	5	11	4
			X	22	100	0	0	67	45	36	14	5	77	27	18	0	9	0	59	32	0	77	0	5	55	77	5	0	55	0	0	9	14	5	5
	13	Development of biomimic farming machines such as small weeding robots that imitate the motions of the "Kabuto-ebi" shrimp or "Ai-gamo" duck, and pollinating robots mimicking bees.	1	154	14	19	68	50	20	44	30	6	48	54	22	12	10	8	33	14	0	45	1	38	43	64	12	1	48	2	0	21	5	10	3
			2	137	10	18	72	47	16	47	31	6	55	58	17	4	9	7	36	9	0	58	0	30	46	72	7	1	45	1	0	19	3	10	1
			X	14	100	0	0	61	36	43	14	7	57	57	14	0	14	0	29	7	0	86	0	14	64	79	7	0	29	0	0	0	14	7	7
	14	Development of remote-controlled, multi-purpose agricultural robots with artificial intelligence, that can make even aged people self-reliant in cultivation and harvesting of crops.	1	171	15	18	67	63	37	43	18	2	50	47	54	3	6	5	44	17	0	54	1	25	38	71	17	0	51	2	1	9	12	13	4
			2	157	11	17	72	61	33	49	16	2	57	37	58	2	3	4	50	10	0	68	1	19	37	80	8	0	55	3	0	4	12	11	1
			X	18	100	0	0	74	56	33	6	6	67	50	44	6	11	0	44	6	0	83	6	6	61	78	6	0	50	17	0	6	33	0	6
	15	Practical use in Japan of advanced farming systems that link the mesh data necessary for cropping as soil maps and other miscellaneous data regarding weather or product distribution.	1	176	9	25	66	64	36	49	15	0	43	68	15	6	2	5	52	23	0	47	1	19	45	61	18	12	45	5	0	15	9	8	3
			2	164	8	25	67	62	30	59	12	0	46	71	9	6	1	3	71	22	0	60	0	8	48	69	10	9	49	5	0	15	5	8	2
			X	13	100	0	0	85	69	31	0	0	38	85	15	0	0	0	92	46	0	54	0	0	54	85	15	0	46	8	0	23	8	15	0
	16	Practical use of a technology capable of producing fermented foods, such as miso (fermented soybean paste) and soy sauce, within short periods of time, through the use of artificial modified enzymes with high reaction rate.	1	146	13	29	58	45	13	45	38	3	53	49	18	8	5	6	21	14	0	74	0	13	32	60	18	11	25	14	2	10	10	14	5
			2	126	10	29	61	42	6	53	40	2	68	39	16	5	2	3	17	9	0	87	1	6	30	71	10	7	21	11	1	5	8	13	2
			X	13	100	0	0	48	15	46	38	0	85	38	8	8	0	0	15	15	0	92	0	0	31	69	15	8	31	31	0	0	8	8	0
	17	Widespread use of high pressure food sterilization (at around 3,000 atm.) as a common sterilization technique through the achievement of a sterilization effect comparable to that of ultra-high pressure full sterilization at this modest pressure level by combining it with physical and chemical methods and applying it in a continuous process.	1	121	12	29	59	53	21	53	24	3	58	44	37	7	9	7	33	24	0	61	1	16	31	63	23	1	37	13	1	10	17	7	3
			2	109	9	30	61	51	12	67	21	0	74	33	38	5	9	3	32	19	0	68	1	17	29	70	12	0	39	11	0	4	20	6	1
			X	10	100	0	0	53	22	44	33	0	80	50	10	20	30	0	30	20	0	80	0	0	10	70	20	0	40	20	0	10	10	0	0
	18	Widespread use of a technology that keeps starch-based foods with high water content from deteriorating for a prolonged period, making it possible to eat such foods at any time without reheating, through combination with aseptic packaging.	1	104	13	26	61	54	24	49	25	3	61	45	46	2	1	7	40	12	1	63	1	18	36	67	19	0	35	4	0	8	15	11	5
			2	94	9	29	63	52	17	57	25	1	67	34	56	1	1	3	50	9	0	77	0	13	33	79	7	0	36	1	0	3	18	11	1
			X	8	100	0	0	69	38	63	0	0	88	38	63	0	0	0	88	0	0	100	0	0	50	75	13	0	38	0	0	0	13	13	0
	19	Practical use of a technology capable of cutting, isolating and utilizing nutritious sections in food proteins, through the use of proteases etc.	1	130	12	27	62	48	16	46	34	4	52	54	39	7	2	8	56	32	1	49	0	18	44	53	20	13	32	7	0	11	14	8	5
			2	115	7	33	60	47	12	54	32	2	57	49	46	6	0	4	67	30	0	57	0	17	44	68	13	9	30	4	0	5	21	7	1
			X	8	100	0	0	66	38	50	13	0	88	63	38	0	0	13	88	25	0	88	0	0	50	63	25	13	63	0	0	13	0	13	0
	20	Widespread use of biodegradable containers and wrapping materials that use bio-oriented materials.	1	204	8	22	70	80	63	31	5	1	56	89	29	2	0	2	50	46	1	50	2	21	35	66	19	2	50	18	1	40	7	9	1
			2	187	6	20	74	86	75	23	1	1	51	90	24	2	0	2	61	51	0	61	0	17	30	80	9	1	58	14	1	40	2	6	2
			X	12	100	0	0	96	92	8	0	0	67	67	33	0	0	0	92	75	0	92	0	0	42	92	17	0	58	33	8	42	8	0	8



(Note) See page 7 for the interpretation of the graphs.

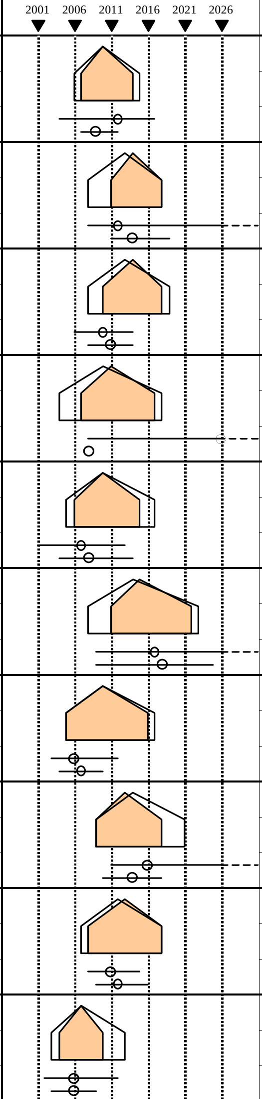
Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic development	Expected effect: Resolution of global problems	Expected effect: People's needs	Expected effect: Expansion of intellectual resources	Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Agriculture (crop production)	21	Widespread use of a cultivation technique across Asia that reduces methane emission from paddy fields, while maintaining/improving rice yields.	1	165	12	26	62	55	27	48	19	6	13	98	4	5		5	12	18	5	1	64	5	24	62	24	14	6	64	5	6	33	4	4	1
			2	152	11	25	64	56	24	56	16	4	5	99	3	4		4	5	17	5	0	74	7	17	70	18	10	3	73	2	6	35	2	1	1
			X	16	100	0	0	84	69	31	0	0	19	100	0	0		6	6	25	13	0	94	6	6	75	31	25	0	88	0	13	44	0	0	0
Agriculture (animal husbandry/grazing)	22	Practical use of techniques for genetic improvement of domestic animals whose disease resistance and fecundity are enhanced by introduction of genes with desirable traits into the fertilized ovum or embryo.	1	160	11	25	64	63	35	51	13	1	44	76	14	18		0	9	74	51	1	40	3	13	58	41	16	28	52	19	1	23	8	46	0
			2	133	11	26	63	63	30	61	8	1	44	77	13	16		0	4	83	54	1	42	2	8	68	44	7	22	56	11	1	22	4	52	0
			X	14	100	0	0	86	71	29	0	0	64	71	29	43		0	0	93	64	0	43	7	0	79	29	21	29	64	29	0	29	7	71	0
	23	Practical use of production of copies of superior cattle by nuclear transplantation.	1	149	13	23	64	63	35	49	14	2	46	73	10	12		1	3	74	50	1	48	1	13	58	42	17	21	44	11	1	16	7	34	1
			2	128	11	24	65	61	27	63	9	2	46	80	6	9		0	2	84	55	0	56	1	6	67	44	9	17	52	5	1	9	3	48	1
			X	14	100	0	0	82	64	36	0	0	50	86	7	29		0	0	86	71	0	71	0	0	79	29	14	14	71	7	0	0	0	57	0
	24	Practical use of a livestock production technology that utilizes embryonic stem (ES) cells.	1	101	19	28	53	65	39	44	15	1	44	70	13	19		1	7	78	51	1	35	2	14	73	42	23	14	52	6	0	17	6	40	1
			2	88	18	28	53	61	26	63	10	0	44	80	9	11		0	1	90	51	0	34	1	3	84	42	8	9	66	2	0	13	2	49	0
			X	16	100	0	0	81	63	38	0	0	56	69	19	25		0	0	94	69	0	50	0	0	88	50	6	13	75	6	0	19	6	56	0
	25	Development of a livestock homeostasis control technology through the elucidation of cytokine networks and cranial-nervous, endocrine and immunological system networks.	1	86	10	36	53	59	31	48	19	2	30	55	22	42		1	15	70	42	1	28	0	22	69	45	24	9	58	2	0	15	10	14	1
			2	75	8	39	53	60	28	57	14	1	28	61	15	43		0	7	83	36	0	23	0	15	76	44	15	4	61	1	1	13	7	15	1
			X	6	100	0	0	58	17	83	0	0	33	83	17	17		0	0	100	67	0	50	0	0	83	67	33	0	83	0	0	17	0	17	0
	26	Practical use of artificial seeds for vegetative propagation lawn grasses etc.	1	138	16	30	54	43	10	46	40	4	43	64	14	4		4	12	54	22	1	38	1	28	45	50	7	12	46	1	0	32	4	1	1
			2	122	17	29	54	42	7	50	41	2	43	64	13	4		3	8	67	16	0	40	2	20	49	56	3	7	48	2	1	30	2	2	0
			X	21	100	0	0	52	24	38	38	0	62	62	24	0		0	0	90	33	0	67	5	0	43	67	10	5	33	0	0	29	0	5	0
	27	Development of a technology to improve cattle products (milk/beef) through the functional modification of rumen microorganisms based on gene manipulation.	1	120	15	29	56	55	25	50	24	2	29	81	14	16		4	13	58	48	0	23	3	25	68	40	15	18	45	8	3	37	8	15	1
			2	104	15	26	59	54	18	60	20	1	30	83	14	9		4	7	73	59	0	29	3	17	78	43	4	10	60	3	2	39	4	14	0
			X	16	100	0	0	69	44	44	13	0	56	75	19	19		6	0	88	75	0	50	13	0	88	69	13	19	81	0	0	44	6	13	0
	28	Practical use of synthetic vaccines for preventing diseases of livestock utilizing molecular designs by gene engineering and protein engineering.	1	113	11	27	63	66	38	50	11	1	48	66	28	15		1	5	72	42	0	28	1	19	53	50	21	16	51	7	1	27	9	13	2
			2	99	11	23	66	63	30	60	10	0	47	70	22	9		0	1	86	48	0	24	0	10	69	55	8	10	59	4	1	26	8	14	1
			X	11	100	0	0	77	55	45	0	0	45	36	64	0		0	0	100	64	0	27	0	0	64	18	18	18	55	0	0	27	0	36	0
	29	Establishment and practical use of a sperm sex identification technique.	1	122	13	26	61	63	35	46	17	2	37	68	16	11		1	7	61	38	2	37	0	23	51	42	24	11	48	3	0	16	5	43	2
			2	105	12	25	63	60	25	65	10	0	36	71	10	10		1	1	85	44	1	40	0	9	59	46	13	7	53	2	0	11	0	50	0
			X	13	100	0	0	85	69	31	0	0	54	69	15	15		0	0	85	62	0	38	0	0	54	31	38	0	62	0	0	8	0	62	0
	30	Practical use of labor-saving, grazing techniques based on computers, mechatronics devices, etc.	1	150	13	26	61	51	19	48	28	4	37	68	19	5		0	1	50	36	1	37	3	18	48	62	15	0	48	2	1	21	9	7	3
			2	132	11	25	64	50	14	59	24	2	39	70	16	5		1	0	68	42	0	47	2	11	56	70	8	0	55	2	0	20	5	7	2
			X	15	100	0	0	68	40	53	7	0	60	67	20	7		0	0	60	47	0	73	7	0	53	67	13	0	73	13	0	13	7	13	7

(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic development	Expected effect: Resolution of global problems	Expected effect: People's needs	Expected effect: Expansion of intellectual resources	Forecasted realization time (2001 2006 2011 2016 2021 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	Leading countries: EU	Leading countries: Former Soviet Union and Eastern Europe	Leading countries: Japan	Leading countries: Other countries	Leading countries: Do not know	Measures the government should adopt (%): Foster human resources	Measures: Promote exchanges among industrial, academic and government sectors and different fields	Measures: Upgrade advanced facilities and equipment	Measures: Develop a research base	Measures: Increase government research funding	Measures: Adjust regulations (relax/toughen)	Measures: Others	Potential problems (%): Adverse effect on the natural environment	Potential problems: Adverse effect on safety	Potential problems: Adverse effect on morals, culture or society	Potential problems: Other adverse effects
Agriculture (animal husbandry/grazing)	31	Widespread use of advanced sustainable grazing techniques that improve pasture productivity and make labor-saving livestock management possible by taking advantage of the functions of organisms forming part of pasture ecosystems.	1	146	9	31	60	54	20	55	23	1	29	85	10	5		3	9	44	45	3	20	7	25	54	34	16	6	53	3	1	40	7	3	1
			2	136	7	29	63	54	19	60	19	1	26	88	7	4		2	4	54	64	1	16	5	16	59	30	7	3	62	4	1	41	3	1	1
			X	10	100	0	0	75	60	20	20	0	30	90	0	10		0	0	40	80	10	20	20	0	70	20	0	0	70	0	0	50	0	0	0
	32	Practical use of fully automated agricultural work execution techniques based on autonomous-travel tractors for the cultivation and harvesting of forage crops.	1	142	16	21	63	48	15	51	32	2	39	58	32	2		2	4	56	30	1	35	0	23	40	65	11	0	48	2	1	16	16	4	4
			2	128	14	22	64	48	10	64	24	2	43	56	34	2		0	2	73	33	2	42	0	13	39	77	7	0	53	1	0	13	16	3	1
			X	18	100	0	0	58	17	83	0	0	61	44	33	0		0	0	56	50	0	78	0	0	33	78	6	0	67	6	0	11	22	0	0
	33	Widespread use of fully automated feed formulation, feeding, milking and animal waste treatment systems.	1	156	19	26	56	63	33	51	16	0	38	72	30	1		3	3	47	57	0	37	1	17	40	62	19	2	52	3	2	20	12	4	3
			2	140	16	26	58	62	29	63	7	1	42	75	24	0		1	0	58	66	0	41	1	11	41	76	9	1	57	1	1	20	8	4	2
			X	23	100	0	0	75	52	43	4	0	52	83	30	0		0	0	57	74	0	48	0	0	52	65	13	0	74	0	4	22	17	4	4
	34	Widespread use of allergy-free livestock product manufacturing techniques through the analysis and modification of the antigen structure of such products (e.g. milk and eggs).	1	133	11	22	68	64	35	51	14	0	29	33	78	8		2	11	64	36	1	43	1	20	51	55	14	14	53	7	2	14	17	12	2
			2	117	11	24	65	61	28	58	14	0	22	28	88	4		1	7	78	40	0	50	1	17	67	64	5	8	62	3	1	6	26	4	0
			X	13	100	0	0	77	54	46	0	0	0	62	85	0		8	0	85	23	0	69	0	8	77	69	15	15	69	0	0	15	31	8	0
	35	Widespread use of animal waste utilization techniques via decomposition into constituents.	1	152	13	26	61	67	43	40	15	2	29	88	24	3		3	12	27	42	1	37	1	26	51	57	15	4	60	5	1	31	5	4	1
			2	141	8	26	67	68	44	41	13	2	27	90	18	1		1	6	23	62	1	46	1	19	60	71	6	3	67	3	1	33	3	4	1
			X	11	100	0	0	80	73	9	9	9	27	82	9	0		9	0	18	82	0	27	0	0	73	64	0	0	55	0	0	36	0	0	9
Forests/forestry industry	36	Development of useful tree varieties with desirable characteristics using gene manipulation, cell fusion and other similar technologies in forest tree breeding.	1	142	14	24	62	59	29	49	20	2	36	84	10	13		1	11	55	27	4	35	6	30	56	30	13	32	49	8	0	52	1	9	2
			2	124	14	24	62	56	22	61	15	2	34	90	6	8		1	6	66	25	2	44	4	21	76	30	9	25	60	4	0	53	0	7	0
			X	17	100	0	0	68	41	53	0	6	47	94	6	6		0	0	82	24	0	71	18	0	76	24	12	12	76	6	0	53	0	6	0
	37	Realization in Japan of systems enabling forest biomass to be used in a balanced manner in terms of energy and economic considerations through the practical use of technologies for efficiency raising and collecting broad-leaved trees, bamboo grass, slash and other yet-unused resources that are presently of relatively little economic importance.	1	124	11	26	63	67	42	46	10	3	33	94	10	9		10	14	26	19	2	35	1	32	51	46	12	3	56	3	4	42	4	2	2
			2	111	11	23	67	65	36	53	10	1	31	93	4	5		6	11	32	16	1	46	2	32	59	47	5	2	67	5	3	37	2	3	0
			X	12	100	0	0	79	67	25	0	8	25	92	8	8		0	0	58	17	0	58	0	8	50	50	0	0	75	8	8	50	0	8	0
	38	Practical use of self-driven planting machines capable of the preparation of large areas of wasteland and the planting of pot seedlings.	1	99	8	22	70	51	20	47	30	3	32	84	13	1		5	13	28	24	2	30	2	36	35	55	13	0	46	0	0	34	4	1	4
			2	90	4	21	74	44	7	57	36	0	30	87	10	0		2	7	30	22	1	37	0	37	37	64	9	0	50	1	0	39	2	2	3
			X	4	100	0	0	50	25	25	50	0	50	75	0	0		0	0	25	25	0	100	0	0	25	25	25	0	50	0	0	25	0	0	25
	39	Extension of the service lives of wood resources and improvement of their recycling rates through advancements in their weatherability and recycling techniques, resulting in a halving of new tree requirements.	1	82	13	13	73	71	47	43	9	1	44	91	9	9		10	16	26	26	2	44	0	30	54	54	12	2	49	5	1	30	4	10	4
			2	71	13	14	73	70	45	46	9	0	46	90	4	0		13	8	28	28	1	48	0	34	56	61	7	0	56	4	0	34	1	7	3
			X	9	100	0	0	92	89	0	11	0	44	100	0	0		22	0	56	22	0	89	0	11	67	78	11	0	56	0	0	56	0	0	0
	40	Practical use of a manufacturing technique for high-strength and versatile wood composite materials which, while retaining their wood characteristics, are easy to shape and process, through advancements in the wood and non-wood material integration technology.	1	76	11	21	68	68	41	50	8	1	57	82	25	3		0	5	41	18	3	62	3	22	46	57	12	0	41	4	1	24	8	7	5
			2	70	10	17	73	64	29	68	3	0	53	81	21	0		0	3	49	19	0	67	1	19	51	69	9	0	41	4	0	29	9	9	1
			X	7	100	0	0	79	57	43	0	0	57	100	0	0		0	0	71	43	0	100	0	0	43	71	29	0	71	14	0	57	14	0	0

(Note) See page 7 for the interpretation of the graphs.

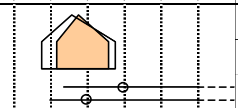
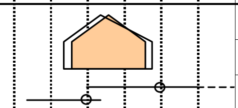
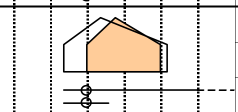
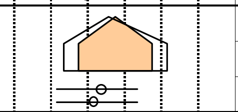
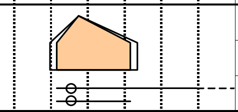
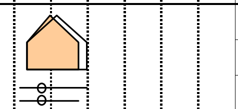
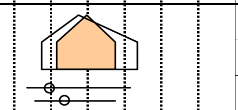
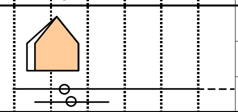
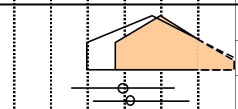
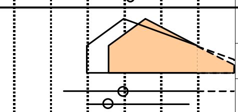
Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic development	Expected effect: Resolution of global problems	Expected effect: People's needs	Expected effect: Expansion of intellectual resources	Forecasted realization time: Will not be realized (%)	Forecasted realization time: Do not know (%)	Leading countries (%): USA	Leading countries: EU	Leading countries: Former Soviet Union and Eastern Europe	Leading countries: Japan	Leading countries: Other countries	Leading countries: Do not know	Measures the government should adopt (%): Foster human resources	Measures: Promote exchanges among industrial, academic and government sectors and different fields	Measures: Upgrade advanced facilities and equipment	Measures: Develop a research base	Measures: Increase government research funding	Measures: Adjust regulations (relax/toughen)	Measures: Others	Potential problems (%): Adverse effect on the natural environment	Potential problems: Adverse effect on safety	Potential problems: Adverse effect on morals, culture or society	Potential problems: Other adverse effects
Forests/forestry industry	41	Practical use of technologies for manufacturing paper and pulp by using the enzyme of wood decaying fungi.	1	88	11	27	61	58	24	62	11	2	58	90	5	2	2	7	50	34	6	51	6	20	53	63	17	11	48	0	1	27	2	3	2
			2	81	9	31	60	57	20	70	10	0	60	93	2	1	1	2	65	36	0	70	1	11	64	73	10	7	49	0	0	30	0	4	1
			X	7	100	0	0	64	29	71	0	0	71	71	0	0	0	0	86	29	0	57	0	0	57	43	14	0	43	0	0	29	0	14	0
	42	Establishment of a quantitative assessment technique for the environmental conservation functions of forest ecosystems, and widespread use of a forest management technique that makes the exploitation of timber resources, while still maintaining such functions.	1	109	10	19	71	80	65	26	8	1	28	98	12	10	1	12	40	42	5	38	1	20	69	39	8	2	61	7	1	39	5	6	2
			2	102	9	20	72	83	67	31	2	0	23	97	10	7	1	5	42	51	1	42	2	20	76	36	6	4	76	4	1	39	4	5	1
			X	9	100	0	0	88	75	25	0	0	22	100	0	11	0	0	33	33	0	56	0	11	78	22	11	0	44	11	11	67	0	0	0
	43	Elucidation of the mechanism whereby organisms belonging to forest ecosystems turn into pests, and development of a prediction technique for the outbreak of major pests and an integrated pest control technique that takes advantage of the self-maintanance functions of forests.	1	96	10	28	61	72	48	42	8	1	20	95	14	5	3	7	48	41	6	33	3	26	72	29	9	7	67	4	1	38	2	3	4
			2	94	9	26	66	75	52	45	3	0	22	97	9	3	3	3	63	52	3	38	2	21	81	23	3	6	73	3	1	44	3	3	1
			X	8	100	0	0	88	75	25	0	0	38	100	13	13	0	0	75	63	13	63	0	0	88	13	0	0	88	13	0	38	0	13	0
	44	Practical use of the forecasting of landslide and avalanche as the result of development in remote sensing techniques using suitable sensors and computer systems.	1	66	3	23	74	65	38	45	15	2	18	55	55	3	5	9	39	15	0	44	0	30	42	48	17	5	59	5	0	18	18	3	6
			2	61	2	21	77	66	38	49	13	0	15	61	66	2	5	5	41	13	0	59	0	26	46	61	8	0	82	0	0	20	23	2	0
			X	1	100	0	0	100	100	0	0	0	0	100	100	0	0	0	100	100	0	100	0	0	100	0	100	0	100	0	0	0	0	0	0
Fisheries industry	45	Realization of the creation of varieties of fisheries-resource aquatic organisms with traits advantageous for cultivation, such as high resistance to changes in water temperature and diseases, through cell fusion, gene manipulation, etc.	1	141	10	25	65	63	34	51	14	1	52	81	13	4	1	6	40	22	1	65	1	18	67	41	21	34	48	7	0	60	6	19	1
			2	126	9	22	69	62	30	60	10	0	56	80	12	3	0	2	43	19	0	74	0	13	76	42	19	28	56	6	0	72	2	17	0
			X	11	100	0	0	61	27	64	9	0	55	55	27	0	0	0	64	27	0	64	0	0	64	27	18	27	64	27	0	55	0	27	0
	46	Widespread use of a management system for the reproduction of coastal fisheries resources based on an environmental control technology designed to guide fry from the nursery to an area more suitable for their growth, while preventing their destruction or scattering of eggs.	1	96	17	27	56	62	36	43	16	5	29	82	14	5	17	10	19	9	1	56	0	30	57	39	30	3	60	5	1	54	2	3	1
			2	79	15	24	61	62	34	49	13	4	30	86	9	3	15	5	19	6	0	73	0	20	68	43	24	1	71	6	3	59	0	1	3
			X	12	100	0	0	79	58	42	0	0	25	92	8	8	17	0	33	17	0	75	0	25	67	58	25	0	67	17	0	50	0	0	0
	47	Practical use of technology to develop an algae-covered area to maximize the productivity potential of fisheries resources, targeting unutilized intertidal zones and shoal zones, centering on sand beaches.	1	96	15	30	55	68	46	36	16	2	32	84	17	3	2	7	20	6	1	69	0	25	55	56	22	3	66	8	0	49	4	2	0
			2	81	17	26	57	69	47	40	10	4	31	83	14	1	1	1	20	6	0	73	0	21	63	59	19	0	72	5	1	49	1	4	1
			X	14	100	0	0	86	79	14	0	7	36	86	7	0	7	0	43	7	0	93	0	7	64	64	7	0	79	14	7	64	0	7	7
	48	Practical use of technologies for using a large volume of deep sea water for new fishing grounds in the open sea.	1	88	9	36	55	56	27	49	18	6	34	82	9	7	9	7	39	10	2	52	3	26	47	58	28	2	63	3	1	68	7	2	0
			2	77	10	31	58	57	24	61	13	3	38	82	8	4	9	5	43	6	0	66	3	19	49	61	23	0	74	1	3	66	6	1	0
			X	8	100	0	0	72	50	38	13	0	63	75	0	25	13	0	75	0	0	75	0	13	88	75	25	0	88	0	0	75	13	0	0
	49	Development of a technology to utilize physiologically active substances derived from algae etc. to encourage the preferential propagation of useful algae in reef zones, while preventing the growth of miscellaneous algae and algae-eating organisms.	1	98	12	30	58	56	25	55	18	3	33	81	9	12	5	12	27	10	1	62	1	24	67	43	19	6	60	5	0	57	3	5	0
			2	88	10	26	64	54	19	64	15	2	34	82	5	8	3	6	28	8	1	74	0	16	70	39	14	0	67	5	1	58	2	3	1
			X	9	100	0	0	69	44	44	11	0	44	78	0	0	11	0	22	11	0	100	0	0	78	44	0	0	67	11	0	56	11	0	0
	50	Practical use of fishing and oceanic information service systems that gather, analyse and disseminate information simultaneously over a wide area through a combination of automatic observation buoys and satellite.	1	98	14	30	56	66	39	49	10	2	40	80	17	12	1	6	51	22	3	64	1	17	50	57	30	6	61	1	2	29	10	7	2
			2	85	14	25	61	64	33	57	7	2	36	81	9	6	2	4	52	20	2	76	0	11	46	65	22	1	67	0	1	33	6	5	2
			X	12	100	0	0	73	50	42	8	0	50	92	8	17	8	8	67	42	8	83	0	8	50	83	17	0	83	0	0	33	8	0	0



(Note) See page 7 for the interpretation of the graphs.

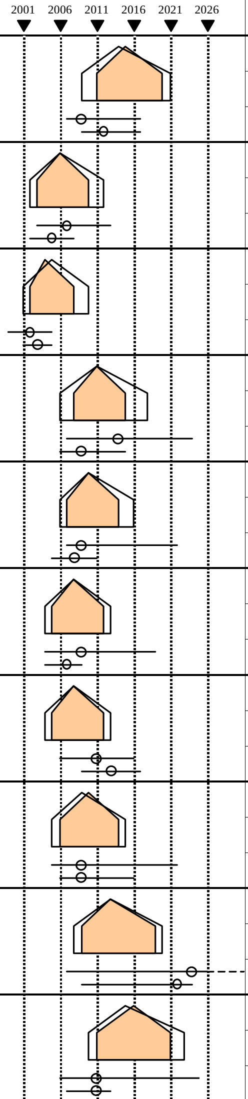
Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%) High	Medium	Low	Importance (index, %) Index	High	Medium	Low	Unnecessary	Expected effect (%) Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Forecasted realization time (2001 2006 2011 2016 2021 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%) USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%) Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%) Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Fisheries industry	51	Practical use of selective fishing methods for catching desired size and species of fish, and of inductive fishing for catching in desirable area through the development of technologies that are able to control the behavior of a shoal of fish.	1	92	17	27	55	68	47	38	11	4	37	87	13	9		8	13	18	21	3	60	1	27	65	54	13	9	58	2	0	49	0	5	0
			2	76	17	29	54	72	51	36	12	1	37	86	9	4		5	9	13	24	1	67	0	18	68	61	11	3	62	3	0	54	0	8	3
			X	13	100	0	0	81	69	23	0	8	38	92	8	8		15	8	15	54	8	69	0	15	54	77	15	8	54	8	0	69	0	0	8
	52	Widespread use of super labor-saving fishing boats designed to automate a series of operations from searching for shoals of fish, dragging and lifting nets. to sorting fish by size and storing them consequently allowing the crew to devote only to monitoring.	1	87	15	24	61	58	34	33	28	5	37	69	23	1		11	9	16	20	1	60	2	26	45	60	21	1	44	9	1	46	9	8	1
			2	77	13	23	64	58	32	39	26	3	35	74	19	1		9	4	16	22	1	66	1	18	43	68	19	0	47	5	1	47	5	5	3
			X	10	100	0	0	80	70	10	20	0	20	90	30	0		20	0	10	40	0	80	0	10	50	70	30	0	40	0	10	60	10	0	0
	53	Practical use of a management technique for migratory fisheries-resource organisms with great traveling distances, based on a prediction system for the relationship between ocean-wide environmental changes and marine organism propagation.	1	91	16	29	55	70	46	43	9	2	37	88	14	15		10	12	48	24	3	55	3	30	67	52	11	8	71	1	1	40	1	8	0
			2	82	13	24	62	70	44	47	7	1	29	88	10	11		6	5	57	20	2	56	1	26	72	48	11	6	71	0	1	38	0	7	1
			X	11	100	0	0	82	73	18	0	9	27	82	9	9		9	0	64	36	0	64	0	27	73	36	18	0	73	0	0	45	0	18	9
	54	Development of an estimation technique for an optimum fisheries production level for each fishing area based on simulation techniques for the propagation of marine organisms of all forms, from primitive to advanced, inhabiting the coastal to offshore fishing zone.	1	90	22	23	54	75	58	26	13	2	34	89	8	19		2	9	42	40	2	50	2	20	68	43	16	6	64	3	0	34	1	7	0
			2	80	20	20	60	80	65	27	9	0	30	91	5	10		3	4	43	38	4	60	1	16	78	44	13	5	78	3	0	35	0	8	0
			X	16	100	0	0	92	88	6	6	0	31	88	0	6		6	6	50	75	6	75	6	6	94	31	19	0	88	6	0	38	0	19	0
	55	Development of production regulation systems as a step toward management of resources and fisheries once it becomes possible to predict the long term (10 to 20 years) changes major fishery resources.	1	94	23	22	54	76	59	30	9	2	36	87	7	18		11	10	41	29	1	57	3	21	63	35	14	10	56	4	1	32	1	7	0
			2	80	15	28	58	84	72	22	6	0	36	91	5	8		6	6	44	29	1	66	1	18	73	33	10	8	69	3	0	38	0	4	0
			X	12	100	0	0	88	83	0	17	0	42	92	8	17		17	8	50	42	0	58	0	17	83	17	25	0	75	8	0	33	0	8	0
	56	Widespread use of a marine ecosystem utilization system that helps maintain a sound balance between fisheries production and sport fishing.	1	90	18	30	52	63	36	44	17	2	31	76	34	3		4	10	50	28	0	44	0	21	46	43	13	6	34	24	0	32	2	14	2
			2	74	16	28	55	63	32	55	12	0	26	78	30	1		4	5	57	23	0	50	0	16	58	42	9	3	42	24	0	34	0	14	1
			X	12	100	0	0	71	50	33	17	0	50	58	42	8		0	8	75	25	0	42	0	17	50	33	17	0	25	42	0	42	0	17	0
Other new industries based on living organisms	57	Practical use of pharmaceutical products utilizing the antibacterial proteins and blood anticoagulants obtained from insects.	1	117	9	25	66	59	28	51	18	2	58	10	79	11		1	8	52	31	1	51	3	21	54	61	17	18	40	8	0	11	18	13	2
			2	105	9	29	63	55	20	62	18	0	61	10	77	5		0	4	65	26	0	65	1	15	64	70	11	10	42	7	0	4	23	10	1
			X	9	100	0	0	64	33	56	11	0	56	11	100	0		0	0	89	33	0	78	0	0	56	89	22	22	44	0	0	0	22	11	0
	58	Practical use of artificial skin utilizing biomaterials, such as silk fibroin protein, from insects.	1	94	2	30	68	56	24	54	20	2	56	10	76	5		3	11	33	18	1	51	1	20	53	62	13	7	43	3	0	9	10	15	2
			2	94	1	31	68	52	13	71	16	0	55	7	74	4		2	7	36	9	1	66	0	14	63	66	10	3	47	3	1	4	15	15	0
			X	1	100	0	0	50	0	100	0	0	0	0	100	0		0	0	0	0	0	100	0	0	0	100	0	0	0	0	0	0	0	0	0
	59	Development of a sustainable production technology for useful materials, by the introduction and expression of desirable genes, in insect cultured cells.	1	115	9	26	65	56	22	60	17	2	70	23	48	14		2	6	56	21	0	45	3	21	59	51	11	17	52	3	0	12	9	13	1
			2	108	6	27	67	53	14	69	17	0	76	12	52	5		1	4	63	14	0	53	1	14	70	58	6	9	63	0	0	10	9	11	0
			X	7	100	0	0	68	43	43	14	0	71	29	57	0		14	0	71	29	0	43	0	0	86	57	0	29	57	0	0	0	29	14	0
	60	Development of technology for cultivating land plants hydroponically on the ocean surface by developing salt-trelant plants.	1	128	13	20	67	53	27	40	23	10	41	77	6	8		11	17	30	13	0	25	0	44	51	36	12	10	49	5	2	39	6	2	0
			2	128	11	20	69	50	19	51	23	7	39	85	5	6		9	9	40	9	0	30	0	46	63	36	7	6	59	2	5	44	2	2	1
			X	14	100	0	0	70	57	21	7	14	64	79	7	0		7	0	43	14	0	64	0	7	71	36	7	7	64	0	7	43	0	0	0

(Note) See page 7 for the interpretation of the graphs.

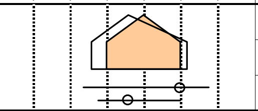
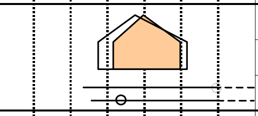
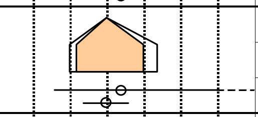
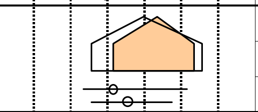
Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time			Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001 2006 2011 2016 2021 2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Other new industries based on living organisms	61	Development of new materials for common daily life items, such as glues and fibers from marine organisms.	1	107	6	17	78	57	27	50	20	3	75	41	26	14		1	10	38	12	2	43	1	32	54	54	15	7	54	3	2	29	6	5	1
			2	94	4	13	83	55	18	63	18	0	74	35	22	6		0	6	45	11	0	61	1	27	70	65	6	4	60	1	0	39	6	2	0
			X	4	100	0	0	69	50	25	25	0	100	50	0	0		0	0	50	0	0	50	0	50	50	50	25	0	100	0	0	50	0	0	0
	62	Development of a new material production technology based on the physiological functions of deep-sea organisms existing at depths in excess of thousands of meters.	1	93	5	17	77	47	16	45	34	5	58	43	20	19		6	15	49	17	0	40	0	30	59	43	22	8	56	1	0	25	2	5	0
			2	83	4	18	78	48	14	53	30	2	66	41	16	18		7	10	69	17	0	57	1	23	73	51	13	4	66	1	1	31	2	4	0
			X	3	100	0	0	50	33	33	0	33	33	33	0	33		0	0	67	0	0	67	0	0	67	33	0	0	67	0	0	33	0	0	0
	63	Advancements in the understanding of the brain-nervous system of livestock animals, leading to widespread use of feed intake improvement techniques and management techniques based on animal welfare.	1	106	12	18	70	51	21	46	31	3	28	58	19	25		4	22	56	40	1	19	2	29	58	35	21	11	42	0	2	16	3	24	4
			2	94	10	20	70	51	17	55	26	2	29	73	13	23		3	12	71	46	0	14	1	21	77	37	12	5	65	0	2	11	2	31	2
			X	9	100	0	0	78	67	22	0	11	33	78	11	44		11	0	89	33	0	33	0	11	78	33	33	22	67	0	11	11	11	44	11
	64	Widespread use of cross-species organ transplantation based on transgenic animals created through the introduction of genes that alleviate or prevent organ rejection as part of organ transplant treatment.	1	99	14	20	66	65	39	46	11	3	41	13	82	23		2	14	77	45	1	27	3	15	58	42	16	14	52	12	1	8	23	58	1
			2	86	14	17	69	65	36	51	12	1	37	6	92	15		1	10	85	45	0	26	1	12	74	47	12	6	66	10	1	2	19	62	0
			X	12	100	0	0	92	83	17	0	0	58	8	100	33		0	0	92	67	0	25	0	0	58	58	17	8	75	33	0	0	25	92	0
	65	Development of a bio-micromachining technology aiming for a drug delivery system to cancer tissue etc. featuring biodegradation after drug discharge.	1	67	6	27	67	68	44	42	11	3	45	7	85	18		1	6	69	37	3	33	0	22	63	49	13	7	51	7	0	7	24	16	3
			2	60	5	23	72	70	46	44	8	2	50	2	85	5		0	2	80	38	0	40	0	15	75	60	12	2	58	3	0	3	33	13	3
			X	3	100	0	0	83	67	33	0	0	0	33	100	33		0	0	100	100	0	100	0	0	67	33	67	0	100	0	0	0	33	100	0
	66	Widespread use of the Internet systems to make the remote diagnoses of crop plants, livestocks or farm household economy and recommend the appropriate preventing methods and countermeasures.	1	195	8	22	70	59	29	48	21	2	54	53	37	8		1	2	68	26	1	29	2	23	40	50	20	15	37	10	2	7	20	11	3
			2	167	8	19	73	57	21	64	14	1	66	54	32	3		0	1	80	27	1	37	2	14	53	68	8	11	44	7	1	2	19	8	2
			X	13	100	0	0	71	54	31	8	8	69	62	31	15		0	0	92	15	0	62	0	0	69	46	15	8	54	8	0	0	23	23	0
	67	Practical use of functional foods which help prevent diseases according to individual body characteristics.	1	144	13	19	68	63	36	49	13	3	37	18	87	8		2	8	47	24	1	49	1	26	44	58	10	9	45	14	1	3	21	15	3
			2	121	15	17	69	60	26	60	12	1	32	11	95	4		0	4	62	20	0	69	1	17	58	74	6	3	54	9	1	2	27	17	0
			X	18	100	0	0	75	56	39	0	6	56	17	89	11		0	0	67	28	0	94	0	0	56	72	11	6	67	0	0	0	17	28	0
	68	Practical use of artificial sugar substitutes with the same cooking characteristics as sucrose which are ideal for diet food preparation.	1	134	11	22	67	41	8	45	40	7	39	16	72	5		4	10	46	19	1	47	1	25	40	59	7	4	29	10	1	4	10	14	1
			2	120	11	20	69	42	8	48	43	3	33	8	84	3		3	6	59	20	0	68	0	18	45	78	2	1	31	8	0	3	17	15	1
			X	13	100	0	0	40	15	38	23	23	15	15	77	8		15	0	62	31	0	92	0	0	38	62	0	0	31	0	0	0	0	15	0
Common	69	Elucidation of the mechanisms of totipotency of plant cells.	1	179	17	30	53	68	43	43	12	2	27	51	4	73		13	14	62	47	1	28	1	23	72	20	21	20	53	2	1	15	3	10	1
			2	155	17	29	54	66	38	49	13	0	20	48	1	76		10	14	72	50	1	28	1	17	86	16	19	14	64	1	0	13	1	9	1
			X	26	100	0	0	79	62	31	8	0	27	35	4	73		4	8	81	77	0	50	0	4	92	15	27	4	77	0	0	8	0	15	4
	70	Development of a technology capable of restoring animal functions from animal tissues having undergone long freeze-storage, through gene amplification.	1	152	11	18	71	52	22	48	26	4	33	53	24	45		9	21	63	30	3	23	1	27	53	28	17	22	45	7	1	18	11	36	1
			2	128	11	17	72	52	15	63	19	2	24	59	18	46		9	16	78	32	0	23	1	17	77	24	11	19	60	2	0	13	10	43	0
			X	14	100	0	0	82	64	36	0	0	29	64	21	43		7	0	93	43	0	36	0	7	71	21	14	21	64	7	0	7	21	50	0

(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%) High	Medium	Low	Importance (index, %) Index	High	Medium	Low	Unnecessary	Expected effect (%) Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Forecasted realization time	Will not be realized (%)	Do not know (%)	Leading countries (%) USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%) Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%) Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Common	71	Development of new plants and its cultivation system which unable to grow plants in water-limited regeon.	1	168	11	19	70	47	17	44	32	8	23	96	4	11		1	11	54	21	5	24	7	30	61	30	15	24	59	1	4	40	3	3	1
			2	145	8	20	72	42	7	54	34	5	18	97	3	8		1	4	62	17	5	26	7	28	74	26	10	20	71	0	3	46	2	1	1
			X	11	100	0	0	59	27	55	18	0	9	100	0	18		0	0	73	18	18	45	18	0	55	36	18	27	73	0	9	18	0	0	0
	72	Development of farming simulation systems that provide a virtual experience of the latest agricultural technologies to assist newly-engaged farmers and improve the conventional farm management.	1	121	9	23	68	42	11	43	39	8	44	41	24	10		3	5	38	12	1	31	1	35	46	43	19	12	33	1	2	7	7	8	3
			2	109	7	17	75	44	10	50	36	4	61	40	23	6		1	3	47	11	0	47	0	33	61	61	8	7	34	1	0	7	5	6	2
			X	8	100	0	0	66	38	50	13	0	63	38	13	38		13	0	50	38	0	63	0	25	38	50	0	25	38	0	0	0	13	25	0
	73	Widespread use of rapid disease diagnostic systems based on the PCR technique etc.	1	176	16	28	56	73	50	42	7	1	30	28	78	9		1	2	77	40	1	45	1	16	47	40	21	30	41	7	1	9	22	23	1
			2	157	17	26	57	79	60	36	4	0	31	21	85	5		0	3	86	39	0	53	1	10	61	45	16	27	45	4	1	3	17	25	1
			X	26	100	0	0	85	69	31	0	0	35	31	81	4		0	0	100	58	0	69	0	0	58	46	23	31	54	8	0	4	15	31	0
	74	Development of a technique capable of the highorder protein structure prediction from a given primary structure and new 3-D protein structure design.	1	138	9	26	64	63	35	49	15	1	57	32	29	54		1	9	73	45	1	30	1	18	60	37	33	26	49	2	1	12	8	11	3
			2	124	8	27	65	61	28	63	10	0	61	16	20	62		2	9	81	45	1	31	0	12	77	30	27	23	62	0	0	10	7	7	2
			X	10	100	0	0	85	70	30	0	0	60	10	20	70		0	10	100	80	0	50	0	0	70	30	60	20	80	0	0	10	10	40	0
	75	Practical use of general-purpose taste measuring equipment provided with a taste sensor capable of sensing taste ingredients and a texture sensor capable of sensing physical	1	144	13	24	63	46	12	50	35	3	42	26	54	13		1	9	33	13	0	49	1	31	51	60	22	8	38	0	1	3	6	13	2
			2	131	9	27	64	44	7	57	35	2	37	9	76	8		1	5	40	8	0	66	1	22	54	80	14	3	34	0	0	2	6	14	1
			X	12	100	0	0	52	27	36	27	9	42	25	75	8		0	0	50	25	0	75	0	8	58	83	25	0	25	0	0	0	8	25	0
	76	Development of household food testers capable of instantaneously determining freshness and microorganic contamination levels of foods.	1	157	13	20	67	59	31	45	22	2	37	30	80	4		2	10	44	17	1	43	1	31	46	67	19	11	42	4	1	6	17	12	2
			2	147	8	24	68	54	20	58	22	0	29	17	93	3		1	6	51	11	1	56	1	27	50	78	7	4	44	3	1	3	19	8	1
			X	12	100	0	0	65	33	58	8	0	33	25	92	0		8	8	58	8	0	67	0	25	58	50	17	0	25	0	0	0	25	0	0
	77	Practical use of containers and packaging with in-built temperature control technology that obviates the need for refrigeration for processed foods aimed at the outdoor lifestyle.	1	99	11	20	69	41	12	34	48	6	41	33	63	3		10	6	48	11	0	33	0	27	33	62	17	2	18	7	1	15	11	10	1
			2	90	6	21	73	35	3	32	63	2	37	17	79	2		6	7	64	10	0	47	1	23	34	78	9	1	13	6	1	17	8	9	0
			X	5	100	0	0	25	0	20	60	20	60	0	40	0		0	0	40	0	0	20	0	40	20	80	0	0	20	0	0	0	0	20	0
	78	Practical use of global monitoring systems that keep watch on the resource and environment of agriculture, forestry and fisheries using the next-generation remote sensing technologies with high-resolution ability.	1	183	8	17	74	72	50	39	9	2	29	91	10	10		2	6	76	28	5	31	2	16	51	51	28	9	64	2	1	22	9	7	2
			2	156	7	14	79	75	54	38	8	1	22	92	5	5		1	3	87	22	2	36	1	10	60	53	19	6	71	1	1	20	2	4	0
			X	11	100	0	0	95	91	9	0	0	27	91	9	9		0	0	100	36	9	55	0	0	64	45	9	9	64	0	0	36	0	18	0
	79	Practical use of resource management systems using artificial intelligence and computer simulation technologies to conserve forest, water, soil, and other natural environments and harmonize the agricultural-forestry ecosystem.	1	158	6	25	70	70	46	44	9	1	30	96	15	9		3	10	60	33	3	29	1	24	60	46	22	13	58	3	0	27	5	3	2
			2	139	4	20	76	72	47	46	7	0	20	94	12	6		3	6	76	29	1	31	0	17	66	42	12	9	66	2	1	24	1	2	0
			X	5	100	0	0	80	60	40	0	0	20	100	0	0		0	0	100	60	0	60	0	0	100	0	0	0	80	0	0	60	0	0	0
	80	Practical use of technologies for efficient management and use of tropical forest and the organisms living there through elucidation of the mechanisms of structure and functions of forest ecosystems in tropical regions.	1	144	7	11	82	56	26	50	20	4	19	97	3	13		6	19	52	35	1	21	3	32	64	36	10	11	62	3	5	38	2	5	2
			2	123	5	12	83	55	18	66	15	1	11	95	2	11		5	12	66	39	2	22	2	26	77	32	4	8	78	1	3	37	1	4	0
			X	6	100	0	0	75	50	50	0	0	0	100	0	33		0	17	67	33	17	50	0	0	100	33	17	17	67	0	17	50	0	0	0



(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time			Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001 2006 2011 2016 2021 2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Common	81	Development of a forest management method that realizes the advanced use of forests, while maintaining sustainable forest operation, on a global scale.	1	105	10	11	79	70	49	36	13	2	26	96	8	5		5	17	43	44	6	25	4	33	58	32	16	15	57	10	3	38	2	5	1
			2	90	8	12	80	75	54	37	9	0	19	99	9	6		0	12	46	48	2	28	3	30	73	27	9	11	67	6	1	40	1	3	0
			X	7	100	0	0	92	83	17	0	0	57	100	0	14		0	0	57	86	0	86	0	0	100	43	14	29	43	14	0	86	0	14	0
	82	Development of an ecosystem management system that enables rare species of organisms dependent on forests to propagate according to their ecological conditions.	1	108	6	8	85	59	27	56	14	3	8	96	7	23		5	14	44	36	3	13	4	38	67	24	15	20	57	3	2	44	1	8	2
			2	97	4	11	85	59	24	65	11	0	7	94	4	20		5	8	53	42	1	10	2	36	81	18	8	15	69	2	1	39	2	6	0
			X	4	100	0	0	75	50	50	0	0	0	100	0	0		25	0	100	50	0	25	0	0	75	0	25	25	50	0	0	25	0	50	0
	83	Elucidation of the mode of action of "forest bathing" that gives favorable effect on human physiology and psychology from the surrounding environment.	1	134	5	11	84	54	22	52	24	2	17	35	81	19		2	13	31	34	3	22	1	42	68	41	15	5	46	1	1	22	4	19	2
			2	113	5	10	85	54	19	60	19	1	12	30	88	12		3	9	40	45	2	27	0	36	77	36	9	4	50	0	0	19	2	13	0
			X	6	100	0	0	67	33	67	0	0	17	50	83	17		0	0	67	33	0	83	0	0	50	17	0	0	67	0	0	17	0	33	0
	84	Practical use of a system of removing almost the entire pollution load on lakes, bays and other closed water bodies that are suffering from water quality degradation by developing environmental restoration technology that utilizes ecosystems and biological functions.	1	191	13	20	67	83	69	26	4	1	30	94	34	9		7	12	43	41	2	39	1	31	64	52	24	5	70	10	1	40	3	9	1
			2	169	12	18	69	88	78	20	2	0	24	93	32	7		3	6	56	46	2	45	0	26	73	53	15	3	78	5	0	38	1	7	1
			X	21	100	0	0	100	100	0	0	0	29	95	24	24		5	10	71	62	0	76	0	5	76	71	19	5	67	10	0	38	0	10	5

(Note) See page 7 for the interpretation of the graphs.

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10. Survey Results in "Production and Machinery"

10.1. Trends in areas of attention

10.1.1. Introduction

Future technologies are already here. That is, some potential future technologies already exist in present-day technologies.

This survey covers a time span of 30 years, which is a generation. It is a long time during which the world could undergo significant changes, but not long enough to see all things that are familiar disappear.

The year 2000 may be described as a watershed which marks the end of an extraordinary millennium. Of the major events of the millennium, the rise of industrial culture is particularly remarkable. It may not be an overstatement to say that the last 1,000 years are best characterized by an exponential progress in science and technology, while it is important to give careful thought to the fact that the 21st century holds a double-edged sword of "a paradise or ruin". So far, we have brought on the following problems by behaving as if we were the master of nature:

1) Depletion of natural resources

2) Environmental changes due to human activities.

Taking this into account, therefore, a new industrial culture must be developed. In this context, we would like to discuss the basis of technological forecasts in the "production and machinery" field.

Since the dawn of history, human beings have been building their societies through the skillful use of tools. The Industrial Revolution introduced "machinery and equipment", which surpassed humans in terms of power and speed, and gave birth to the "production technology" field.

Subsequently, "machinery and equipment" gradually picked up some of the human skills, and displayed "adroitness", a human-like quality, in many applications. People's initial fear about "machinery and equipment" gradually gave way to a sense of awe. However, this soon developed into a kind of "collusion", and humans began to treating nature like a slave, using "machinery and equipment" as an extension of themselves.

If humans continue doing this, half the plant and animal species on earth will be extinct well within 200 years. In fact, if the greenhouse effect is taken into consideration, this could happen within a few tens of years. We have come to the realization that the environmental problems caused by such irresponsible human behavior would greatly undermine both biological diversity and human survivability. This has given rise to the establishment and strengthening of regulatory controls ó consisting of technical standards and guidelines applicable to machines and licensing and certification systems applicable to people.

Meanwhile, technological innovations in recent years have been bringing "machinery and equipment" and "information and communication" together, leading to a new industrial revolution.

While "Production technologies" have so far single-mindedly pursued the "processing" of the earth's natural resources, this represents a gross bias towards "making things" and a negligence about the development of certain element technologies essential for the survival and prosperity of mankind contrary to the raison dÍÎtre of technology.

(1) Learning from nature

As the end of the 20th century draws near, many industries are confronted by environmental problems and are approaching a major turning point. Namely, industries are moving in the direction of reducing/eliminating waste generation, rather than heavily relying on treatment/disposal, as is the case at present. This trend is expected to accelerate in the 21st century, and will one day relieve industry, administrative agencies and even environmental organizations of dealing with waste collection, treatment and disposal ó tasks required at the end of the waste management cycle under current practice and at present strongly emphasized for pollution control reasons. To learn from nature, the concept of industrial ecology must be introduced by drawing an analogy from natural ecosystems.

In future, manufacturers will be required to incorporate waste disposal costs into production costs in industrialized countries and think hard about how to change production systems, products and raw materials to minimize overall costs.

(2) Nature's helping hand

Nobody would deny that human beings are nature's parasites, and it is also true that human productive activities and their growth rely heavily on energy use. We must therefore work hard to fast-forward the development of clean energy technologies, and use them to reduce air pollution caused by the mass consumption of energy, as well as making it an important breakthrough towards the resolution of global environmental problems such as global warming. Sunlight, which is available anywhere on earth, is a typical dispersed energy source, and, because of its low density nature, high efficiency use is essential.

(3) Technology is part of culture

Culture gives birth to different languages and different forms of music and literature. If so, there is no reason why there cannot be different forms of technology for different needs (in terms of areas, cultures and environmental requirements). For example, what about a technology in which human beings and machinery take care of qualitative (i.e. judgmental) and quantitative aspects of tasks, respectively? Such a technology would allow customer-preference, small-batch and flexible-production to be placed at the basis of production activities, as well as saving energy and resources. In fact, this type of system would respect and promote human skills, originality and creativity, society's greatest assets, and can therefore be called an anthropocentric system, a system that revolves around human needs. On this basis, it is necessary to develop a new industrial culture by adequately mobilizing technology and production capacity.

(4) “Four-in-one-type” technologies

Past technologies centered around “making things”. However, now is the time to go back to basics. Namely, in addition to the thing (what), technologies must also focus on the situation (where and when), conditions (why and how) and people (who).

10.1.2. Prediction about relationship between tools, information, energy, environment, living organisms and human beings

(1) Tools (implements and machinery)

From an overall degree of importance index viewpoint, hopes were pinned on the advent of intelligent material systems for the realization of new engineering endeavors, such as “08. Practical use of room temperature superconductors in industrial products” (degree of degree of importance index 88) and “10. Widespread use of high functionality materials and super materials based on atomic and molecular structure control”, (degree of importance index 81). Other topics of note were “05. Development of machine tools with constructions immune to thermal deformation” and “01. Radical change in the theories of designing artificial objects based on microtechnology” in terms of “contribution to socioeconomic development”.

(2) Information (electronics)

Hopes are pinned on flow-on effects of information (electronics) technology. Topics in point include: “18. Practical use of superprecision processing technologies capable of measurement to the angstrom order and femtosecond order”, in terms of overall importance (degree of importance index 81); “24: Technologies for direct machining from design data based on automation of machining process designing” and “26: Widespread use of decentralized manufacturing systems based on internationalization and networking”, in terms of “contribution to socioeconomic development”; “38: Widespread use of virtual reality communication systems that provide people with limited mobility with services that satisfy their everyday needs”, in terms of “response to people’s needs”; and “17: Beginning of impact of silicon microscopic structures control technology production and machinery area”, in terms of “expansion of human intellectual resources”.

(3) Energy

Hopes are pinned on topics including the following: “42: Widespread use of nonfossil energy sources in all areas of life including home, industry and transportation” (degree of importance index 94), and “44: Practical use of technologies that enable the direct storage of electricity” (degree of importance index 90); “45: Widespread use of industrial heat recovery systems based on thermoelectric devices”, “43: Practical use of bioreactor systems in solid waste treatment plants” and “46: Widespread use of automobiles and power engines that use hydrogen as fuel”, in terms of the “resolution of global scale problems”; and “41: Development of a space propulsion technology based on 'distortions in space' created by ultra-strong magnetic field generators”, in terms of “expansion of human intellectual resources”.

(4) Environment

Hopes are pinned on topics such as the following: “50: Widespread use of designing, producing, collecting and recycling systems which make it possible to recycle most used materials” (degree of importance index 92), “51: Widespread use of global environmental conservation measures based on carbon dioxide recovery technology etc. throughout the world” (degree of importance index 87), and “49: Widespread use of low entropy-generating eco-factories, which give due consideration to the impact on ecosystems” (degree of importance index 86) , in terms of overall importance; and “47: Development of a global warming countermeasure technology that involves the ejection of heat energy having accumulated on the earth's surface into outer space”, in terms of “resolution of global scale problems”.

(5) Living organisms

Hopes are pinned on topics such as the following: “55: Practical use of technologies for mass-producing hydrogen from organic substances through utilization of solar energy and biological systems” (degree of importance index 78), in terms of overall importance; and “52: Discovery of new laws, etc. relating to the functions of living organisms, leading to a radical change in the theories of designing artificial objects”, in terms of “expansion of human intellectual resources”.

(6) Human beings

Topics of particular note are “70: Widespread use of earthquake damage alleviation systems for industrial complexes, etc. based on the operation of safety devices in response to initial mild tremors” (degree of importance index 88), in terms of overall importance; “71: Widespread use of science museums capable of fostering scientific skills in children through play”, in terms of “expansion of human intellectual resources”; and “67: Widespread use of production systems that provide comprehensive support for senior citizens and people with disabilities”, in terms of “response to people’s needs”.

(Tadao Kawaguchi)

10.2. Forecast topic framework

In the course of compiling forecast topics, a framework representing the organization of technologies in tabulated matrix form was drawn up for each field, with objectives and technological domains defining the rows and columns of the table, respectively. The framework is designed to present an overall picture of technological development in each field in terms of future prospects, importance, etc. as seen from the present perspective, and is also used as a working framework for future reviews of forecast topics.

Table 10.2-1 Forecast Topic Framework for Production and Machinery Field

<table>
<tr><th>Domain
Relationship</th><th>Common foundation</th><th>Manufacturing systems (production)</th><th>Administration/distribution system (distribution)</th><th>Social/global systems (consumption)</th></tr>
<tr><td>Tools (implements and machinery)</td><td>01 02 03 04 05 06 07</td><td>08 09 10 11 12 13 14 15</td><td></td><td>16</td></tr>
<tr><td>Information (electronics)</td><td>17 18 19</td><td>20 21 22 23 24 25 26</td><td>27 28 29 30 31 32 33 34</td><td>35 36 37 38 39 40</td></tr>
<tr><td>Energy</td><td>41 42 43</td><td>44 45</td><td></td><td>46</td></tr>
<tr><td>Environment</td><td>47</td><td>48 49</td><td></td><td>50 51</td></tr>
<tr><td>Living organisms</td><td>52 53 54 55 56 57 58 59 60</td><td>61 62 63 64</td><td></td><td></td></tr>
<tr><td rowspan="2">Human beings</td><td rowspan="2">65</td><td></td><td>64</td><td rowspan="2">67 68 69 70 71</td></tr>
<tr><td colspan="2">66</td></tr>
</table>

* Topic 64 appears in two cells as two domain-relationship combinations apply to it.

* Figures appearing in the table represent topic numbers.

10.3. Topics with high degree of importance

Degree of importance index scores (Note 1) averaged at 64.5 for topics in the production and machinery field as a whole. Topics considered of particular importance to Japan (top 20 topics in terms of degree of importance index score) are listed in the table below. Notably, up to 9 topics featuring in the top 20 related to the environment and energy.

Table 10.3-1 Top 20 Topics in Terms of Degree of Importance Index

Topic	Degree of importance index	Forecasted realization time (year)
42 Widespread use of non-fossil energy sources (wind, geothermal, solar (photovoltaic/solar thermal) and waste heat) in all areas of life including household, industry and transportation.	94	2018
50 Widespread use of designing, producing, collecting and recycling systems which make it possible to recycle most used materials through legally establishing manufacturers' responsibilities for collection and disposal of disused products.	92	2012
44 Practical use of technologies that enable the direct storage of electricity (superconducting magnets, flywheels and capacitors).	90	2016
08 Practical use of room temperature superconductors in industrial products.	88	2016
70 Widespread use of earthquake damage alleviation systems for industrial complexes, nuclear facilities, etc. based on the early operation of safety devices in response to initial mild tremors.	88	2009

Topic	Degree of importance index	Forecasted realization time (year)
51 Advancements in technological development such as carbon dioxide recovery and detoxification of harmful wastes, leading to the widespread use of global environmental conservation measures throughout the world.	87	2018
49 Widespread use of low entropy-generating eco-factories, which give due consideration to the impact on local ecosystems throughout product life cycles, from manufacture to disposal.	86	2017
18 Practical use of superprecision processing technologies (machining, analysis and testing) through the availability of length, displacement and surface roughness measurement to the angstrom order and time measurement to the femtosecond order, as a result of advancements in beam technology, involving ions, electrons and lasers, and equipment control technology.	81	2009
10 Establishment of atomic and molecular structure control techniques, leading to widespread use of high functionality materials and super materials, designed to operate under extreme conditions.	81	2019
19 Radical changes to the production and machinery area through multimedia technology (interface between the analog world of human perception, characterized by visual and auditory senses, and the digital world of computers and other digitally operated artificial objects).	80	2006
17 Impact of engineering techniques that control silicon microscopic structures (to choose desired atomic and molecular arrangements at will) felt in all aspects of the production and machinery area.	78	2010
55 Practical use of technologies for mass-producing hydrogen by decomposing organic substances through application of solar energy and biological systems.	78	2021
43 Practical use of bioreactor systems in solid waste treatment plants.	77	2014
33 Strengthening of the relationship between consumption and production and advancements in networking between stores and factories, leading to widespread mergers between manufacturers and retailers/wholesalers and between manufacturers and distributors.	73	2007
15 Widespread use of ultrapure refining techniques not only in chemical engineering but also throughout the industry - in resource recovery, support, production efficiency improvements, etc.	73	2014
01 Discovery of a number of new laws, effects and phenomena through microtechniques, leading to a radical change in the theories of designing artificial objects.	73	2011
69 Widespread use of safety measures for industrial complexes, aircraft, tankers, large storage tanks, as suitable for their size and functionality, based on potential danger assessment and accident scenario prediction techniques.	73	2010
67 Widespread use of production systems that provide comprehensive support for senior citizens suffering from functional degeneration (cerebral and physical) and for people with disabilities.	73	2013
06 Widespread use of quick assembly and disassembly techniques which do not use bolt and nut joints.	71	2010
09 Practical use of liquid crystal polymers in electronics and information technology as materials that feature memory, archival and switching functions.	70	2009

Note 1: Degree of importance index = (number of “high” responses × 100 + number of “medium” responses × 50 + number of “low” responses × 25 + number of “unnecessary” responses × 0) ÷ total number of degree of importance responses

10.4. Forecasted realization times

Forecasted realization times were distributed as shown in the diagram below.

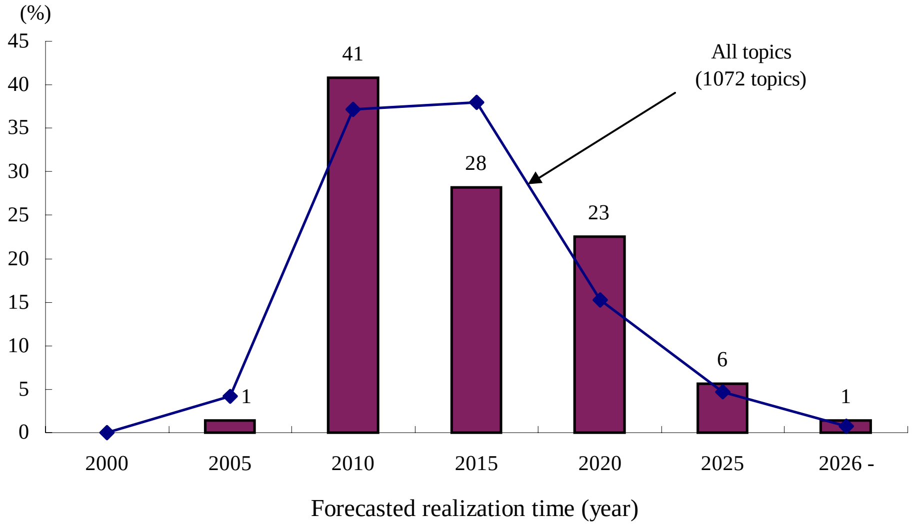
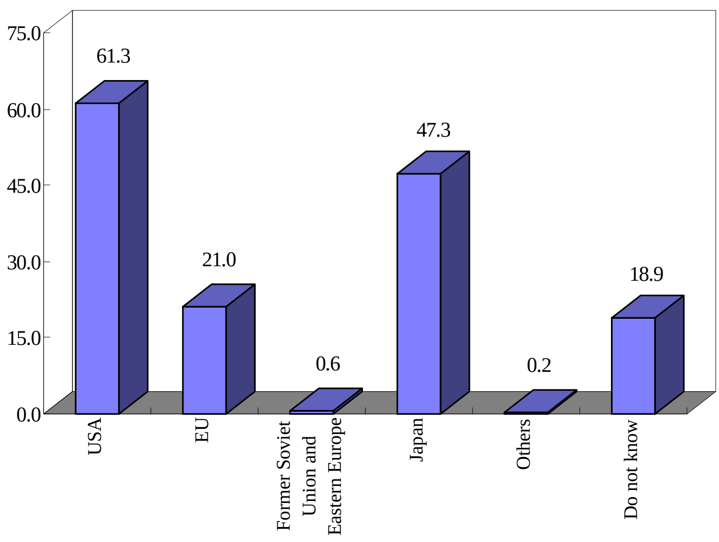


Fig. 10.4-1 Trends in Forecasted Realization Times

The distribution of forecasted realization times in this field peaked in the 2006-2010 period a little earlier than the general trend covering all topics, which saw its forecasted realization time distribution peaking in the 2011-2015 period. However, the distribution from 2016 onward was very similar.

10.5. Current leading countries etc.

Responses to the question concerning current leading countries etc. were as shown in the diagram below. Named by 61.3% of the respondents, the U.S. ranked No. 1 in this field, followed by Japan, which was 14% behind.



10.6. Comparison with the 5th Survey (previous survey)

Of the 71 topics included in the latest survey, 19 (27%) were identical to the previous survey, 13 (18%) were modified, and 39 (55%) were newly introduced. For identical topics, the results of the latest survey were compared with those of the previous survey in terms of degree of importance index scores and forecasted realization times, as shown in the table below.

Degree of importance index scores rose for 7 topics, remained the same for 1 topic and fell for 11 topics. “54: Practical use of technologies for producing glucide by artificial photosynthesis” saw the greatest jump, up 11 points, while “58: Development of high energy converting efficiency machines which apply the biological energy converting mechanism” saw the greatest drop, down 16 points.

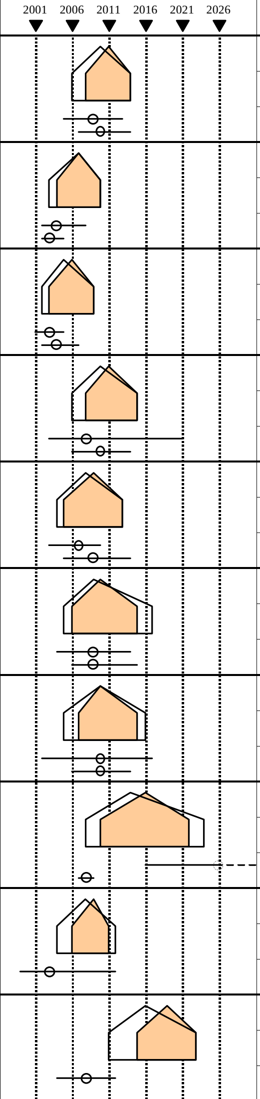
From the 4th to the 5th Survey, forecasted realization times were pushed back for 13 of the 28 identical topics, brought forward for 6 topics and remained the same for 2 topics. In contrast, from the 5th to the 6th Survey, forecasted realization times were pushed back for all topics. “53: Development of technology to synthesize protein from carbon dioxide and ammonia, via a bioreactor” and “55: Practical use of technologies for mass-producing hydrogen from organic substances through application of solar energy and biological systems” saw their forecasted realization time pushed back most (15 years).

Table 10.6-1 Comparison with 5th Survey for Identical Topics

Topic	Importance index / forecasted realization time	
	6th survey	5th survey
02 Widespread use of intelligent materials which respond and adapt to external stimuli by changing their characteristics accordingly leading to the improvement of machine functions (e.g. shape memory alloys, piezoelectric ceramics, magnetostrictive materials, and electroviscous and magneto viscous fluids)	61/2007	52/2000
11 Realization of new material plants utilizing high-vacuum and weightless conditions in space.	52/2017	61/2008
24 Automation of most machining process designing jobs based on artificial intelligence techniques, leading to the widespread use of technologies for directly machining from design data.	66/2010	67/2004
27 Practical use of pocket-size voice actuated interpreting machines that enable people to communicate even if they do not speak each other's language.	64/2012	76/2008
28 Widespread use of automatic translation machines capable of rendering foreign-language documents into Japanese (or vice-versa) in offices.	66/2009	71/2003
37 Widespread use of operatorless systems enabling at-home health examination and diagnosis.	63/2011	52/2006
39 Development of home-use-robots that carry out chores such as vacuuming and clothes washing by learning their owners’ habits.	41/2014	38/2004
45 Widespread use of industrial heat recovery systems based on thermoelectric devices.	70/2016	69/2009
46 Widespread use of automobiles and power engines that use hydrogen as fuel instead of petroleum or alcohol.	68/2017	78/2009
50 Widespread use of designing, producing, collecting and recycling systems which make it possible to recycle most used materials through legally establishing manufacturers' responsibilities for collection and disposal of disused products.	92/2012	92/2004
51 Advancements in technological development such as carbon dioxide recovery and detoxification of harmful wastes, leading to the widespread use of global environmental conservation measures throughout the world.	87/2018	96/2011
53 Development of technology to synthesize protein from carbon dioxide and ammonia, via a bioreactor.	66/2018	73/2003
54 Practical use of technologies for producing glucide by artificial photosynthesis applying the mechanism of natural photosynthesis.	70/2019	59/2005
55 Practical use of technologies for mass-producing hydrogen by decomposing organic substances through application of solar energy and biological systems.	78/2021	74/2006

Topic	Importance index / forecasted realization time	
	6th survey	5th survey
56 Development of flexible actuators resembling human muscles, which can be applied to small, lightweight robots.	53/2013	68/2005
58 Development of high energy converting efficiency machines which apply the biological energy converting mechanism.	60/2021	76/2010
61 Practical use of basic chemical product manufacturing processes that utilize the efficiency of microorganisms living in extreme environmental conditions (e.g. ultra high pressure and high pH).	58/2014	59/2006
68 Practical use of "behavior alarm" systems based on elucidation of physical and psychological mechanisms that cause human error.	62/2014	68/2011
71 Spread of science museums capable of fostering scientific skills of children through play based on the applied use of natural history and science education techniques.	60/2007	53/2001

Note: Up until the 5th Survey, realization meant realization in Japan unless otherwise specified. However, this was changed to mean realization somewhere in the world in the 6th Survey. Therefore, care should be taken when comparing forecasted realization times from the two surveys.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic development	Expected effect: Resolution of global problems	Expected effect: People's needs	Expected effect: Expansion of intellectual resources	Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2026) 	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Tools (implements and machinery)	1	Discovery of a number of new laws, effects and phenomena through microtechniques, leading to a radical change in the theories of designing artificial objects.	1	115	15	34	51	73	52	35	13	0	67	21	33	59		2	11	77	24	1	58	2	15	53	49	35	5	50	3	2	14	13	12	1
			2	90	12	29	59	73	52	38	10	0	69	13	36	62		0	4	78	17	0	54	1	13	59	50	34	1	49	1	0	12	13	13	0
			X	11	100	0	0	91	82	18	0	0	73	36	45	73		0	0	82	45	0	73	9	0	73	64	36	0	55	0	0	9	9	9	0
	2	Widespread use of intelligent materials which respond and adapt to external stimuli by changing their characteristics accordingly leading to the improvement of machine functions (e.g. shape memory alloys, piezoelectric ceramics, magnetostrictive materials, and electroviscous and magneto viscous fluids)	1	129	11	36	53	62	32	51	17	0	81	19	38	12		0	5	64	26	2	59	0	22	41	64	29	6	31	3	1	10	12	4	2
			2	104	9	33	59	61	26	66	8	0	81	15	38	3		0	2	70	16	0	62	0	17	38	72	24	3	35	1	0	10	13	0	1
			X	9	100	0	0	89	78	22	0	0	100	22	33	0		0	0	100	11	0	67	0	0	22	78	33	11	56	0	0	22	11	0	0
	3	Widespread use of hard coatings generated via the complex-shape diamond thin-film production technique in sliding surfaces of bearings, special tools, etc.	1	107	13	37	50	54	22	51	26	1	84	21	9	7		0	5	47	23	8	60	0	19	31	53	32	4	30	3	0	11	7	1	4
			2	90	12	39	49	52	10	78	12	0	90	12	7	1		0	3	48	14	4	76	0	19	27	69	29	1	29	1	1	10	6	0	3
			X	11	100	0	0	55	9	91	0	0	91	0	9	9		0	0	64	27	0	100	0	0	27	82	18	0	45	0	0	9	18	0	9
	4	Development of friction surface control techniques (electrical, contact angle and air resistance) through elucidation of friction generation mechanisms.	1	109	12	42	46	57	25	55	19	1	70	38	10	36		4	10	42	39	2	45	0	33	52	42	36	2	35	1	1	9	4	0	4
			2	86	10	44	45	56	18	70	12	0	81	28	6	30		0	5	48	38	1	50	0	31	64	45	36	0	37	0	0	6	3	0	2
			X	9	100	0	0	72	56	22	22	0	78	44	11	33		0	0	67	56	0	89	0	0	67	11	22	0	56	0	0	11	0	0	0
	5	Development of machine tools with constructions immune to thermal deformation.	1	117	29	28	43	64	37	47	14	2	88	13	9	10		9	11	30	42	2	63	1	20	37	54	24	3	44	1	1	9	4	2	3
			2	98	27	36	38	66	37	53	10	0	95	9	4	5		4	7	28	47	1	69	1	17	38	65	18	1	46	0	0	6	4	1	2
			X	26	100	0	0	82	65	31	4	0	96	19	4	4		4	4	19	50	0	96	4	4	42	69	15	0	58	0	0	12	0	0	8
	6	Widespread use of quick assembly and disassembly techniques which do not use bolt and nut joints.	1	114	18	34	47	66	42	40	16	2	82	22	19	8		9	14	32	23	1	38	0	42	37	48	18	4	27	5	1	11	7	4	4
			2	95	16	33	52	71	46	46	9	0	83	19	12	3		8	6	35	19	0	46	0	40	42	56	12	1	25	3	0	12	8	1	1
			X	15	100	0	0	77	57	36	7	0	67	27	20	7		13	0	40	20	0	53	0	27	40	33	7	0	27	7	0	7	13	7	7
	7	Practical use of metal attachment and metal growth methods in metal processing, replacing current metal removal method.	1	112	25	30	45	63	34	49	16	1	90	31	6	17		4	7	47	27	4	48	0	23	41	54	31	2	35	1	0	13	4	1	3
			2	99	22	36	41	65	32	63	5	0	92	21	4	5		1	4	62	20	2	61	0	14	47	64	27	0	34	1	0	15	4	0	1
			X	22	100	0	0	75	55	36	9	0	95	18	5	9		5	0	64	23	5	77	0	0	68	59	18	0	50	0	0	18	0	0	5
	8	Practical use of room temperature superconductors in industrial products.	1	99	4	16	80	82	67	29	4	0	78	71	10	28		4	12	61	38	5	59	1	23	55	45	30	11	58	2	0	13	7	3	1
			2	88	2	15	83	88	77	22	1	0	82	70	3	19		2	8	67	33	2	69	1	18	59	42	30	2	67	1	0	14	8	0	1
			X	2	100	0	0	100	100	0	0	0	50	100	0	50		0	0	100	50	0	50	0	0	100	0	50	0	100	0	0	0	50	0	0
	9	Practical use of liquid crystal polymers in electronics and information technology as materials that feature memory, archival and switching functions.	1	56	5	23	71	70	47	40	11	2	89	20	21	13		0	2	52	16	0	73	0	11	38	54	25	5	43	0	0	11	11	4	2
			2	54	0	19	81	70	46	43	11	0	91	9	19	2		0	2	57	6	0	80	0	13	37	69	15	0	46	0	0	7	13	2	2
			X	0	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10	Establishment of atomic and molecular structure control techniques, leading to widespread use of high functionality materials and super materials, designed to operate under extreme conditions.	1	87	5	22	74	79	60	35	5	0	80	22	15	49		3	13	68	29	1	52	0	21	55	43	45	6	59	2	0	13	7	1	3
			2	76	0	13	87	81	64	32	4	0	88	7	5	41		1	8	75	17	0	49	0	16	61	39	41	3	64	1	0	16	9	1	1
			X	0	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

(Note) See page 7 for the interpretation of the graphs.

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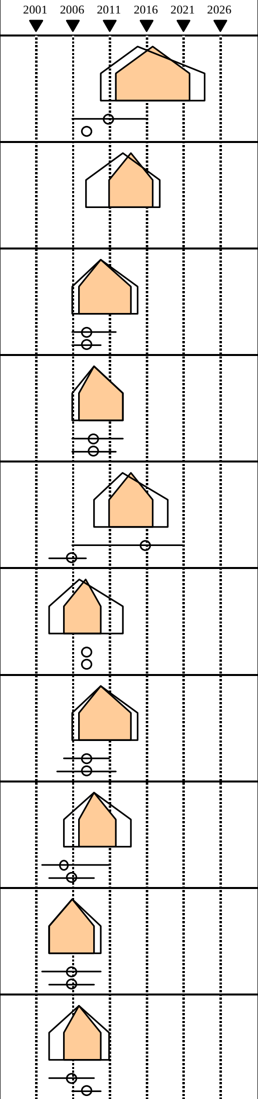
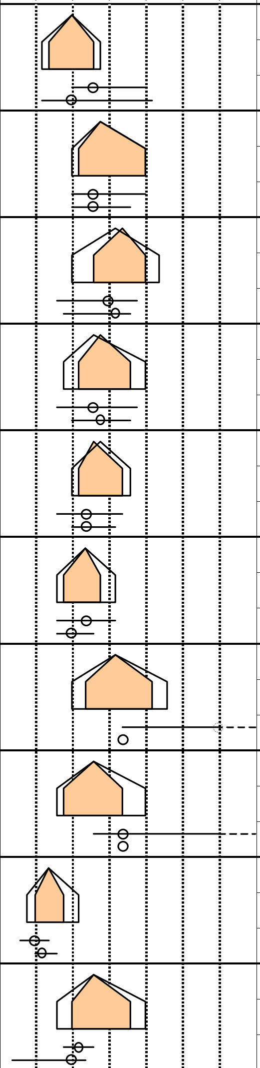
Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic development	Expected effect: Resolution of global problems	Expected effect: People's needs	Expected effect: Expansion of intellectual resources	Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Tools (implements and machinery)	11	Realization of new material plants utilizing high-vacuum and weightless conditions in space.	1	104	4	11	86	58	31	42	24	3	70	30	3	59		8	8	92	18	14	21	0	5	38	22	38	5	60	2	0	18	9	7	3
			2	92	1	13	86	52	18	58	22	2	71	20	2	62		5	9	90	14	9	23	0	7	36	17	39	1	70	1	1	26	8	2	0
			X	1	100	0	0	25	0	0	100	0	100	0	0	100		0	0	100	100	0	100	0	0	100	100	100	0	0	0	0	0	100	0	0
	12	Development of artificial high performance catalysts enabling the manufacture of basic chemical products at near normal temperature and pressure conditions.	1	32	0	28	72	65	37	57	0	7	56	59	3	16		3	6	69	47	3	34	0	19	41	28	28	22	34	3	0	31	6	0	0
			2	26	0	15	85	63	27	73	0	0	69	65	0	0		0	8	73	42	0	19	0	19	46	35	27	8	46	8	0	35	0	0	0
			X	0	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	13	Widespread use of remote maintenance of equipment and facilities with advanced and multiple functions - to be carried out from outside the plant.	1	154	22	31	47	58	26	54	18	2	78	18	42	5		3	8	61	14	0	68	0	17	33	51	19	1	32	17	1	3	32	11	3
			2	131	21	31	49	58	22	65	12	2	82	14	41	2		2	6	63	8	0	69	0	14	34	66	15	1	37	13	1	2	43	10	2
			X	27	100	0	0	68	41	52	4	4	78	22	26	0		11	0	67	4	0	74	0	4	41	63	15	4	37	19	0	0	37	11	7
	14	Development of maintenance robots capable of diagnosing and repairing machinery and equipment previously carried out by humans.	1	161	22	32	46	60	31	48	18	3	74	12	49	4		4	7	57	18	0	73	1	10	37	55	18	2	34	11	1	1	28	14	1
			2	137	22	30	48	62	30	57	12	1	82	7	45	4		3	4	62	13	0	82	0	5	36	72	11	1	38	7	0	0	40	10	1
			X	30	100	0	0	70	50	33	13	3	83	3	37	10		7	0	50	20	0	87	0	0	50	67	7	3	43	10	0	0	43	17	3
	15	Widespread use of ultrapure refining techniques not only in chemical engineering but also throughout the industry - in resource recovery, support, production efficiency improvements, etc.	1	57	7	21	72	71	51	35	12	2	65	79	9	11		0	5	42	56	0	46	0	23	35	42	26	9	46	9	0	39	5	5	0
			2	45	4	16	80	73	51	40	9	0	53	80	7	4		0	0	44	58	0	44	0	22	40	56	11	2	56	9	0	40	0	2	0
			X	2	100	0	0	100	100	0	0	0	100	100	50	0		0	0	50	50	0	50	0	50	0	100	50	0	50	50	0	50	0	0	0
	16	Widespread use of mega-space structures that make all-weather, 24-hour-a-day life-styles possible, including leisure activities.	1	85	1	6	93	34	6	27	56	11	58	7	54	1		4	7	59	5	2	41	0	22	7	19	7	0	8	33	4	25	24	25	1
			2	71	1	6	93	32	3	27	63	7	63	1	62	0		3	4	65	4	1	48	0	18	10	25	3	0	4	51	7	34	21	38	1
			X	1	100	0	0	50	0	100	0	0	0	0	100	0		0	0	100	0	0	0	0	0	0	0	0	0	0	100	0	0	0	100	0
Information (electronics)	17	Impact of engineering techniques that control silicon microscopic structures (to choose desired atomic and molecular arrangements at will) felt in all aspects of the production and machinery area.	1	77	9	26	65	77	58	38	3	1	87	16	10	45		0	5	82	30	0	66	1	6	57	31	35	6	52	1	0	8	3	4	5
			2	67	4	22	73	78	59	38	2	2	87	4	6	52		0	3	93	25	0	63	0	3	75	28	36	0	64	0	1	9	6	1	1
			X	3	100	0	0	83	67	33	0	0	100	0	0	67		0	0	100	33	0	67	0	0	100	33	33	0	100	0	0	0	33	0	0
	18	Practical use of superprecision processing technologies (machining, analysis and testing) through the availability of length, displacement and surface roughness measurement to the angstrom order and time measurement to the femtosecond order, as a result of advancements in beam technology, involving ions, electrons and lasers, and equipment control technology.	1	125	18	29	53	76	56	37	6	1	96	10	10	30		1	2	78	40	1	74	0	8	50	39	44	4	48	2	0	5	6	2	2
			2	104	12	33	56	81	64	33	3	0	96	5	7	25		0	3	86	35	0	76	0	4	59	40	42	1	52	0	0	4	6	1	1
			X	12	100	0	0	96	92	8	0	0	92	17	8	25		0	0	92	58	0	92	0	0	67	17	42	0	75	0	0	0	8	8	0
	19	Radical changes to the production and machinery area through multimedia technology (interface between the analog world of human perception, characterized by visual and auditory senses, and the digital world of computers and other digitally operated artificial objects).	1	154	19	32	48	74	53	39	7	1	90	11	55	16		0	3	90	19	1	47	1	5	45	51	23	5	39	20	1	3	28	27	3
			2	129	17	34	49	80	61	36	3	0	91	5	53	6		0	1	95	16	1	48	1	2	47	61	19	3	36	19	0	1	33	29	1
			X	22	100	0	0	86	73	27	0	0	95	9	55	5		0	0	95	14	0	36	0	0	41	68	14	5	41	36	0	0	36	27	0
	20	Practical use of the operation via keyboardless input devices (voice, gaze and electroencephalogram) of computerized manufacturing systems.	1	153	10	33	58	58	28	49	21	2	73	3	69	7		1	2	78	19	1	51	0	15	41	52	24	3	37	8	1	1	24	18	2
			2	135	7	30	63	57	21	64	14	1	75	1	74	1		1	1	86	10	1	55	0	10	41	63	19	1	39	4	0	0	36	20	1
			X	10	100	0	0	80	70	10	20	0	80	0	60	0		0	0	80	20	0	50	0	10	40	40	0	0	50	0	0	0	30	10	0



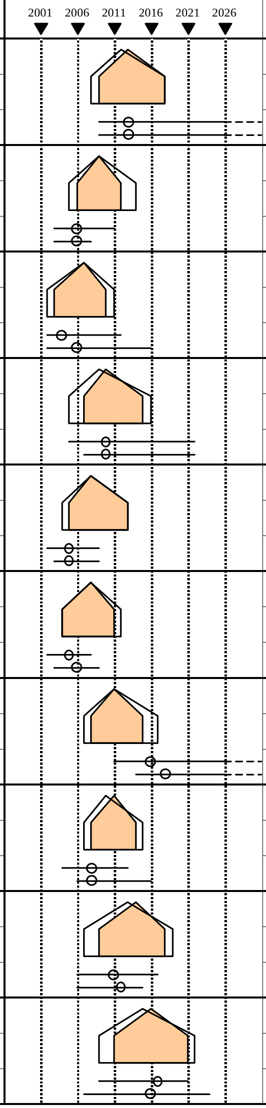
(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time			Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001 2006 2011 2016 2021 2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Information (electronics)	21	Widespread use of systems capable of automatically indexing printed documents in databases and searching for them through advancements in pattern recognition technology.	1	143	6	29	65	62	33	50	16	1	82	3	50	11		1	2	72	13	1	52	1	15	34	46	17	13	24	11	1	0	22	25	2
			2	122	5	27	68	62	29	61	11	0	89	1	61	5		0	2	84	7	0	60	0	7	37	59	11	7	25	9	1	0	19	33	0
			X	6	100	0	0	63	33	50	17	0	83	0	50	17		0	0	67	0	0	67	0	0	33	50	0	17	33	0	0	0	0	0	0
	22	Widespread use of massive systems formed through the networking of machines and devices and evolving structure systems, superior in flexibility, security and maintainability.	1	123	16	33	51	64	38	43	16	3	85	13	31	12		2	4	72	15	0	40	0	13	41	42	23	4	37	14	2	7	27	20	2
			2	102	15	32	53	64	35	53	11	1	90	7	28	8		1	2	78	10	0	42	0	15	50	53	21	1	39	10	1	3	36	20	1
			X	15	100	0	0	78	60	33	7	0	100	13	33	20		0	7	73	20	0	60	0	7	53	53	7	0	40	13	0	7	20	27	7
	23	Establishment of a technology capable of measuring human sensations (e.g. five senses, stress and comfort level) and widespread use of products designed and manufactured based on it.	1	119	15	29	56	64	37	45	16	2	59	3	74	23		7	3	44	25	0	40	3	30	45	41	12	9	35	6	1	1	18	18	3
			2	105	13	28	59	63	32	59	10	0	62	0	83	13		2	4	55	20	0	52	2	25	54	52	10	4	44	3	0	0	19	22	0
			X	14	100	0	0	89	79	21	0	0	50	0	86	29		0	7	50	29	0	57	0	21	57	50	14	7	79	0	0	0	14	21	0
	24	Automation of most machining process designing jobs based on artificial intelligence techniques, leading to the widespread use of technologies for directly machining from design data.	1	162	27	32	41	66	39	47	14	1	89	6	20	10		6	2	65	27	2	69	0	8	44	54	17	7	26	4	2	2	10	12	3
			2	137	25	32	43	66	36	54	9	0	95	1	14	6		4	1	69	23	1	72	0	7	49	66	12	2	28	2	1	1	12	12	1
			X	34	100	0	0	78	59	35	6	0	97	3	18	12		0	3	82	38	0	88	0	0	65	68	21	3	32	3	3	3	12	15	3
	25	Practical use of virtual manufacturing systems that support manufacturing activities, including modeling, designing, production, operation (including maintenance), and waste disposal (e.g. by achieving optimization and efficiency improvements, and making application for approval/permission easier).	1	154	23	32	45	64	37	47	14	2	87	28	26	10		3	6	73	21	1	40	1	12	42	55	17	6	37	16	3	6	13	12	3
			2	127	20	29	50	62	30	60	9	2	91	19	20	5		3	6	83	15	0	40	0	9	45	70	12	3	36	10	2	2	17	13	2
			X	26	100	0	0	80	62	35	4	0	92	23	8	12		4	4	88	19	0	58	0	4	54	77	12	4	46	12	4	0	27	15	4
	26	Widespread use of decentralized manufacturing systems (through functional distribution along the lines of clients, providers and manufacturers) based on internationalization and networking.	1	135	22	25	53	68	43	46	10	2	87	24	17	3		2	7	77	21	1	41	0	11	27	53	12	6	30	28	3	3	16	21	4
			2	111	21	25	54	70	43	53	5	0	93	22	8	1		2	3	85	18	0	46	0	6	24	71	2	2	33	28	2	1	17	26	0
			X	23	100	0	0	89	78	22	0	0	91	26	9	4		0	0	96	30	0	43	0	0	35	83	0	0	35	22	4	0	13	22	0
	27	Practical use of pocket-size voice actuated interpreting machines that enable people to communicate even if they do not speak each other's language.	1	113	2	16	82	65	39	43	17	1	58	12	71	15		3	2	48	12	0	58	1	22	40	35	17	5	36	9	3	1	7	19	3
			2	103	1	17	83	64	34	53	13	0	63	5	81	9		3	1	48	9	0	72	0	16	57	46	8	2	43	5	2	0	5	27	1
			X	1	100	0	0	100	100	0	0	0	0	0	100	0		0	0	0	0	0	100	0	0	100	100	0	0	0	0	0	0	100	0	0
	28	Widespread use of automatic translation machines capable of rendering foreign-language documents into Japanese (or vice-versa) in offices.	1	125	2	16	82	65	39	45	15	1	74	5	46	16		1	2	37	10	1	65	1	17	44	39	14	9	29	5	2	1	4	18	2
			2	110	1	15	84	66	38	52	10	0	83	2	56	6		1	2	30	7	1	85	0	11	57	47	9	4	35	3	0	0	3	22	0
			X	1	100	0	0	100	100	0	0	0	0	0	100	0		0	0	0	0	0	100	0	0	0	100	100	0	100	0	0	0	100	100	0
	29	Widespread use of teleconferencing systems in offices.	1	148	5	24	71	49	17	47	32	3	73	15	39	8		3	1	72	20	1	50	1	11	16	21	14	2	15	28	5	0	22	17	2
			2	123	4	22	74	48	12	58	27	3	82	9	39	4		2	1	79	13	0	52	0	11	14	24	11	1	8	41	6	0	24	18	0
			X	5	100	0	0	70	40	60	0	0	100	20	0	0		0	0	80	0	0	80	0	0	20	0	40	0	20	60	0	0	20	60	0
	30	Widespread use of 100% paperless operation in offices.	1	151	5	23	73	47	18	39	38	6	53	55	14	2		40	5	64	17	1	25	1	17	13	17	9	4	11	26	6	3	21	22	1
			2	129	4	19	77	46	14	43	39	3	53	64	9	0		40	4	78	13	0	26	0	12	11	22	4	2	8	47	4	2	21	24	0
			X	5	100	0	0	65	40	40	20	0	40	80	0	0		60	0	60	20	0	0	0	0	20	0	0	0	20	40	0	0	40	20	0

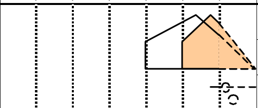
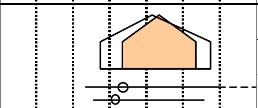
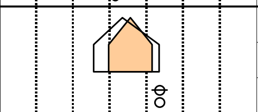
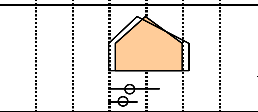
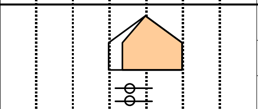
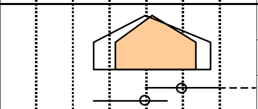
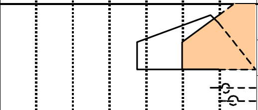
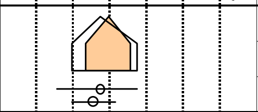
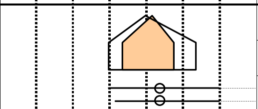
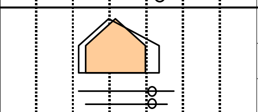


(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time		Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Information (electronics)	31	<u>Widespread use</u> of interactive AI systems that help people create ideas by offering useful triggers and contexts.	1	86	6	26	69	48	19	40	40	2	59	3	27	49	13	6	73	10	1	26	0	16	49	30	12	9	29	2	1	0	15	17	2
			2	77	5	18	77	46	13	46	41	0	60	3	29	42	9	5	83	9	0	23	0	13	64	35	6	3	32	3	1	0	13	22	0
			X	4	100	0	0	63	50	0	50	0	100	0	25	25	25	0	100	50	0	25	0	0	50	25	25	0	0	0	0	0	0	25	0
	32	<u>Practical use</u> of operation via keyboardless input devices (voice, gaze and electroencephalogram) of computerized office/distribution systems.	1	119	5	27	68	52	21	45	34	1	71	4	71	8	3	4	71	12	0	45	1	13	46	34	14	8	29	8	0	1	24	18	2
			2	104	2	26	72	48	11	59	29	1	71	1	81	2	1	5	84	7	0	43	0	11	61	43	9	5	30	4	0	0	32	15	0
			X	2	100	0	0	63	50	0	50	0	100	0	50	0	0	0	50	50	0	50	0	50	50	0	0	0	100	0	0	0	50	50	0
	33	Strengthening of the relationship between consumption and production and advancements in networking between stores and factories, leading to <u>widespread</u> mergers between manufacturers and retailers/wholesalers and between manufacturers and distributors.	1	129	12	26	61	72	46	49	5	0	92	13	40	2	3	2	79	17	1	50	1	11	11	36	9	5	13	50	2	1	19	19	1
			2	107	7	24	68	73	47	52	1	0	94	7	43	1	1	0	85	13	0	54	0	6	8	50	3	2	7	71	0	0	19	22	0
			X	8	100	0	0	81	63	38	0	0	100	25	13	0	0	0	100	0	0	38	0	0	13	50	0	0	13	63	0	0	25	38	0
	34	<u>Practical use</u> of home electronic ordering systems that allow customers to design their own products (e.g. a car to one's taste) on a global scale.	1	120	10	23	67	51	22	40	34	4	77	4	53	3	7	9	68	14	1	34	1	16	13	28	4	5	8	38	3	3	20	18	1
			2	107	7	23	70	47	13	52	31	4	74	0	68	1	5	4	79	6	0	38	0	13	9	36	1	2	5	57	2	2	26	21	0
			X	7	100	0	0	61	29	57	14	0	71	0	57	0	0	0	100	14	0	14	0	0	0	14	0	0	0	43	0	0	71	14	0
	35	<u>Widespread use</u> of telecommuting via multimedia information exchange tools (e.g. e-mail, teleconferencing and WWW) based on the Internet and intranets, except where face-to-face meetings are essential.	1	158	8	23	69	51	21	45	32	3	70	18	72	7	8	6	81	22	1	25	0	9	15	25	10	2	15	42	5	0	27	43	1
			2	134	5	22	72	49	15	53	30	2	72	11	81	3	4	4	87	14	0	21	0	7	15	28	5	1	12	64	2	0	19	49	1
			X	7	100	0	0	68	43	43	14	0	57	0	86	0	0	0	86	14	0	0	0	14	0	14	0	0	29	71	0	0	29	71	0
	36	<u>Spread</u> of network-centered life-styles (via one or more computers per person).	1	160	9	26	65	57	27	47	24	2	79	11	74	11	4	3	88	21	1	30	0	5	16	18	9	8	9	34	4	1	29	34	2
			2	135	6	22	72	54	19	59	20	2	82	1	86	4	5	1	91	16	0	30	0	4	15	24	5	2	7	56	1	0	30	45	0
			X	8	100	0	0	78	63	25	13	0	63	0	100	0	0	0	100	25	0	25	0	0	0	25	0	0	38	50	0	0	38	75	0
	37	<u>Widespread use</u> of operatorless systems enabling at-home health examination and diagnosis.	1	106	5	19	76	62	36	44	18	2	42	3	94	0	6	4	52	17	0	23	3	32	17	32	8	10	28	42	1	0	44	22	2
			2	91	3	13	84	63	33	55	10	2	43	0	96	0	2	3	66	18	0	24	1	23	13	37	4	3	30	59	0	0	49	20	0
			X	3	100	0	0	100	100	0	0	0	33	0	100	0	0	0	67	33	0	0	0	0	0	33	0	0	67	33	0	0	0	33	0
	38	<u>Widespread use</u> of virtual reality communication systems that provide people with limited mobility with services that satisfy their everyday needs (e.g. entertainment, welfare and medical care).	1	107	7	19	75	53	23	46	29	2	43	3	94	2	3	7	63	20	2	26	1	21	26	28	14	6	27	29	2	0	32	28	1
			2	89	4	18	78	49	11	63	22	3	35	0	94	1	1	2	71	13	0	24	1	17	26	42	2	1	28	44	0	0	43	35	0
			X	4	100	0	0	63	25	75	0	0	50	0	100	25	0	0	75	0	0	25	0	0	25	25	0	0	50	50	0	0	0	50	0
	39	<u>Development</u> of home-use-robots that carry out chores such as vacuuming and clothes washing by learning their owners' habits.	1	123	15	24	61	44	15	39	38	8	45	2	89	2	11	5	46	8	1	51	1	21	30	37	9	2	22	9	2	1	19	26	1
			2	101	16	22	62	41	10	42	39	8	43	0	90	1	12	1	50	2	0	70	0	16	39	52	2	0	28	5	1	0	22	29	0
			X	16	100	0	0	69	50	31	13	6	50	0	94	6	6	0	56	6	0	88	0	0	50	50	0	0	38	6	0	0	25	31	0
	40	<u>Practical use</u> of new home electronics products which offer more features than mere information processing and data accumulation (e.g. ultra-small mass spectrograph and prescription drug dispenser (home microfactory)) via the integration of micromachine technology and sensor technology with electronic circuit technology.	1	84	19	19	62	51	24	39	31	6	65	13	74	7	11	6	45	19	0	43	2	29	42	35	20	6	32	13	1	1	26	13	2
			2	76	14	17	68	48	19	41	35	5	67	5	87	3	5	3	50	17	0	57	1	25	55	43	14	1	36	8	1	0	36	14	0
			X	11	100	0	0	70	55	27	9	9	64	9	82	9	9	0	64	36	0	55	9	18	55	27	27	0	64	0	0	0	27	0	0

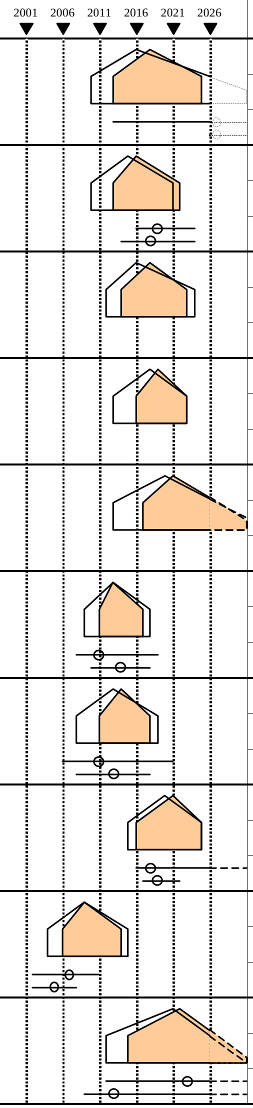


(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic development	Expected effect: Resolution of global problems	Expected effect: People's needs	Expected effect: Expansion of intellectual resources	Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Energy	41	Development of a space propulsion technology based on "distortions in space" created by ultra-strong magnetic field generators (stronger than 1 billion T).	1	27	11	19	70	56	27	46	23	4	56	33	11	59		11	22	52	19	7	26	0	19	26	22	41	4	52	4	0	37	22	7	4
			2	21	5	10	86	55	19	62	19	0	67	19	5	57		19	10	57	14	10	29	0	19	29	5	29	0	62	5	5	52	19	5	5
			X	1	100	0	0	100	100	0	0	0	0	0	0	100		0	0	100	100	0	100	0	0	100	0	100	0	100	0	0	0	0	0	0
	42	Widespread use of non-fossil energy sources (wind, geothermal, solar (photovoltaic/solar thermal) and waste heat) in all areas of life including household, industry and transportation.	1	114	7	19	74	85	75	18	7	0	56	96	18	5		4	11	60	39	3	49	1	17	37	39	18	3	63	23	0	32	5	1	3
			2	93	5	15	80	94	89	8	3	0	57	98	12	1		1	10	71	38	0	48	0	13	32	34	8	0	74	18	0	40	2	0	1
			X	5	100	0	0	90	80	20	0	0	40	100	0	0		0	0	60	40	0	60	0	20	0	20	0	0	80	40	0	40	0	0	0
	43	Practical use of bioreactor systems in solid waste treatment plants	1	56	5	21	73	76	56	41	2	2	36	95	16	0		2	0	34	29	0	48	0	29	29	45	16	13	55	23	0	21	4	4	2
			2	43	2	19	79	77	53	47	0	0	30	95	9	0		2	0	42	30	0	63	0	21	21	56	0	5	77	23	0	30	2	0	0
			X	1	100	0	0	100	100	0	0	0	0	100	0	0		0	0	100	100	0	100	0	0	100	0	0	100	100	0	0	0	0	0	0
	44	Practical use of technologies that enable the direct storage of electricity (superconducting magnets, flywheels and capacitors).	1	105	7	19	74	84	69	28	2	1	52	95	9	4		5	10	52	30	2	41	0	30	43	37	26	2	61	13	0	17	11	1	4
			2	84	8	18	74	90	81	18	1	0	56	94	7	1		5	6	63	26	0	50	0	24	54	33	15	0	71	10	0	24	8	0	0
			X	7	100	0	0	93	86	14	0	0	86	100	0	0		0	14	86	43	0	100	0	0	71	43	29	0	100	14	0	0	0	0	0
	45	Widespread use of industrial heat recovery systems based on thermoelectric devices.	1	68	4	25	71	65	40	41	19	0	32	99	4	3		7	9	32	18	1	35	0	41	35	40	19	1	51	15	0	13	7	0	3
			2	59	5	24	71	70	44	49	7	0	31	98	0	2		2	10	41	14	0	44	0	37	37	49	7	0	66	8	0	14	5	0	0
			X	3	100	0	0	42	0	67	33	0	0	100	0	0		0	0	67	0	0	67	0	0	67	33	0	0	67	0	0	0	33	0	0
	46	Widespread use of automobiles and power engines that use hydrogen as fuel instead of petroleum or alcohol.	1	109	7	21	72	67	42	43	12	3	42	92	7	2		11	13	49	36	4	54	3	23	33	42	17	3	45	24	0	20	20	2	2
			2	93	8	18	74	68	42	49	7	2	46	95	3	0		6	9	54	33	0	70	0	16	38	48	4	0	62	23	1	24	26	1	1
			X	7	100	0	0	93	86	14	0	0	29	100	0	0		0	0	86	71	0	86	0	0	57	57	0	0	71	14	0	29	29	0	0
Environment	47	Development of a global warming countermeasure technology (sky radiator) that involves the ejection of heat energy (radiation wavelengths of 8 - 13 microns) having accumulated on the earth's surface into the outer space.	1	37	8	11	81	60	38	32	24	5	14	92	0	11		16	27	35	14	0	19	0	46	38	22	14	3	46	5	0	30	3	0	0
			2	30	7	10	83	70	45	45	10	0	10	100	0	3		20	13	43	10	0	17	0	43	37	23	0	0	60	10	0	30	7	0	0
			X	2	100	0	0	100	100	0	0	0	0	100	0	0		0	0	100	50	0	50	0	0	100	50	0	0	100	0	0	50	0	0	0
	48	Practical use of a widely-applicable low noise technology, leading to its application in various manufacturing machines.	1	107	14	21	64	56	23	54	22	0	49	36	64	2		4	13	22	23	0	49	0	36	33	36	21	0	33	12	0	11	11	2	2
			2	89	11	21	67	53	16	65	19	0	45	31	73	0		3	4	17	15	0	60	0	31	30	57	12	0	35	8	0	12	10	1	0
			X	10	100	0	0	55	20	60	20	0	30	10	90	0		0	0	30	30	0	100	0	0	50	70	20	0	40	10	0	20	10	0	0
	49	Widespread use of low entropy-generating eco-factories, which give due consideration to the impact on local ecosystems throughout product life cycles, from manufacture to disposal.	1	103	15	16	70	83	69	24	6	0	44	95	17	6		3	12	26	61	0	35	1	21	38	51	18	3	56	24	1	26	3	5	2
			2	90	10	16	74	86	73	26	1	0	34	98	11	1		1	8	26	68	0	42	0	16	38	61	10	0	67	19	1	36	1	2	0
			X	9	100	0	0	100	100	0	0	0	33	100	0	0		0	0	22	89	0	44	0	0	44	44	0	0	67	11	0	22	0	0	0
	50	Widespread use of designing, producing, collecting and recycling systems which make it possible to recycle most used materials through legally establishing manufacturers' responsibilities for collection and disposal of disused products.	1	138	11	21	68	85	70	29	1	0	48	95	17	2		5	8	30	70	1	36	0	12	30	39	14	4	46	45	1	25	3	9	1
			2	111	10	14	76	92	85	15	0	0	40	99	10	1		4	6	20	84	0	33	0	9	28	50	6	1	56	56	0	30	2	5	0
			X	11	100	0	0	86	73	27	0	0	45	100	9	9		0	0	0	100	0	18	0	0	36	64	0	0	55	36	0	27	0	9	0

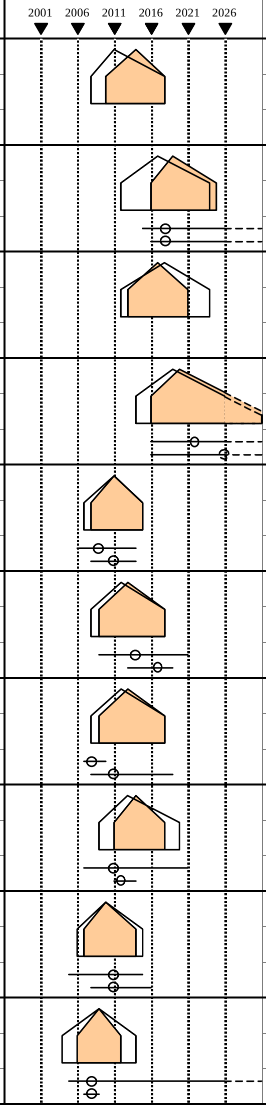
(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time		Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Environment	51	Advancements in technological development such as carbon dioxide recovery and detoxification of harmful wastes, leading to the widespread use of global environmental conservation measures throughout the world.	1	88	9	22	69	84	72	21	6	1	33	98	14	2	7	11	48	55	1	47	1	23	49	33	25	1	58	27	2	18	6	6	2
			2	77	8	22	70	87	75	24	0	1	25	95	8	1	4	14	47	69	0	47	0	17	53	27	14	0	74	21	0	23	4	1	0
			X	6	100	0	0	100	100	0	0	0	33	100	17	0	0	33	83	100	0	83	0	0	67	67	17	0	83	17	0	17	0	0	0
Living organisms	52	Discovery of new laws, effects and phenomena based on the functions of living organisms, leading to a radical change in the theories of designing artificial objects.	1	82	7	27	66	68	44	42	14	0	62	26	18	78	0	22	54	24	4	29	0	29	62	37	15	10	48	5	0	10	6	16	1
			2	67	7	25	67	65	38	47	15	0	66	18	15	79	0	18	58	18	1	30	0	30	75	31	10	4	46	1	1	6	7	16	0
			X	5	100	0	0	90	80	20	0	0	80	40	40	60	0	0	0	20	0	20	0	20	20	20	0	0	40	0	0	0	0	0	0
	53	Development of technology to synthesize protein from carbon dioxide and ammonia, via a bioreactor.	1	26	0	19	81	66	38	50	13	0	31	85	8	35	4	8	42	12	4	15	0	46	38	23	15	15	65	8	0	19	12	4	0
			2	22	0	27	73	66	36	55	9	0	27	86	0	32	5	5	41	9	0	14	0	55	36	18	18	14	73	5	0	23	14	5	0
			X	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	54	Practical use of technologies for producing glucide by artificial photosynthesis applying the mechanism of natural photosynthesis.	1	25	0	20	80	65	36	52	12	0	40	80	16	32	0	8	52	16	8	20	0	40	36	20	20	20	60	8	0	20	4	0	0
			2	21	0	19	81	70	48	38	14	0	33	81	0	33	0	14	43	10	0	19	0	48	48	14	14	19	71	5	0	24	5	0	0
			X	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	55	Practical use of technologies for mass-producing hydrogen by decomposing organic substances through application of solar energy and biological systems.	1	38	0	18	82	72	49	41	11	0	37	95	5	18	3	11	37	26	5	37	0	39	45	21	24	18	63	5	0	11	11	0	3
			2	33	0	15	85	78	58	39	3	0	33	91	0	9	3	12	33	21	0	39	0	45	48	15	18	9	67	0	0	12	9	0	3
			X	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	56	Development of flexible actuators resembling human muscles, which can be applied to small, lightweight robots.	1	101	19	21	60	55	21	54	24	0	74	4	77	14	5	8	61	25	2	60	0	18	48	46	21	6	51	3	0	1	9	10	2
			2	91	20	11	69	53	14	67	19	0	79	2	77	8	1	4	68	22	1	70	0	13	54	49	13	3	57	2	0	3	9	10	1
			X	18	100	0	0	67	39	50	11	0	72	0	83	22	6	0	67	33	0	94	0	0	56	44	6	0	78	6	0	0	6	17	0
	57	Widespread use of computer programs that automatically improve their own functionality through learning - by imitating the functions of living organisms.	1	88	15	24	61	55	20	60	20	0	68	2	45	43	2	11	69	23	0	38	0	18	52	44	14	15	38	3	1	3	7	13	0
			2	77	14	19	66	57	19	69	12	0	73	1	49	32	1	9	78	18	0	42	0	14	68	55	6	1	39	1	1	1	8	17	0
			X	11	100	0	0	73	45	55	0	0	82	0	45	45	0	0	82	36	0	73	0	9	73	55	9	0	64	0	0	0	9	0	0
	58	Development of high energy converting efficiency machines which apply the biological energy converting mechanism.	1	57	9	18	74	64	32	61	7	0	65	56	25	32	4	11	40	16	2	25	0	42	53	28	7	9	53	4	0	7	4	7	2
			2	46	7	17	76	60	21	79	0	0	76	52	24	13	0	11	52	7	0	22	0	41	61	26	0	0	59	2	0	7	9	13	0
			X	3	100	0	0	83	67	33	0	0	67	67	33	33	0	0	67	33	0	0	0	33	33	0	0	0	67	0	0	0	33	0	0
	59	Development of micromachine elements (integration of machine elements, sensors and electronic circuitry) capable of detecting and controlling physical processes and quantities such as motion, light, sound and heat.	1	89	18	18	64	66	40	44	15	1	82	15	61	13	0	3	62	33	0	64	2	19	49	44	28	3	51	3	0	2	11	7	1
			2	76	17	12	71	65	33	59	8	0	80	4	62	5	0	3	67	26	0	68	1	14	66	46	12	0	58	3	0	1	12	9	0
			X	13	100	0	0	85	75	17	8	0	77	15	46	8	0	0	62	54	0	69	8	8	54	46	0	0	62	0	0	8	15	8	0
	60	Development of new evolving structure systems and self-multiplicating and repairing devices via elucidation of biological mechanisms (e.g. homeostatics and homeodynamics including autosynthetic control and in vivo nuclear reaction (reaction by which elements are formed in a living organism)).	1	57	12	25	63	63	33	50	17	0	74	14	25	53	7	12	60	16	2	37	0	32	70	32	11	12	60	2	2	7	11	12	2
			2	47	6	23	70	62	26	70	4	0	83	9	19	45	2	15	68	11	0	30	0	28	79	28	4	2	64	2	0	9	17	17	0
			X	3	100	0	0	67	33	67	0	0	67	0	0	67	0	0	67	67	0	67	0	33	67	33	0	0	100	0	0	0	0	33	0



(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time	Will not be realized (%)	Do not know (%)	Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001 2006 2011 2016 2021 2026			USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Living organisms	61	Practical use of basic chemical product manufacturing processes that utilize the efficiency of microorganisms living in extreme environmental conditions (e.g. ultra high pressure and high pH).	1	21	0	10	90	51	16	58	26	0	43	62	5	24		0	14	38	19	5	24	0	43	38	24	10	24	48	5	0	14	5	10	0
			2	17	0	6	94	58	25	56	19	0	47	53	6	12		0	6	47	24	6	24	0	35	35	18	6	24	65	6	0	24	12	12	0
			X	0	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	62	Widespread use of biomimetics (technology to study and imitate superior functions and mechanisms of living organisms and synthetically create even better systems) throughout industries.	1	61	13	30	57	59	28	53	17	2	74	18	25	51		8	8	51	28	0	36	0	30	61	43	15	7	46	3	0	5	10	18	2
			2	45	9	29	62	59	25	61	14	0	76	11	22	36		7	9	49	16	0	40	0	29	60	40	9	2	49	4	0	4	13	20	0
			X	4	100	0	0	75	50	50	0	0	50	0	50	75		0	0	100	0	0	50	0	0	75	25	0	0	50	0	0	0	0	50	0
	63	Widespread use of biofabrication (technology to produce materials and living organisms that are useful for humans by incorporating living organisms or their building blocks into components for production processes) in various industries.	1	42	2	14	83	58	27	56	12	5	71	40	14	29		7	14	48	33	5	33	0	29	40	24	5	21	33	5	0	19	10	21	2
			2	28	4	14	82	61	26	67	7	0	82	36	14	25		4	25	54	29	0	36	0	29	54	25	4	14	43	4	0	11	7	21	0
			X	1	100	0	0	50	0	100	0	0	100	0	0	0		0	100	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0
	64	Development of techniques to consciously design machines (evolving machines) and manufacturing systems in which the rules of self-organization manufacturing (a manufacturing method that utilizes self-organizing machines and materials) are directly applied.	1	86	16	23	60	55	23	52	23	2	77	3	15	44		9	14	47	16	0	28	1	29	57	30	12	2	52	1	0	5	7	12	2
			2	70	14	23	63	55	17	67	16	0	83	0	13	43		9	14	56	13	0	29	0	31	71	29	10	0	63	1	0	4	14	20	0
			X	10	100	0	0	60	20	80	0	0	80	0	0	80		10	10	70	10	0	20	0	20	80	0	20	0	60	0	0	20	10	10	0
Human beings	65	Widespread use of robots for work in hazardous or extreme conditions, ensuring worker safety, while bringing about changes in employment opportunities and modes.	1	154	19	23	58	66	40	46	13	1	67	16	77	3		1	5	51	22	0	73	0	15	36	51	22	3	45	22	1	3	18	19	2
			2	127	16	24	60	65	37	52	10	2	74	10	76	1		0	4	52	11	0	79	0	13	34	60	13	0	56	17	0	2	21	20	0
			X	20	100	0	0	71	55	30	5	10	70	5	70	5		0	5	50	5	0	95	0	0	45	45	5	0	50	25	0	0	30	30	0
	66	Development of brain support systems that make judgment processes, skills, know-how and experiences of some people accessible to others for reuse or learning purposes.	1	112	12	26	63	60	28	60	12	1	68	1	51	35		4	8	62	24	2	37	0	21	52	39	18	10	43	4	1	3	17	29	1
			2	92	10	25	65	56	17	73	10	0	82	1	48	27		5	7	73	17	0	40	0	13	68	39	8	1	49	2	0	2	14	39	0
			X	9	100	0	0	67	33	67	0	0	78	0	67	33		11	0	78	11	0	67	0	0	67	44	11	0	44	11	0	0	33	67	0
	67	Widespread use of production systems that provide comprehensive support for senior citizens suffering from functional degeneration (cerebral and physical) and for people with disabilities.	1	116	8	23	69	69	45	45	8	3	46	3	91	6		3	4	38	39	1	35	1	27	44	40	14	4	53	16	2	0	23	28	2
			2	91	10	18	73	73	51	43	4	2	48	0	90	4		0	2	45	49	0	38	0	21	45	40	7	0	75	9	2	0	24	30	0
			X	9	100	0	0	78	67	22	0	11	78	0	100	33		0	0	67	33	0	33	0	11	56	22	0	0	89	11	0	0	22	33	0
	68	Practical use of "behavior alarm" systems based on elucidation of physical and psychological mechanisms that cause human error.	1	88	9	26	65	63	35	48	14	2	47	6	81	18		3	5	44	22	1	30	1	33	53	45	13	2	44	8	0	1	27	31	2
			2	78	6	22	72	62	29	64	6	1	47	3	78	8		1	5	50	15	0	32	0	33	63	49	6	0	53	4	0	1	27	35	0
			X	5	100	0	0	65	40	40	20	0	60	0	100	0		0	0	60	40	0	60	0	0	60	20	20	0	100	0	0	0	40	40	0
	69	Widespread use of safety measures for industrial complexes, aircraft, tankers, large storage tanks, as suitable for their size and functionality, based on potential danger assessment and accident scenario prediction techniques.	1	96	11	20	69	71	47	42	11	0	64	30	59	5		0	4	59	34	1	31	0	30	38	51	11	5	44	24	0	6	24	5	2
			2	81	6	17	77	73	50	43	8	0	78	25	59	2		0	4	64	32	0	31	0	28	33	64	7	2	58	20	0	5	31	1	0
			X	5	100	0	0	90	80	20	0	0	80	40	60	20		0	0	100	60	0	40	0	0	0	60	0	0	60	20	0	20	20	0	0
	70	Widespread use of earthquake damage alleviation systems for industrial complexes, nuclear facilities, etc. based on the early operation of safety devices in response to initial mild tremors.	1	94	7	22	70	84	70	28	1	1	40	48	61	4		1	4	40	16	1	70	0	16	33	41	17	5	61	21	0	9	18	5	2
			2	80	3	20	78	88	78	19	3	1	41	49	66	1		1	3	38	10	0	78	0	8	35	49	8	3	75	11	0	4	16	3	0
			X	2	100	0	0	100	100	0	0	0	50	100	50	0		0	0	100	0	0	100	0	0	50	100	0	0	50	50	0	0	0	0	0



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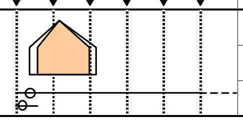
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001 2006 2011 2016 2021 2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Human beings	71	Spread of science museums capable of fostering scientific skills of children through play based on the applied use of natural history and science education techniques.	1	113	4	13	83	60	34	41	23	3	42	8	38	54		0	4	64	35	0	20	0	20	19	22	24	3	44	13	4	1	3	24	1
			2	95	4	13	83	60	34	42	22	2	44	6	48	58		0	1	78	33	0	20	0	13	16	20	25	0	59	12	2	0	1	29	0
			X	4	100	0	0	88	75	25	0	0	0	0	50	100		0	0	100	75	0	25	0	0	25	50	50	0	50	25	0	0	0	25	0

(Note) See page 7 for the interpretation of the graphs.

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11. Survey Results in “Urbanization and Construction”

11.1. Trends in areas of attention

11.1.1. Urbanization and construction technologies at momentous turning point

According to Isaac Asimov, the earliest engineer to be documented in history books is Imhotep, who is said to have designed the Step Pyramid. As this example testifies, architectural and civil engineering are the oldest and most prestigious technological disciplines, and have been constantly advancing over thousands of years, meeting the needs of the time using the latest technologies available in each period.

Recently, however, society's attitudes towards these time-honored disciplines have begun to change quite rapidly. In the past, the development of farmland and residential land through the reclamation of swamps, construction of embankments to prevent rivers from overflowing and the creation of flatlands by cutting into mountains were unconditionally praised as great and important enterprises. However, the recent trend is that various development projects throughout Japan almost invariably meet with protest movements. For example, the Isahaya Bay reclamation project faces passionate public opposition, and there are groups of people who are proposing a ban on the use of the Nagara River Estuary Dam, even after its completion.

On the other hand, there have been frequent incidents of civil work projects failing to achieve their goals despite their seemingly high standards, as examples such as the tunnel cave-in accident in Furubira, Hokkaido, and debris flow in Otari, Nagano, show. Technologies in this field are therefore now due for a drastic review, even in light of the fact that a sizable part of urbanization and construction projects is integrated into regional economic fabrics as government public works projects in Japan.

Based on the above perspective, as well as building on the accumulated know-how from past surveys, the questionnaires for the latest survey were prepared centering on four technological areas. The first area is the provision of greater safety and security. While this is the starting point of urbanization and construction technologies, further efforts are needed to ensure greater safety and security by introducing cutting-edge technologies. Partly due to the frequent occurrence of accidents during the survey period, respondents' interest centered on this area, with many topics given high degree of importance index scores.

The second area is response to environmental and energy problems, of which public awareness is rapidly increasing on a global scale. Recent developments include a change in the approach to river improvement projects from traditional straight-line concrete structures to the realization of meandering rivers that are more in line with the natural environment. Although respondents considered this aspect in their assessment of the topics, they generally did not seem to regard it a pressing issue, judging from the degree of importance index scores and forecasted realization times.

The third area is response to a mature society, an important issue for Japan as a country whose population is rapidly aging. While in the past urban spaces and architectural spaces were basically designed with only healthy and fit persons in mind, there is a need to change the spatial structure of the entire society, taking into consideration the rapid increase in the aged population in the future. Despite this, the perceived importance of the topics relating to this area was generally low.

The fourth area is cost reduction and quality improvement of projects. Due to the fact that technologies in this field are primarily designed to satisfy national or local needs and are therefore tailored to domestic conditions, the industry has been slow in responding to the need for internationalization. As a result, the level of competition in the industry is still inadequate, leading to high project costs compared to overseas projects. In the face of growing international competition, reducing costs while maintaining quality will soon become the essential survival condition for the industry. Nevertheless, a sense of crisis seems to be lacking among those concerned, judging from the fact that topics relating to technologies in this area were greeted with low degree of importance index scores and pushed-back forecasted realization times. As has been explained, this field encompasses the oldest technological disciplines in human history, but global-scale changes in social conditions now require a fundamental shift in its technological philosophy. It is hoped that in future technological development will be undertaken with this understanding in mind.

(Yoshio Tsukio)

11.1.2. Development of safe and secure urban spaces

The Great Hanshin-Awaji Earthquake and Tokyo subway sarin attack have shown that Japanese cities, which were until recently regarded as the safest in the world, could turn into dangerous spaces, and this made the restoration of that sense of safety an extremely important task. In the past, the Japanese approach towards safety centered on “hardware”-oriented preparatory measures with emphasis placed on the prevention/alleviation of disasters and accidents within the limits assumed possible. This approach, however, turned out to be almost useless in coping with disasters/accidents that exceed these limits or are totally unexpected. Against this background, the establishment of a total crisis management structure incorporating a “software”-oriented approach as well, particularly an emergency response system, has become an important task for the National Government, local governments, private companies, etc. For example, regarding earthquake preparedness, seismometer networks are being strengthened throughout Japan, and various organizations are engaged in the development of real-time earthquake preparedness systems, which, in the event of an earthquake, gather magnitude information from these seismometers and instantly carry out an estimation of expected damage, etc. Info-communications and other cutting-edge technologies are being vigorously introduced in the disaster prevention/preparedness area, and technologies such as the Internet, remote sensing, sensor technology and virtual reality are expected to play an ever greater role as component technologies that support the development of safe urban spaces.

In line with such social trends, six out of the seven topics with highest degree of importance index scores in the urbanization and construction field turned out to be from the “ensuring safety” category. Notably, this seems to be more a sign of high expectations for software-oriented disaster prevention/preparedness based on information systems (see topics 03, 04 and 11) than a result of lingering memories of the recent earthquake disaster. “13: Practical use in Japan of a demolition technology for commercial nuclear power plants”, the topic with the highest degree of importance index score in the last survey, was again given the highest degree of importance index score in the latest survey. In terms of purpose-specific importance, “securing safety” was rated relatively high, with the scores of 16 topics classified in this category averaging 68.9.

In terms of future technological forecasts, too, hopes are pinned on topics relating to “safety”, which represents the most basic social needs. Future important tasks in this field include the establishment of disaster risk estimation and preparedness systems for new urban spaces which have never experienced major disasters or accidents, such as super-highrise buildings and deep underground spaces. To create safe spaces, adequate consideration at the planning stage is necessary as a first step. While the importance of making the utmost use of human imagination is obvious, the development of new systems such as virtual-reality simulators that enable disaster education/training based on behavioral psychology through the virtual experience of disasters which have never been experienced will also be necessary. It is believed that a disaster monitoring system which can swiftly detect the outbreak or telltale signs of a disaster and issue a warning through the incorporation of the latest sensor and info-communications technologies should be developed on a priority basis. To put crisis management in place, an aspect said to be lacking throughout Japanese society, the establishment of an integrated crisis management system linked to information networks and databases is strongly desired.

(Fumio Yamazaki)

11.1.3. Establishment of environmental conservation and nature rehabilitation technologies

(1) Environmental conservation

Over the years, socioeconomic activities based on mass production, mass consumption and mass disposal have become entrenched, and problems attributable to population concentration in cities, such as air pollution, water pollution and skyrocketing waste generation, have come to the fore. On the other hand, in depopulated areas, the devastation of forests and farmland is advancing due to a decline in productive activities in these areas, raising concerns about increased risks for disasters and the destruction of the natural environment. These environmental problems are quite different from conventional pollution problems. Namely, instead of being attributed to specific toxic substances and geographically limited in terms of their impacts making the establishment of causal links relatively easy ó they arise from the combined environmental load of daily activities of numerous organizations, such as private companies, and individuals, and affect wide areas, while also having an impact on the soil, air, oceans and other natural resources as mankinds common assets. To solve these problems, it is necessary to change the current socioeconomic systems and people's lifestyles and build a low-environmental-load society which makes sustainable development possible.

Environmental conservation requires answers to these questions: what are the natural ecosystems to be conserved? and what is environmental pollution?. From the viewpoint of coexistence with nature, when undertaking technological development, consideration needs to be given to the expected biological stress caused to each affected species due to the environmental (pollution) load placed on its habitat and cross-species impacts involving all living organisms including animals, plants and microorganisms as well as humans.

In terms of the degree of importance, most topics were rated medium to high. However, with the share of medium actually greater, the perceived importance shown in the survey does not seem to match widespread calls for environmental conservation.

Overall, topics relating to the urban environment are dominant. Regarding the gathering of environmental information and technological development, considerable progress has been made in recent years through both a microscopic approach, involving, for example, a soil microorganism monitoring technology based on genetic engineering techniques, and macroscopic approach involving remote sensing technology based on aircraft and satellites. In future, technological development is expected to make further progress centering on the following topics, accompanying mutual interaction between them: "17: Widespread use of various urban environmental information in urban environmental control in Japan" "23: Development of a technology that detects physiological changes in soil microorganisms and plants to measure the level of environmental pollution" and "25: Widespread use in Japan of development techniques aimed at coexisting with nature". Their forecasted realization times all fell in the 2010~2012 range.

(2) Energy conservation

Energy conservation is one of the most important tasks for Japan as a country with few natural resources, and must be tackled with both a sense of urgency and long-term perspective. Alongside resources conservation technologies, energy conservation technologies, such as the use of natural energy sources, centering on solar energy, waste heat recovery, cogeneration and other multi-stage energy utilization techniques, and the averaging of electric power consumption through heat storage will become a central R&D area for developed countries.

For topics 33~37, which relate to this area, medium was the most common degree of importance rating. Their forecasted realization times ranged as follows: 2008~2011 for 34. Practical use in Japan of a highly efficient heating and cooling system through a combination of solar energy and super heat pumps, 36. Practical use in Japan of a technology to store coldness and waste heat and utilize them for home air conditioning an 37. Practical use in Japan of distributed energy supply systems for houses (practical use of energy conservation technologies); and 2013 for 35. Widespread use in Japan of energy-self-sufficient buildings and houses.

(3) Resource conservation and recycling

As long as people pursue affluent lifestyles, there is mass consumption of resources, and technological advances expedite the sophistication and volume production of goods, leading to increased and more diversified waste generation The following are some of the problems we must all face in the near future: the exhaustion of oil resources, expected to happen within a few tens of years; diminishment of forestry resources, essential for global environmental conservation; shortage of waste landfill disposal sites, expected to reach capacity within several years; and soil pollution by pollutants such as oils/fats and organochlorine compounds, which threaten natural ecosystems. Therefore, identifying them as urgent and top priority issues, the Japanese Government and local governments have been working on the legislative framework for resource conservation, resource recycling, waste treatment/disposal and cleaning up of polluted soils, etc. in recent years, as well as engaging in active technological development.

All four topics relating to resource conservation and recycling except for topic 30 i.e., “29: Spread in Japan of community-based efforts to utilize unused energy sources etc., “31: Widespread use in Japan of technological systems for automatic separation of municipal waste into combustibles, metals, etc.,” and “38: Practical use in Japan of technology that facilitates the recycling of almost all construction byproducts”, were given a greater recognition of importance than other topics, with each receiving a degree of importance index score of around 80. Their forecasted realization times were all 2009. The adjustment of relevant regulations (relaxation/toughening/establishment/abolishment) has been identified as an effective measure the government should adopt in Japan, scoring about 50%, which is far greater than the scores of other topics, and this shows that a strong government legislative inducement is desired. For the realization of the above topics, reliance on regulatory controls is insufficient. Rather, the understanding and cooperation of each individual, as a generator of waste, is essential for resource conservation and recycling, as is the technological development to establish a simple system with a low labor requirement.

(Yoichi Nojiri)

11.1.4. Response to mature society

Japan is rapidly approaching an unprecedented aging society, and public opinion agrees that this has made aged welfare and disabled assistance issues that require urgent attention. At the same time, today’s trends towards diverse and individual lifestyles have led to sophistication in the quality requirements for urban and living environments.

In the urbanization and construction field, technological development has been in progress to satisfy these needs. For example, barrier-free urban facilities and houses have begun to spread in recent years. Houses are a typical example of small-volume multi-line production goods, and efforts are being made to offer customers as much choice as possible through the flexible factory production of building components and flexible partitioning designs.

Future technological development topics include Widespread use in cities of information systems with a human interface which can be used by senior citizens and disabled people with the same ease as normal healthy adults (topic 44), and Widespread use of systems for guiding visually impaired people using magnetic sensors (topic 45). These topics rated very high in terms of the expected response to people’s needs effect, with topics 44 and 45 ranked No. 1 (99%) and No. 3 (98%), respectively, among all topics.

In Japan, strong needs exist for the introduction of nursing robots (topic 46) and other similar areas where a strong objection still exists in Europe and North America because of a perceived conflict with human values.

Notably, in areas such as Environmental design based on techniques tailored to measure human sensitivity and feelings (topic 39), Imaginary experience systems utilizing virtual reality technology (topic 40), and Information systems with a human interface friendly to senior citizens and disabled people(topic 44), respondents commonly thought that Europe and North America, especially the US, were leading countries, rather than Japan.

Ever since the collapse of the bubble economy, the trend towards greater diversification and individualization in people’s social lives has been increasing. Although such a trend theoretically leads to the generation of an infinite number of needs, a question remains as to which technologies can actually make a contribution in this respect, as science and technology that supports such social lives tends to take the form of a comprehensive and integrated system of technologies, e.g. computer-related infrastructure, rather than specific individual technologies. For example, if homeworking through telecommuting or short-distance commuting become a way of life, not only will it give workers much more free time and greatly contribute to their lifestyle changes thus further accelerating the diversification and individualization of social lives but it may also trigger a change in urban structure itself.

Against this background, demands for the development of a research base and upgrading of advanced facilities and equipment, as measures the government should adopt in response to a mature society, are relatively subdued, while calls for an improvement in the basic research environment ó through, for example, the promotion of exchanges among industrial, academic and government sectors and different fields, and an increase in government research funding ó are vocal.

Among all areas, response to a mature society scored the lowest (44.2) in terms of the degree of importance to Japan, more than 20 points below the highest score (68.9), which was given to securing safety.

However, instead of indicating a low perceived importance for topics relating to response to a mature society, the results seem to suggest that respondents thought that the development of advanced technologies had a limited applicability in this area. In other words, this may be interpreted that the upgrading of backward technologies, i.e. an improvement in the overall quality of conventional technologies, was considered to have a higher priority than the development of advanced technologies.

Overall, the United States was considered as the current leading country in the response to mature society area, followed by Japan and the EU, in that order. In contrast to most other areas, where Japan was considered the leading country, its rating was relatively low in this area.

Named by an overwhelming number of respondents, response to people's needs was at the top of the expected effects, followed by contribution to socioeconomic development. Regarding potential problems in Japan, adverse effect on morals, culture or society was considered No. 1 in this area. Notably, only a few respondents chose adverse effect on the natural environment or adverse effect on safety, in contrast to other areas.

In terms of forecasted realization times, there was a relatively small variation between the topics in this area, with most falling in the 2006~2010 range.

(Yukio Nishimura)

11.1.5. Productivity improvement, cost reduction and quality maintenance

Even after the collapse of the bubble economy, Japans construction investment has been kept at high levels, 17-18% of the GDP. Nevertheless, the market environment is undergoing a major change, as a fall in private sector capital investment and the struggling stock market attract attention.

Accounting for 10% of the work force, the construction industry is one of Japans core industries, and, combined with associated industries such as construction material and construction machinery industries, its influence is enormous. Nevertheless, it still has backward aspects, such as low productivity and poor working environments, compared to other industries.

While productivity improvement is an ongoing area of attention, the present focus is on the kind of productivity improvement that leads to cost reduction and quality maintenance, which are highly desired by customers.

Cost reduction is a particular focus of attention due to, among other things, an increasing awareness of price differentials relative to other countries and social costs, while the Great Hanshin-Awaji Earthquake, which struck on January 17, 1995 once more reminded us of the importance of quality maintenance, in light of the fact that structures designed and constructed to the same specifications suffered varied degrees of damage, ranging from collapse to minor damage.

Productivity improvement requires a balanced approach towards hardware and software-oriented technologies, involving not only greater mechanization and an improvement in production efficiency but also an improvement in the production and distribution mechanisms, various deregulation measures, and the like. The utilization of rapidly advancing info-communications technologies also holds great promise.

Although the construction industry has traditionally directed its technological development efforts towards productivity improvement, it still needs to achieve a productivity level comparable to those in other fields by strengthening its technological development structure through cooperation and joint research with other industries in the future.

According to the results of the latest survey, topics in the productivity improvement area recorded mid-range degree of importance index scores (47~58), while those in the quality maintenance area, including 14. Practical use in Japan of rational seismic reinforcement techniques, which was classified into these curing safety category, scored high.

Regarding expected effects, most topics in the productivity improvement area were given high sores in terms of contribution to socioeconomic development, with the level of expectation particularly high for new material development (54) and intelligent robot development (55 and 56).

The forecasted realization times of about 80% of the topics fell in the 2006ñ2015 range. Notably, however, topics relating to new material development and intelligent robot development mentioned above have been moved back substantially (7-10 years) from the last survey, despite the high level of expectation expressed. This seems to suggest that respondents made a more realistic assessment of technological development aimed at productivity improvement this time around.

Regarding promotion measures for technological development relating to productivity improvement including cost reduction and quality maintenance, the promotion of exchanges among industrial, academic and government sectors and different fields (60%) and an increase in government research funding (40%) were ranked high, highlighting the importance of the revitalization of private sector technological development through such measures as cooperation between the industrial and academic sectors and the provision of research subsidies.

(Shoichi Kobayashi)

11.2. Forecast topic framework

In the course of compiling forecast topics, a framework representing the organization of technologies in tabulated matrix form was drawn up for each field, with objectives and technological domains defining the rows and columns of the table, respectively. The framework is designed to present an overall picture of technological development in each field in terms of future prospects, importance, etc. as seen from the present perspective, and is also used as a working framework for future reviews of forecast topics.

Table 11.2-1 Forecast Topic Framework for Urbanization and Construction Field

<table>
<tr><th>Domain
Objective</th><th>City functions (overall hardware/software infrastructure of cities)</th><th>Basic facilities (lifeline facilities etc. of cities in general)</th><th>Civil engineering (individual civil engineering structures)</th><th>Architecture (individual architectural structures)</th></tr>
<tr><td rowspan="2">Ensuring safety</td><td rowspan="2">01 02 03 04 05 06 07 08 09</td><td rowspan="2">10 11</td><td>12</td><td>13 14 15</td></tr>
<tr><td colspan="2">16</td></tr>
<tr><td rowspan="2">Coexistence with nature/environmental conservation</td><td rowspan="2">17 18 19</td><td rowspan="2">20 21 22 23 24</td><td>25 26 27</td><td></td></tr>
<tr><td colspan="2">28</td></tr>
<tr><td rowspan="2">Resource and energy conservation/recycling</td><td rowspan="2">29</td><td rowspan="2">30 31</td><td>32 33</td><td>34 35 36 37</td></tr>
<tr><td colspan="2">38</td></tr>
<tr><td>Response to increasingly diverse and individual lifestyles</td><td>39</td><td></td><td></td><td>40 41 42 43</td></tr>
<tr><td>Promotion of welfare/response to aging society</td><td></td><td>44</td><td>45</td><td>46</td></tr>
<tr><td rowspan="2">Improvement of productivity</td><td rowspan="2">47</td><td rowspan="2"></td><td>48 49 50 51</td><td>52 53 54 55 56 57</td></tr>
<tr><td colspan="2">58</td></tr>
<tr><td rowspan="2">Advanced use of national land and cities</td><td rowspan="2">59 60</td><td rowspan="2">61 62 63 64</td><td>65</td><td></td></tr>
<tr><td colspan="2">66</td></tr>
<tr><td>Effective use of new frontier spaces</td><td>67 68</td><td>69</td><td>70</td><td>71 72 73 74</td></tr>
</table>

* Figures appearing in the table represent topic numbers.

11.3. Topics with high degree of importance

Degree of importance index scores (Note 1) averaged at 56.0 for topics in the urbanization and construction field as a whole. Topics considered of particular importance to Japan (top 20 topics in terms of degree of importance index score) are listed in the table below. As many as 9 safety-related topics featured in the top 20. Rated most important, 13. Practical use in Japan of a demolition technology for decommissioned commercial nuclear power plants was the only topic scoring more than 90 points (92).

Table 11.3-1 Top 20 Topics in Terms of Degree of Importance Index

Topic	Degree of importance index	Forecasted realization time (year)
13 Practical use in Japan of a safe and rational demolition technology for decommission of commercial nuclear power plants.	92	2009
05 Practical use in Japan of a mid-term (5 - 10 years in advance) prediction technique for large-scale (Magnitude 8 or stronger) earthquakes based on analyses of the distribution of strains in the earth's crust and past earthquake records.	87	2017
04 Development of a nationwide network for detecting earthquakes, and widespread use in Japan of a disaster prevention system that gives advance warning of earthquakes at a distance of at least 50km.	86	2011
62 Establishment in Japan of a wide-area integrated water management technique covering rivers, dammed reservoirs, etc., leading to widespread use of efficient water resource utilization systems in major urban zones.	83	2009
03 Development of disaster forecasting and information transfer systems incorporating studies in social and behavioral psychology, in order to prevent panic in big cities in event of major earthquakes or fires.	81	2009
11 Widespread use in Japan of remote monitoring and control systems for enhancing the safety of essential services of utilities. (e.g. water, electricity and gas)	80	2007
01 Widespread use in Japan of warning, forecasting, evacuation assistance and crowd control systems that dramatically reduce human loss in the event of a natural disaster involving rivers, roads, etc. based on localized weather forecasts.	80	2008
20 Widespread use in Japan of active environmental clean-up facilities that absorb and fix air pollutants such as CO_2, NO_x and freons in urban areas, where the majority of emissions occur.	79	2016
31 Widespread use in Japan of technological systems for automatic separation of combustibles, metal, glass, and other substances from city garbage and other general wastes in terms of hardness, specific gravity, moisture, and color, etc.	79	2009
29 Spread of community-based efforts to utilize unused energy sources and recycle household wastes etc. in Japan.	79	2009
38 Practical use in Japan of technology that facilitates the recycling of almost all construction by products such as concrete debris, asphalt waste and surplus soil.	78	2009
14 Practical use in Japan of techniques to assess the soundness of foundations of existing structures and to seismically strengthen existing foundations.	78	2004
64 Realization in Japan of the decentralization of various city functions currently concentrated in large cities through significant advancements in telecommunications and transportation systems.	78	2014

Topic	Degree of importance index	Forecasted realization time (year)
25 Widespread use in Japan of development techniques aimed at coexisting with nature (e.g. conservation of ecosystems and creation of wildlife habitats) through the elucidation of the mechanisms whereby development impacts on ecosystems.	74	2011
06 Practical use in Japan of online data base on natural disasters in Japan necessary for risk management.	71	2009
21 Widespread use in Japan of compact wastewater treatment systems capable of treating persistent substances and harmful materials with high efficiency via biotechnology.	69	2010
16 Practical use in Japan of a technology to effectively control and absorb vibrations in massive structures caused by winds and earthquakes.	64	2004
22 Practical use in Japan of a technology to clean up polluted closed sea areas in the vicinity of major cities by constructing various facilities for seawater purification, replacement, etc.	64	2014
48 Development of a technology capable of measuring locations of active faults and their stress conditions using a vibration generator placed on the ground without relying on blasting tests.	63	2009
30 Widespread use in Japan of community-level nonpotable water supply systems to reuse highly treated wastewater and sewage for landscaping and other miscellaneous purposes in large cities.	62	2009

Note 1: Degree of importance index = (number of “high” responses × 100 + number of “medium” responses × 50 + number of “low” responses × 25 + number of “unnecessary” responses × 0) ÷ total number of degree of importance responses

11.4. Forecasted realization times

Forecasted realization times were distributed as shown in the diagram below.

Compared to the general trend covering all topics, the distribution of forecasted realization times peaked early, but was similar after the peak. While 84% of the topics were forecasted to be realized by 2015, there is a fair degree of unevenness, with realization times for some topics falling in 2026 or later. The earliest realization time was 2004, which was given to the following two topics: “14: Practical use in Japan of techniques to seismically strengthen existing foundations” and “16: Practical use in Japan of a technology to effectively control and absorb vibrations in massive structures.” The latest realization time, on the other hand, was 2026 or later, which was given to “73: Realization of manned laboratories on Mars.”

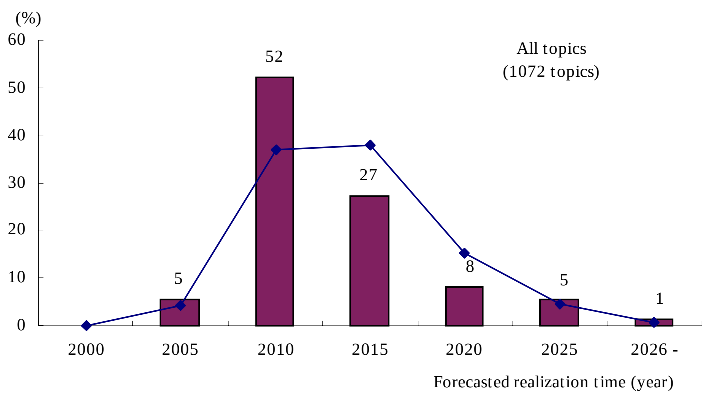


Fig. 11.4-1 Trends in Forecasted Realization Times

11.5. Current leading countries etc.

Responses to the question concerning current leading countries etc. were as shown in the diagram below. Named by almost half of the respondents, Japan ranked No. 1, followed by the U.S. and the EU, with do not know responses outstripping EU responses.

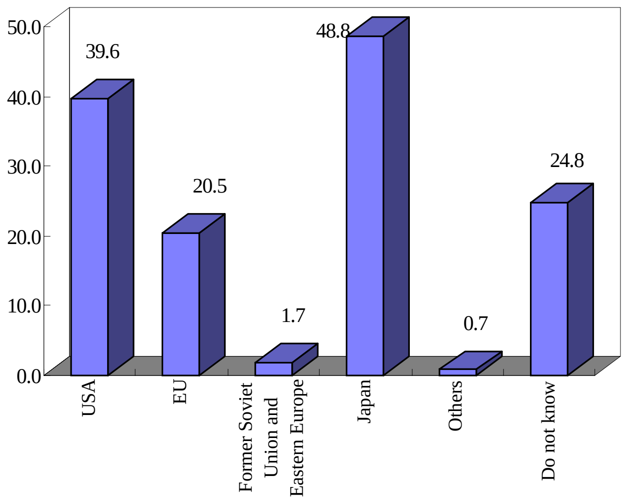


Fig. 11.5-1 Current Leading Countries etc. (%)

11.6. Comparison with the 5th Survey (previous survey)

Of the 73 topics included in the latest survey, 32 (44%) were identical to the previous survey, 16 (22%) were modified, and 25 (34%) were newly introduced. For identical topics, the results of the latest survey were compared with those of the previous survey in terms of degree of importance index scores and forecasted realization times, as shown in the table below.

Degree of importance index scores rose only for 2 topics ("13: Practical use in Japan of a demolition technology for decommissioned commercial nuclear power plants" and "62: Widespread use of efficient water resource utilization systems in major urban zones based on a wide-area integrated water management technique"), remained the same for 1 topic and fell for the remaining 29 topics. Five topics saw their degree of importance index scores plunge by 20 or more points, with "56: Widespread use in Japan of intelligent robots on construction sites experiencing the greatest drop" (26 points).

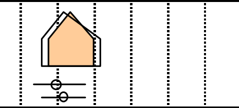
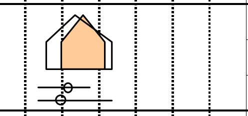
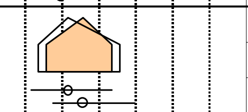
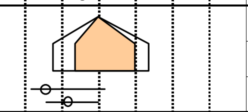
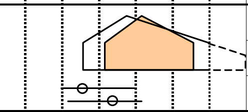
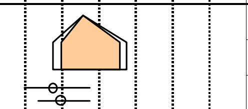
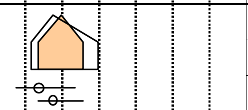
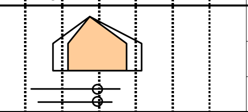
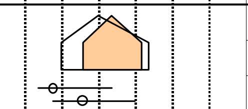
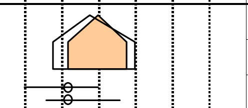
Compared to the 5th Survey, forecasted realization times were pushed back for all topics. The change was smallest for "06: Practical use in Japan of online data base on natural disasters in Japan" and "19: Widespread use in Japan of city planning etc. based on an understanding of the relationship between green resources and human physiology and psychology" (3 years) and greatest for "71: Elucidation of the impact of living in a super high-rise building on human physiology and psychology" (13 years).

Table 11.6-1 Comparison with 5th Survey for Identical Topics

Topic	Degree of importance index / forecasted realization time	
	6th survey	5th survey
03 Development of disaster forecasting and information transfer systems incorporating studies in social and behavioral psychology, in order to prevent panic in big cities in event of major earthquakes or fires.	81/2009	81/2005
04 Development of a nationwide network for detecting earthquakes, and widespread use in Japan of a disaster prevention system that gives advance warning of earthquakes at a distance of at least 50Km.	86/2011	87/2007
06 Practical use in Japan of online data base on natural disasters in Japan necessary for risk management.	71/2009	75/2006
07 Development of fire-fighting and rescuing technologies for fires occuring in high-rise buildings.	59/2006	79/2001
08 Introduction of robots to fire-fighting activities and their widespread use in search and rescue operations in fire events in Japan.	55/2010	67/2003
09 Practical use of emergency response systems to deal with disasters (e.g. fires and earthquakes) occurring in deep underground facilities in Japan.	54/2013	69/2007
10 Widespread use in Japan of continuous-removal and clearing systems of snow to eliminate snow-related disasters involving roads and buildings in snowy regions.	46/2011	58/2002
11 Widespread use in Japan of remote monitoring and control systems for enhancing the safety of essential services of utilities. (e.g. water, electricity and gas)	80/2007	83/2002
13 Practical use in Japan of a safe and rational demolition technology for decommission of commercial nuclear power plants.	92/2009	91/2004
18 Better understanding in Japan of environmental preservation function of trees, grass, and shrubs (in preventing urban “heat stress” and noise), resulting in the practical use of “urban tree and shrubs” which are highly durable and can be easily maintained.	47/2011	65/2004
19 Elucidation of the relationship between green resources, such as forests, and human physiology and psychology, leading to the widespread use of city planning, forest development and landscaping techniques based on it in Japan.	53/2010	66/2007
22 Practical use in Japan of a technology to clean up polluted closed sea areas in the vicinity of major cities by constructing various facilities for seawater purification, replacement, etc.	64/2014	89/2006
31 Widespread use in Japan of technological systems for automatic separation of combustibles, metal, glass, and other substances from city garbage and other general wastes in terms of hardness, specific gravity, moisture, and color, etc.	79/2009	85/2003
34 Practical use in Japan of a highly efficient heating and cooling system through a combination of solar energy and super heat pumps.	60/2008	68/2002
35 Widespread use in Japan of energy-self-sufficient buildings and houses through advancements in natural energy source utilization technologies.	60/2013	68/2008
41 Development of interior finishing materials which possess sensing functions for temperature, humidity, etc., and to adjust indoor environment.	32/2011	49/2002
43 Widespread use in Japan of houses in which rooms and furnishing can be easily altered or converted in step with alternation of generations or shift in life stages.	51/2008	61/2003
46 Widespread use in Japan of houses equipped with robots and other devices that assist senior citizens and disabled people with everyday tasks, including eating meals, bathing, going to the toilet, and having entertainment, to carry these out without human assistance.	56/2014	79/2006
51 Widespread use in Japan of a comprehensive database of design conditions, such as soil characteristics, geology and weather, to be used in planning and designing.	55/2008	73/2002
54 Development of highly durable high-performance bonding agents for steel, enabling substantial rationalization of steel construction.	47/2015	60/2005

Topic	Degree of importance index / forecasted realization time	
	6th survey	5th survey
55 Development of new materials to replace reinforced concrete leading to easier field work.	53/2018	71/2008
56 Widespread use in Japan of intelligent robots on construction sites to reduce construction period and to ensure safety.	53/2011	79/2004
58 Development of construction techniques which incorporate built-in maintenance and demolition functions for buildings and civil structures.	56/2013	67/2004
62 Establishment in Japan of a wide-area integrated water management technique covering rivers, dammed reservoirs, etc., leading to widespread use of efficient water resource utilization systems in major urban zones.	83/2009	80/2002
63 Widespread use in Japan of new joint-use duct systems in cities to contain housing cable for wire broadcasting, vacuum garbage collection pipelines, distribution pipelines, and regional heating and cooling pipes.	55/2013	80/2004
65 Practical use in Japan of technologies for surveying existing embedded objects and ground properties lying deeper than 5 meters from the surface, in response to increasing use of underground space.	48/2009	67/2000
67 Realization of deep underground cities where people can reside.	25/2023	33/2016
68 Realization of marine cities by progress in offshore engineering.	37/2021	52/2009
70 Practical use in Japan of a technology to construct super high-rise buildings (around 1,000 m tall) with living spaces.	27/2020	37/2015
71 Elucidation of the impact of living in a super high-rise building (around 1,000 m tall) on human physiology and psychology.	32/2018	44/2005
72 Realization of facilities in the outer space where people in general can live in long period.(at least one year)	30/2025	32/2019
73 Realization of manned laboratories on Mars.	23/2026 or later	30/2020 or later

Note: Up until the 5th Survey, realization meant realization in Japan unless otherwise specified. However, this was changed to mean realization somewhere in the world in the 6th Survey. Therefore, care should be taken when comparing forecasted realization times from the two surveys.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time			Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001 2006 2011 2016 2021 2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Ensuring safety	1	Widespread use in Japan of warning, forecasting, evacuation assistance and crowd control systems that dramatically reduce human loss in the event of a natural disaster involving rivers, roads, etc. based on localized weather forecasts.	1	188	10	30	60	76	53	44	3	0	21	10	92	4		3	4	39	7	0	50	1	31	45	51	28	10	51	16	5	13	40	5	2
			2	172	8	30	62	80	61	38	1	0	20	5	98	2		1	4	38	3	0	65	0	26	48	59	24	7	64	12	1	11	52	3	1
			X	14	100	0	0	96	93	7	0	0	21	21	100	0		0	0	50	7	0	93	0	0	71	36	50	0	86	0	0	7	57	7	0
	2	Widespread use in Japan of high-speed, high-efficiency seawater desalination and sewage purification systems to cope with urban disasters and droughts.	1	175	8	25	67	60	32	45	22	1	31	61	66	3		5	4	26	22	1	54	5	29	29	49	27	3	56	20	3	41	14	3	4
			2	156	5	27	68	59	27	56	17	0	23	61	75	0		1	3	23	21	1	68	3	21	26	62	22	1	66	15	1	55	8	1	3
			X	8	100	0	0	75	63	13	25	0	50	75	75	0		0	0	50	50	0	75	0	0	50	63	13	0	88	38	0	38	0	0	0
	3	Development of disaster forecasting and information transfer systems incorporating studies in social and behavioral psychology, in order to prevent panic in big cities in event of major earthquakes or fires.	1	187	11	25	64	75	55	37	8	0	22	7	95	6		5	5	57	13	1	34	1	22	55	57	10	11	44	13	2	2	43	27	3
			2	168	7	26	68	81	63	35	2	0	20	3	96	3		4	3	71	8	0	38	1	16	67	69	7	7	56	8	1	2	50	26	2
			X	11	100	0	0	95	91	9	0	0	18	0	91	18		0	0	64	9	0	55	0	9	82	55	9	9	82	0	0	9	55	27	0
	4	Development of a nationwide network for detecting earthquakes, and widespread use in Japan of a disaster prevention system that gives advance warning of earthquakes at a distance of at least 50km.	1	197	11	31	58	79	61	32	6	1	26	5	95	8		14	6	37	8	2	73	3	13	44	40	25	12	63	5	4	3	32	12	5
			2	176	8	30	62	86	74	22	4	0	28	2	95	2		8	5	39	4	1	79	2	9	57	44	19	6	74	2	2	2	44	10	1
			X	14	100	0	0	93	86	14	0	0	29	7	93	0		14	0	50	7	0	93	0	7	64	43	21	14	71	0	7	7	29	7	7
	5	Practical use in Japan of a mid-term (5 - 10 years in advance) prediction technique for large-scale (Magnitude 8 or stronger) earthquakes based on analyses of the distribution of strains in the earth's crust and past earthquake records.	1	182	8	31	61	81	66	27	7	1	28	9	88	18		21	6	35	8	2	70	7	13	58	34	27	14	62	3	2	4	28	20	5
			2	163	5	29	66	87	77	19	4	1	29	4	93	7		22	4	34	4	1	80	1	12	69	29	19	6	71	1	3	2	33	19	2
			X	8	100	0	0	94	88	13	0	0	25	13	88	0		38	0	38	13	0	100	0	0	88	25	13	0	75	0	0	25	38	0	0
	6	Practical use in Japan of online data base on natural disasters in Japan necessary for risk management.	1	185	13	25	62	67	42	44	14	1	40	10	92	3		4	4	56	12	1	32	0	23	30	45	21	38	54	11	2	3	34	15	2
			2	163	10	22	68	71	45	50	5	0	42	2	96	1		3	4	69	7	0	34	0	18	28	50	13	40	64	6	0	1	42	13	0
			X	16	100	0	0	94	88	13	0	0	63	0	100	0		6	0	94	6	0	44	0	0	31	50	13	63	63	0	0	0	31	13	0
	7	Development of fire-fighting and rescuing technologies for fires occuring in high-rise buildings.	1	150	7	27	67	59	27	56	17	1	27	1	95	1		1	3	71	9	0	31	0	18	23	45	25	1	40	37	1	3	38	4	3
			2	137	5	20	74	59	24	64	11	1	28	0	99	0		1	2	82	7	1	33	0	11	17	64	23	1	46	34	1	1	48	1	1
			X	7	100	0	0	68	43	43	14	0	14	0	100	0		0	0	71	14	0	71	0	0	14	86	29	0	29	43	0	0	57	0	0
	8	Introduction of robots to fire-fighting activities and their widespread use in search and rescue operations in fire events in Japan.	1	121	7	14	79	54	22	53	25	1	23	1	97	3		6	3	42	11	0	49	1	29	29	54	28	0	51	15	1	0	35	7	5
			2	115	3	11	85	55	19	63	17	0	20	0	98	1		3	2	50	9	0	63	1	22	23	75	25	0	61	12	0	0	48	3	3
			X	4	100	0	0	75	50	50	0	0	0	0	100	0		0	0	25	0	0	75	0	0	25	75	25	0	50	25	0	0	50	0	0
	9	Practical use of emergency response systems to deal with disasters (e.g. fires and earthquakes) occurring in deep underground facilities in Japan.	1	178	11	26	63	54	22	52	25	1	50	15	79	2		4	6	29	24	4	40	1	28	34	52	20	1	42	32	1	13	28	6	1
			2	157	9	23	68	54	19	58	22	1	54	6	83	1		3	4	25	24	0	50	1	29	33	64	16	1	51	32	0	14	38	3	1
			X	14	100	0	0	75	50	50	0	0	43	21	79	0		0	0	36	50	0	57	14	7	43	71	14	0	86	21	0	21	43	7	0
	10	Widespread use in Japan of continuous-removal and clearing systems of snow to eliminate snow-related disasters involving roads and buildings in snowy regions.	1	138	6	22	72	48	15	47	36	2	44	13	89	1		11	7	6	12	5	38	2	42	26	43	20	1	53	10	2	35	16	8	3
			2	124	4	19	77	46	11	51	37	1	40	6	94	0		7	5	4	9	6	52	2	39	21	54	13	1	72	7	2	53	11	2	1
			X	5	100	0	0	80	60	40	0	0	40	20	100	0		0	0	20	0	20	100	20	0	40	80	40	0	80	0	0	20	60	0	0

(Note) See page 7 for the interpretation of the graphs.

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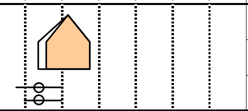
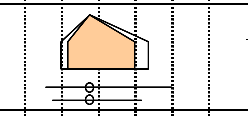
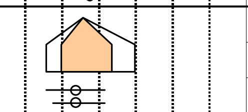
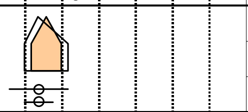
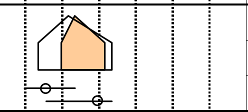
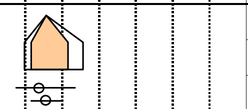
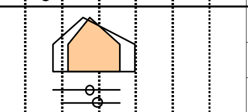
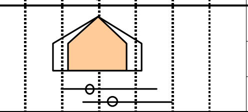
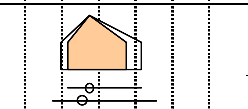
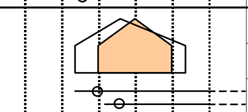
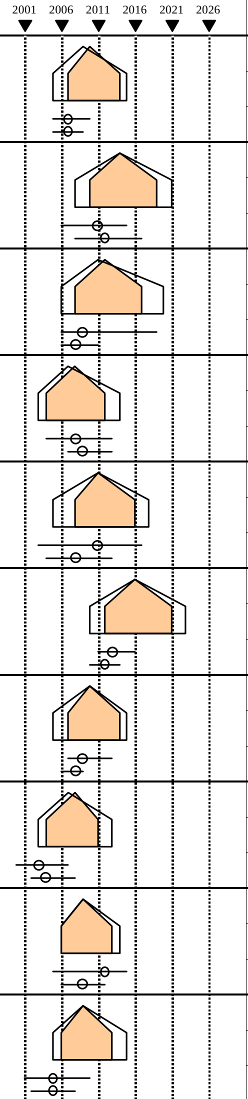
Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic development	Expected effect: Resolution of global problems	Expected effect: People's needs	Expected effect: Expansion of intellectual resources	Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Ensuring safety	11	Widespread use in Japan of remote monitoring and control systems for enhancing the safety of essential services of utilities. (e.g. water, electricity and gas)	1	171	15	29	57	77	58	36	7	0	53	6	94	1		1	1	42	13	1	51	1	26	29	68	14	7	37	31	2	2	37	5	2
			2	158	12	28	60	80	63	32	4	0	53	1	96	0		0	1	48	10	0	62	1	18	23	75	12	4	42	33	1	1	46	5	1
			X	19	100	0	0	87	74	26	0	0	68	0	89	0		0	0	53	16	0	95	0	0	16	79	16	5	53	42	0	0	53	5	0
	12	Widespread use in Japan of systems that detect the danger of rock mass collapse in advance based on the elucidation of its mechanisms and that accordingly assist with appropriate accident prevention measures such as road closure.	1	165	14	30	56	62	32	51	17	0	24	3	95	5		13	8	12	12	1	41	1	44	48	44	15	15	55	16	1	13	25	3	5
			2	152	11	32	58	62	28	64	9	0	22	1	95	3		9	8	8	6	1	48	1	44	54	51	11	7	72	9	1	9	35	2	3
			X	16	100	0	0	72	50	38	13	0	25	0	81	6		19	0	19	31	0	88	0	0	69	56	13	13	88	0	0	6	38	0	0
	13	Practical use in Japan of a safe and rational demolition technology for decommission of commercial nuclear power plants.	1	131	10	31	60	85	71	28	1	0	39	80	53	6		2	5	66	48	3	43	1	14	49	60	21	1	57	24	2	56	40	11	2
			2	124	6	32	61	92	83	17	0	0	32	83	49	2		3	2	78	50	2	46	1	8	44	70	13	0	66	21	1	70	42	4	1
			X	8	100	0	0	100	100	0	0	0	38	75	50	0		13	0	75	63	0	38	0	13	38	88	13	0	63	25	0	50	50	13	0
	14	Practical use in Japan of techniques to assess the soundness of foundations of existing structures and to seismically strengthen existing foundations.	1	213	30	44	26	75	53	41	6	0	46	8	91	2		1	1	29	7	0	81	0	10	44	58	19	4	51	29	2	3	28	5	2
			2	189	26	46	29	78	56	41	3	0	52	4	94	0		1	1	32	4	0	91	1	6	46	68	12	2	58	26	1	2	40	4	1
			X	49	100	0	0	87	73	27	0	0	53	4	94	0		0	2	27	2	0	98	0	0	43	78	18	2	53	24	0	4	29	2	0
	15	Widespread use in Japan of systems that control the safety and efficiency of energy-related building facilities using remote measuring technology.	1	112	9	25	66	48	13	55	31	1	41	55	55	2		1	5	49	16	4	34	0	29	36	57	16	9	33	21	3	11	31	5	2
			2	119	5	17	78	47	8	66	27	0	33	56	62	0		1	3	61	13	1	44	0	25	31	72	8	4	40	17	3	9	39	5	3
			X	6	100	0	0	67	33	67	0	0	50	83	67	0		0	0	83	17	0	50	0	17	33	33	17	0	67	50	0	33	33	33	0
	16	Practical use in Japan of a technology to effectively control and absorb vibrations in massive structures caused by winds and earthquakes.	1	209	29	30	42	68	41	50	9	0	53	9	82	7		1	2	38	7	0	90	1	5	41	56	24	2	45	31	2	5	25	4	4
			2	188	25	28	47	64	32	63	5	0	59	4	88	2		1	1	39	3	0	94	1	4	36	70	14	1	52	22	2	4	35	2	3
			X	47	100	0	0	73	48	50	2	0	62	6	79	4		0	2	49	4	0	98	0	0	36	77	15	2	60	23	2	9	30	2	4
Coexistence with nature/environmental conservation	17	Widespread use of various urban environmental information obtained through monitoring based on remote sensing technology etc. (e.g. levels of pollution and greening) in urban environmental control in Japan.	1	149	8	25	67	57	22	61	16	1	22	74	60	4		3	7	52	34	1	29	0	28	40	46	20	22	45	17	3	23	15	10	2
			2	135	6	22	72	53	13	74	14	0	17	79	64	1		1	4	59	29	1	31	0	24	41	58	13	21	48	11	1	33	9	13	1
			X	8	100	0	0	81	63	38	0	0	50	63	88	0		0	0	88	50	0	63	0	0	50	63	25	38	50	25	0	38	0	13	0
	18	Better understanding in Japan of environmental preservation function of trees, grass, and shrubs (in preventing urban "heat stress" and noise), resulting in the practical use of "urban tree and shrubs" which are highly durable and can be easily maintained.	1	121	8	17	74	46	10	55	31	3	22	62	61	5		2	8	17	24	1	31	0	45	36	45	15	22	35	14	0	55	8	3	2
			2	118	7	14	79	47	10	63	26	2	18	68	69	1		3	7	13	25	1	35	0	46	40	60	5	17	42	8	0	64	3	2	0
			X	8	100	0	0	63	25	75	0	0	75	50	88	0		0	0	63	50	0	75	0	0	38	63	13	25	38	13	0	63	0	0	0
	19	Elucidation of the relationship between green resources, such as forests, and human physiology and psychology, leading to the widespread use of city planning, forest development and landscaping techniques based on it in Japan.	1	127	11	24	65	48	15	52	27	6	18	54	76	12		7	9	23	36	2	22	2	39	45	50	10	12	46	20	2	33	11	13	1
			2	119	6	23	71	53	16	64	18	2	12	65	82	5		4	7	23	43	1	22	1	39	45	62	3	8	50	18	2	48	7	9	0
			X	7	100	0	0	71	43	57	0	0	29	43	86	29		0	0	29	86	0	29	0	0	43	57	0	0	43	57	0	29	14	29	0
	20	Widespread use in Japan of active environmental clean-up facilities that absorb and fix air pollutants such as CO_2, NO_x and freons in urban areas, where the majority of emissions occur.	1	108	6	19	75	74	53	38	5	4	33	83	56	7		7	11	30	32	1	38	0	33	44	53	22	8	58	17	1	40	13	7	3
			2	105	3	15	82	79	61	37	2	1	27	90	55	2		5	7	34	35	1	49	1	27	47	61	16	2	66	13	1	53	10	3	1
			X	3	100	0	0	100	100	0	0	0	67	67	67	0		0	0	67	0	0	67	33	0	0	100	0	0	100	33	0	67	67	0	0

(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Medium	Low	Importance (index, %): Index	High	Medium	Low	Unnecessary	Expected effect (%): Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Forecasted realization time: Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Coexistence with nature/environmental conservation	21	Widespread use in Japan of compact wastewater treatment systems capable of treating persistent substances and harmful materials with high efficiency via biotechnology.	1	119	8	18	74	70	46	46	8	1	41	84	66	8	3	8	40	34	1	45	1	26	39	53	24	24	44	28	2	46	9	8	1
			2	109	6	12	82	69	39	59	2	0	39	83	73	4	1	6	38	30	1	53	0	28	44	60	20	18	49	25	1	55	7	6	1
			X	7	100	0	0	100	100	0	0	0	43	86	86	0	0	0	57	14	0	71	0	0	29	57	14	0	57	71	0	29	0	0	0
	22	Practical use in Japan of a technology to clean up polluted closed sea areas in the vicinity of major cities by constructing various facilities for seawater purification, replacement, etc.	1	121	10	25	65	64	38	47	13	3	31	80	48	4	11	6	27	28	0	38	0	39	47	48	25	10	58	15	2	53	7	5	2
			2	112	10	18	72	64	34	55	11	0	23	87	52	1	7	4	23	24	0	45	0	36	43	50	19	8	71	9	1	61	1	4	1
			X	11	100	0	0	75	55	36	9	0	27	100	36	0	9	0	36	45	0	82	0	9	36	64	0	27	73	36	0	45	0	9	0
	23	Development of a technology that detects physiological changes in soil microorganisms and plants to measure the level of environmental pollution.	1	79	6	15	78	54	21	56	22	1	24	70	48	19	1	13	39	25	0	29	0	42	58	39	24	27	41	6	0	39	8	3	0
			2	77	5	9	86	55	18	66	16	0	19	86	47	9	0	6	43	25	0	27	0	39	68	35	18	19	49	3	0	44	4	3	0
			X	4	100	0	0	100	100	0	0	0	25	75	50	0	0	0	75	50	0	75	0	0	25	0	0	50	50	25	0	25	25	0	0
	24	Practical use in Japan of a technology designed to remove nitrogen and phosphorus from closed water areas such as lakes and reservoirs to prevent the outbreak of water blooms and other abnormal algae growth.	1	116	11	20	69	59	29	52	18	1	22	76	53	5	3	4	19	29	0	45	1	33	36	53	21	17	54	16	2	44	3	3	1
			2	107	7	21	73	60	26	63	11	0	16	81	57	1	3	3	14	33	0	61	0	28	34	62	13	8	65	9	1	52	2	3	0
			X	7	100	0	0	75	57	29	14	0	43	71	86	0	14	0	43	57	0	100	0	0	29	29	14	14	86	29	0	57	14	0	0
	25	Widespread use in Japan of development techniques aimed at coexisting with nature (e.g. conservation of ecosystems and creation of wildlife habitats) through the elucidation of the mechanisms whereby development impacts on ecosystems.	1	129	19	24	57	72	48	44	6	2	36	78	53	18	4	10	28	56	1	24	2	21	53	52	14	19	43	23	2	38	5	12	2
			2	122	13	18	69	74	51	45	3	1	23	89	50	11	2	7	25	62	0	28	0	20	60	60	7	11	48	20	1	49	2	8	2
			X	16	100	0	0	90	80	20	0	0	44	88	63	6	0	0	25	69	0	44	0	0	69	63	13	13	44	31	0	38	6	19	0
	26	Widespread use in the world of desert greening technology to control the desertification.	1	135	4	11	84	47	20	33	40	7	37	93	17	9	7	10	33	16	1	24	5	43	51	45	13	14	47	2	1	44	4	6	4
			2	124	3	6	91	45	16	36	42	6	28	99	11	2	6	6	35	10	2	27	6	46	65	49	6	6	56	2	2	56	2	6	1
			X	4	100	0	0	56	25	50	25	0	0	100	0	0	25	0	50	0	0	50	0	25	75	50	0	25	75	0	0	50	0	0	0
	27	Widespread use in Japan of road noise barriers capable of reducing noise effectively by active noise control technology.	1	136	7	27	66	52	19	51	29	2	29	15	91	4	9	9	21	17	0	48	1	35	35	45	29	1	42	17	2	20	20	4	2
			2	129	4	26	70	51	16	57	27	0	23	9	95	2	6	5	22	14	0	63	0	28	33	57	16	1	53	11	2	27	24	4	2
			X	5	100	0	0	80	60	40	0	0	40	40	80	0	0	0	20	40	0	100	0	0	60	80	0	0	40	20	0	20	40	0	0
	28	Widespread use in Japan of a technology that dramatically increases the earthquake-safety of historic buildings.	1	189	19	32	49	52	20	49	30	1	28	5	53	20	1	5	32	13	1	66	2	18	42	38	14	4	54	24	4	3	14	25	2
			2	170	17	31	52	51	14	64	22	0	25	3	61	25	0	1	35	9	0	81	1	11	46	40	5	1	66	22	3	1	13	36	1
			X	29	100	0	0	66	34	62	3	0	31	7	76	17	0	0	62	10	0	79	0	3	31	38	3	0	59	38	0	7	7	24	3
Resource and energy conservation/recycling	29	Spread of community-based efforts to utilize unused energy sources and recycle household wastes etc. in Japan.	1	167	10	31	59	73	51	40	8	1	38	85	51	3	0	3	18	53	1	31	1	23	31	55	13	4	51	47	3	28	13	21	2
			2	153	8	29	63	79	59	39	2	1	32	90	57	0	1	1	14	63	0	36	1	21	28	69	7	1	59	46	4	44	8	16	1
			X	12	100	0	0	92	83	17	0	0	42	92	83	0	0	0	42	92	0	42	8	0	33	92	0	0	75	42	17	42	8	25	8
	30	Widespread use in Japan of community-level nonpotable water supply systems to reuse highly treated wastewater and sewage for landscaping and other miscellaneous purposes in large cities.	1	160	12	29	59	63	35	47	17	1	29	69	63	3	3	4	18	39	3	36	1	27	24	49	16	3	47	46	5	25	11	13	1
			2	143	9	27	64	62	29	62	9	0	21	80	69	0	0	1	13	50	1	50	1	25	20	63	10	1	57	49	2	38	6	10	0
			X	13	100	0	0	85	69	31	0	0	38	85	77	0	0	0	15	62	0	77	0	8	15	77	15	8	62	54	0	15	15	15	0



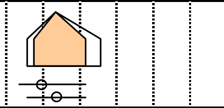
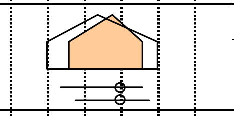
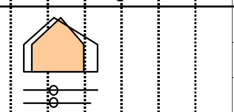
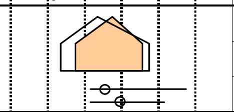
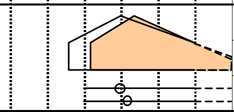
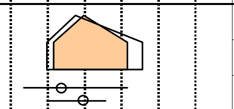
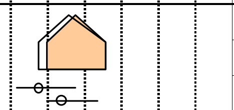
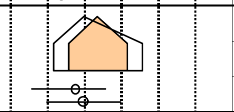
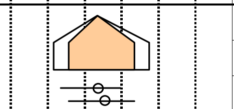
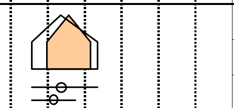
(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance (index, %): High	Importance (index, %): Medium	Importance (index, %): Low	Importance (index, %): Unnecessary	Expected effect (%): Socioeconomic development	Expected effect (%): Resolution of global problems	Expected effect (%): People's needs	Expected effect (%): Expansion of intellectual resources	Forecasted realization time: Will not be realized (%)	Forecasted realization time: Do not know (%)	Leading countries (%): USA	Leading countries (%): EU	Leading countries (%): Former Soviet Union and Eastern Europe	Leading countries (%): Japan	Leading countries (%): Other countries	Leading countries (%): Do not know	Measures the government should adopt (%): Foster human resources	Measures the government should adopt (%): Promote exchanges among industrial, academic and government sectors and different fields	Measures the government should adopt (%): Upgrade advanced facilities and equipment	Measures the government should adopt (%): Develop a research base	Measures the government should adopt (%): Increase government research funding	Measures the government should adopt (%): Adjust regulations (relax/toughen)	Measures the government should adopt (%): Others	Potential problems (%): Adverse effect on the natural environment	Potential problems (%): Adverse effect on safety	Potential problems (%): Adverse effect on morals, culture or society	Potential problems (%): Other adverse effects
Resource and energy conservation/recycling	31	Widespread use in Japan of technological systems for automatic separation of combustibles, metal, glass, and other substances from city garbage and other general wastes in terms of hardness, specific gravity, moisture, and color, etc.	1	124	3	25	72	74	53	38	9	1	40	83	42	3	4	5	15	41	0	43	1	31	23	54	15	2	52	34	2	26	9	15	2
			2	118	1	20	79	79	60	38	3	0	35	91	43	2	3	3	10	52	0	54	1	22	19	66	8	0	66	34	2	37	3	14	3
			X	1	100	0	0	25	0	0	100	0	0	100	0	0	100	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0
	32	Widespread use in Japan of "snow dam" technology to store snow and use it as cold heat source.	1	88	8	26	66	39	8	43	40	9	34	70	30	6	17	14	6	22	9	30	1	45	41	42	17	1	52	15	2	57	8	2	1
			2	87	5	22	74	37	2	44	50	3	31	78	25	1	10	6	3	30	7	45	1	38	38	52	13	0	64	6	1	71	3	2	1
			X	4	100	0	0	31	0	50	25	25	50	25	25	0	50	0	0	50	25	50	0	25	25	50	0	0	50	0	0	25	0	0	0
	33	Widespread use in Japan of economical and stable photovoltaic power generation systems designed for road and tunnel lighting.	1	142	6	22	73	49	19	42	35	4	36	77	25	4	6	3	36	18	0	43	1	37	24	53	17	3	51	26	1	23	13	6	4
			2	136	2	18	79	46	10	54	36	0	29	85	25	2	3	2	36	15	0	53	1	32	25	63	13	1	58	19	1	35	10	1	2
			X	3	100	0	0	67	33	67	0	0	0	67	33	0	0	0	67	33	0	33	0	0	33	67	0	0	67	0	0	33	0	0	0
	34	Practical use in Japan of a highly efficient heating and cooling system through a combination of solar energy and super heat pumps.	1	121	8	23	69	61	33	44	21	1	43	87	33	2	1	2	32	20	1	48	2	32	32	62	17	3	52	23	2	32	12	3	2
			2	119	8	17	76	60	26	62	12	0	39	91	30	1	0	0	32	20	1	61	1	24	25	71	10	2	62	18	0	41	8	2	2
			X	9	100	0	0	78	56	44	0	0	44	78	33	0	0	0	78	44	0	67	0	0	44	78	22	0	67	33	0	44	22	0	0
	35	Widespread use in Japan of energy-self-sufficient buildings and houses through advancements in natural energy source utilization technologies.	1	163	12	21	66	61	34	42	23	1	36	91	40	4	9	7	30	40	0	31	1	32	33	56	23	4	46	34	4	28	10	10	2
			2	153	10	18	72	60	27	57	15	1	27	91	41	0	3	4	32	57	0	31	1	25	25	70	14	3	54	32	2	38	7	7	2
			X	16	100	0	0	81	63	38	0	0	31	94	44	0	0	0	50	81	0	44	6	6	25	63	19	13	63	44	0	44	0	13	6
	36	Practical use in Japan of a technology to store coldness and to waste heat and utilize them for home air conditioning.	1	143	10	23	67	55	21	58	21	1	34	88	41	1	3	7	24	29	1	36	1	38	28	54	24	3	41	30	1	24	10	7	1
			2	135	8	19	73	53	13	72	15	0	24	92	36	0	2	3	25	35	0	50	0	30	23	67	14	2	47	28	0	33	7	4	2
			X	11	100	0	0	61	27	64	9	0	55	82	36	0	9	0	45	64	0	64	0	9	0	73	18	9	82	45	0	36	0	0	0
	37	Practical use in Japan of distributed energy supply systems for houses utilizing fuel cells, cogeneration, etc..	1	135	9	28	63	53	18	57	24	1	37	85	39	1	2	4	43	27	1	45	1	26	27	55	23	3	44	33	2	21	13	9	1
			2	126	9	23	68	54	17	66	17	0	30	90	36	0	1	4	48	24	0	58	1	21	21	75	13	2	52	30	1	35	9	4	2
			X	11	100	0	0	70	45	45	9	0	36	91	45	0	0	0	82	45	0	55	0	9	9	82	18	9	64	82	0	36	0	9	0
	38	Practical use in Japan of technology that facilitates the recycling of almost all construction by products such as concrete debris, asphalt waste and surplus soil.	1	194	23	38	39	70	46	44	9	1	48	88	23	2	12	7	12	27	1	53	0	24	31	59	16	3	53	45	4	33	5	8	1
			2	177	20	41	39	78	57	41	2	0	44	95	18	1	3	3	10	31	0	72	0	17	21	73	8	2	60	47	1	45	6	5	1
			X	36	100	0	0	83	66	34	0	0	33	100	14	0	3	0	8	42	0	92	0	6	17	78	3	0	58	58	3	50	3	0	0
Response to increasingly diverse and individual lifestyles	39	Practical use of environmental design based on techniques tailored to measure human sensitivity and feelings towards the environment in Japan.	1	117	12	21	67	44	11	47	36	5	16	22	70	20	11	11	33	24	0	31	0	36	52	48	17	8	25	11	2	13	12	26	1
			2	106	9	16	75	42	5	55	40	1	9	14	84	17	8	8	42	24	0	33	0	36	61	60	11	4	25	6	1	12	8	39	2
			X	10	100	0	0	58	30	40	30	0	0	10	80	30	10	0	70	30	0	20	0	20	50	40	10	0	40	0	0	0	10	70	0
	40	Widespread use in Japan of devices in ordinary households that enable people to enjoy imaginary experiences of trips, sporting events, etc. utilizing virtual reality technology.	1	101	4	18	78	25	3	14	60	22	31	3	65	18	8	12	73	11	0	44	0	14	24	45	24	4	10	14	5	1	13	58	3
			2	107	3	12	85	24	1	12	66	21	24	2	79	16	8	7	78	7	0	44	0	11	25	56	23	1	6	10	3	1	8	65	3
			X	3	100	0	0	42	0	67	33	0	0	0	100	0	0	0	33	33	0	100	0	0	67	100	33	0	0	0	0	0	0	100	0

(Note) See page 7 for the interpretation of the graphs.

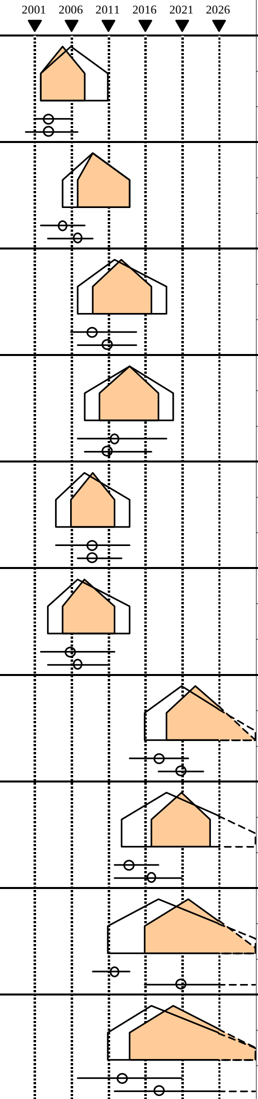
Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time			Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001 2006 2011 2016 2021 2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Response to increasingly diverse and individual lifestyles	41	Development of interior finishing materials which possess sensing functions for temperature, humidity, etc., and to adjust indoor environment.	1	117	15	19	67	35	5	33	55	7	36	23	85	7		3	13	21	13	0	36	2	47	32	50	19	4	23	21	3	8	20	9	3
			2	111	10	20	70	32	3	26	65	5	25	12	89	4		2	10	19	10	1	36	0	50	30	69	12	0	19	16	0	8	33	7	1
			X	11	100	0	0	48	9	73	9	9	36	9	73	18		0	9	45	18	0	55	0	36	55	55	18	0	18	18	0	9	36	9	0
	42	Practical use in Japan of an indoor environment control technology to prevent the outbreak and propagation of household mites and molds.	1	101	13	18	69	46	13	49	34	4	14	7	93	8		3	11	18	18	1	40	0	43	34	52	11	15	26	14	1	16	21	12	4
			2	97	6	19	75	44	9	51	38	2	9	4	98	3		1	6	13	12	1	53	1	36	33	69	4	8	27	9	1	13	33	7	3
			X	6	100	0	0	67	33	67	0	0	33	0	100	0		0	0	50	33	0	67	0	33	33	83	0	0	50	33	0	0	50	17	0
	43	Widespread use in Japan of houses in which rooms and furnishing can be easily altered or converted in step with alternation of generations or shift in life stages.	1	154	18	30	52	50	17	50	32	1	31	19	88	1		6	5	18	19	1	45	1	34	23	49	9	3	29	47	2	4	18	18	3
			2	135	15	29	56	51	15	58	27	0	25	12	96	1		5	2	17	17	0	53	0	35	17	62	5	1	28	55	1	3	23	23	1
			X	20	100	0	0	73	50	40	10	0	40	30	90	0		5	0	20	20	0	70	0	15	20	70	5	0	65	40	5	10	20	30	0
Promotion of welfare/response to aging society	44	Widespread use at Japanese urban public facilities of information systems with a human interface, which can be used by senior citizens and disabled people with the same ease as normal healthy adults.	1	126	3	26	71	60	27	58	13	2	29	0	98	9		2	4	53	48	0	15	1	17	31	45	19	7	50	29	3	0	25	26	1
			2	115	2	19	79	58	19	74	7	0	21	0	98	4		0	3	63	56	0	11	1	15	27	64	11	5	63	21	2	0	31	32	1
			X	2	100	0	0	100	100	0	0	0	50	0	100	0		0	0	100	50	0	100	0	0	0	100	0	0	100	0	0	0	0	0	0
	45	Widespread use in Japan of systems for guiding visually impaired people on footpaths using magnetic sensors.	1	102	2	22	76	49	15	53	30	2	19	0	97	6		2	9	28	35	0	33	0	32	29	46	18	0	53	27	5	1	34	21	3
			2	101	1	14	85	47	7	67	26	0	11	0	99	4		0	5	32	39	0	33	0	31	28	56	10	0	61	24	3	1	47	20	2
			X	1	100	0	0	100	100	0	0	0	0	0	100	0		0	0	100	100	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0
	46	Widespread use in Japan of houses equipped with robots and other devices that assist senior citizens and disabled people with everyday tasks, including eating meals, bathing, going to the toilet, and having entertainment, to carry these out without human assistance.	1	116	3	16	80	54	21	55	21	3	30	0	96	3		6	7	33	36	1	29	1	29	27	51	17	3	57	22	5	0	31	31	1
			2	109	3	12	85	56	20	67	12	1	22	0	97	1		5	6	30	49	0	24	0	34	25	61	9	1	67	17	2	0	42	38	0
			X	3	100	0	0	83	67	33	0	0	33	0	100	0		33	0	0	33	0	33	0	67	0	33	33	0	67	0	0	0	0	33	0
Improvement of productivity	47	Widespread use in Japan of a technology capable of creating 3-D map images from such materials as numerical maps and photographic images for application in city planning, etc.	1	171	12	31	57	50	16	53	31	0	65	14	40	19		0	4	61	19	1	45	0	22	42	47	21	22	33	8	4	5	18	15	5
			2	153	10	26	64	49	11	61	27	0	82	8	42	14		0	2	70	14	1	51	0	18	42	61	14	20	37	7	2	3	23	15	3
			X	15	100	0	0	68	36	64	0	0	93	7	40	13		0	0	80	33	0	67	0	0	47	80	7	20	40	7	0	0	7	13	0
	48	Development of a technology capable of measuring locations of active faults and their stress conditions using a vibration generator placed on the ground without relying on blasting tests.	1	151	11	30	59	64	36	49	14	1	29	19	66	25		11	9	40	11	1	54	1	26	48	46	28	9	48	5	3	7	18	5	2
			2	136	10	27	63	63	31	61	7	2	34	11	74	18		7	5	56	6	2	74	1	18	53	51	21	4	63	1	1	6	29	1	2
			X	14	100	0	0	79	58	42	0	0	43	14	57	14		7	0	71	21	0	86	0	7	50	71	21	7	71	7	0	14	21	0	0
	49	Widespread use in Japan of new structural materials made from polymeric fibers, ceramics and other new raw materials for application in buildings, bridges, weirs, etc.	1	183	23	29	48	49	17	46	37	1	81	23	38	8		3	4	43	26	0	58	1	24	37	56	23	4	42	30	2	17	20	4	4
			2	162	20	32	48	50	15	55	29	1	87	17	31	2		2	3	46	23	0	73	1	16	31	68	16	2	48	29	1	17	32	1	1
			X	32	100	0	0	56	24	55	17	3	78	16	31	6		3	3	56	13	0	75	0	6	34	69	22	0	63	16	0	6	38	3	0
	50	Practical use of design techniques that ensure the desired performance of structures based on a quantitative evaluation of the durability and earthquake resistance of reinforced concrete members.	1	197	31	38	31	60	29	53	17	0	54	13	66	12		3	4	51	32	0	57	3	16	47	47	18	7	42	31	3	5	20	8	5
			2	179	30	38	32	60	25	67	8	0	68	7	74	5		1	2	53	25	0	72	1	11	47	61	10	4	50	31	0	3	35	4	1
			X	53	100	0	0	72	45	53	2	0	70	6	70	9		2	0	64	38	0	81	0	0	51	77	6	8	51	26	0	2	30	6	4

(Note) See page 7 for the interpretation of the graphs.

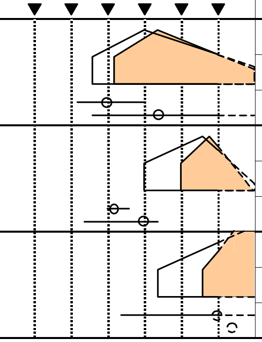
Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time			Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001 2006 2011 2016 2021 2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Improvement of productivity	51	Widespread use in Japan of a comprehensive database of design conditions, such as soil characteristics, geology and weather, to be used in planning and designing.	1	206	20	33	46	58	27	51	21	1	67	22	51	12		1	5	47	17	0	38	0	29	33	41	15	37	44	16	2	11	26	6	3
			2	186	19	34	47	55	19	62	18	1	83	13	49	10		1	2	62	13	0	47	1	24	30	45	10	38	58	12	1	9	32	5	3
			X	35	100	0	0	69	43	49	9	0	91	11	63	9		0	3	71	20	0	60	0	17	37	51	11	37	66	26	0	3	40	11	3
	52	Development of intelligent materials with self-diagnostic and self-repairing functions.	1	143	13	29	58	44	11	48	37	4	69	15	52	18		9	17	34	10	0	31	0	43	52	46	29	7	45	8	1	8	20	3	5
			2	130	10	29	61	44	8	57	33	2	75	10	47	11		8	8	43	6	0	35	0	42	57	51	22	2	48	8	1	8	34	2	2
			X	13	100	0	0	58	23	62	15	0	85	8	69	15		8	8	46	23	0	62	0	31	77	38	23	0	69	8	0	0	38	0	0
	53	Widespread use in Japan of inspection techniques that enable easy detection of deterioration and crack existing inside steel structures.	1	179	17	33	50	61	31	51	19	0	51	12	70	7		2	8	37	17	0	55	1	29	42	54	27	4	37	13	1	2	21	4	2
			2	156	13	33	54	57	21	66	13	0	61	6	76	2		2	3	40	10	1	70	1	21	46	72	19	1	37	7	0	1	34	3	2
			X	20	100	0	0	73	50	40	10	0	60	0	80	15		10	0	70	20	5	85	0	0	65	80	15	0	50	15	0	0	40	5	5
	54	Development of highly durable high-performance bonding agents for steel, enabling substantial rationalization of steel construction.	1	140	14	29	58	45	9	58	30	3	73	10	31	10		16	17	31	11	1	28	0	49	42	45	24	5	24	20	1	7	25	6	6
			2	126	13	30	57	47	10	62	28	1	92	4	25	5		13	10	39	7	0	31	0	54	52	59	17	1	22	18	1	4	40	4	2
			X	16	100	0	0	66	38	50	13	0	81	0	19	13		25	13	44	13	0	63	0	38	56	63	19	0	38	19	0	0	38	0	6
	55	Development of new materials to replace reinforced concrete leading to easier field work.	1	170	21	33	46	53	21	51	27	2	79	28	25	14		22	19	23	16	2	22	1	51	45	44	22	5	32	14	2	15	12	8	6
			2	151	24	29	47	53	17	60	23	1	94	18	25	8		20	17	30	14	1	27	0	57	54	52	16	1	38	15	1	22	20	6	3
			X	36	100	0	0	58	28	50	19	3	86	25	28	11		36	19	36	14	3	42	0	47	61	50	14	3	39	14	3	22	19	8	8
	56	Widespread use in Japan of intelligent robots on construction sites to reduce construction period and to ensure safety.	1	198	14	34	53	54	20	55	24	1	75	8	45	6		2	5	28	9	1	72	1	15	34	60	23	2	35	20	3	2	24	11	6
			2	174	13	31	56	53	15	66	18	0	89	2	39	2		1	2	29	5	0	86	1	10	33	72	20	0	36	18	1	0	41	8	3
			X	22	100	0	0	58	18	77	5	0	91	5	50	0		0	0	41	14	0	100	0	0	45	73	36	0	59	14	0	0	27	9	14
	57	Widespread use in Japan of architectural design systems with an improved human interface for designers through the introduction of artificial intelligence and virtual reality technologies.	1	154	13	29	58	43	7	52	39	2	60	4	40	23		3	8	59	20	0	43	1	25	48	53	18	6	29	6	3	1	11	17	5
			2	138	12	28	59	42	4	55	40	0	74	1	38	16		1	5	72	14	0	49	1	17	50	72	9	4	25	3	3	0	11	30	3
			X	17	100	0	0	58	25	56	19	0	71	0	35	24		0	6	76	18	0	59	0	18	35	76	0	6	35	6	6	0	12	35	12
	58	Development of construction techniques which incorporate built-in maintenance and demolition functions for buildings and civil structures.	1	186	16	34	49	55	23	54	21	2	69	40	32	8		5	8	30	12	0	34	0	41	43	49	17	2	28	32	2	8	22	7	3
			2	161	17	32	51	56	20	64	14	1	81	37	28	4		3	4	36	9	0	45	0	37	39	64	8	0	29	35	1	6	35	4	2
			X	27	100	0	0	74	48	52	0	0	67	52	41	7		4	7	44	19	0	63	0	22	48	70	4	0	44	41	0	4	22	7	7
Advanced use of national land and cities	59	Widespread use in Japan of "three-dimensional" cities where the space above railway lines etc. is utilized through the establishment of artificial ground foundations and the like.	1	178	16	32	52	51	20	45	31	3	79	13	44	3		13	8	26	18	0	46	2	25	17	38	7	1	27	66	2	21	37	15	4
			2	162	14	28	57	49	15	53	29	3	88	7	44	2		10	2	25	18	0	66	2	17	12	46	2	0	25	75	2	17	50	10	3
			X	23	100	0	0	62	35	48	13	4	87	17	35	4		9	0	52	30	0	78	0	0	4	52	4	0	26	83	0	30	35	22	9
	60	Widespread use in Japan of integrated data (land ownership, use, transactions etc.) obtained through GIS (geographical information system) in land policy and urban planning.	1	170	20	26	54	59	28	54	17	1	80	13	48	8		4	5	59	22	1	42	1	24	31	42	11	32	37	36	2	6	40	20	4
			2	156	17	24	59	59	25	65	10	1	89	6	46	5		4	1	69	17	1	50	1	16	21	54	8	29	38	37	1	3	35	22	2
			X	27	100	0	0	81	63	37	0	0	96	7	70	15		0	0	81	33	0	67	4	4	15	48	15	33	52	41	4	4	41	22	4

(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%) High	Medium	Low	Importance (index, %) Index	High	Medium	Low	Unnecessary	Expected effect (%) Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Forecasted realization time: Will not be realized (%)	Do not know (%)	Leading countries (%) USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%) Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%) Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Advanced use of national land and cities	61	Development in Japan of design and construction technology for floating airports along coastal areas.	1	163	16	26	58	62	35	43	20	2	89	35	24	6	1	4	26	14	0	67	1	18	28	57	17	1	57	42	4	60	24	7	2
			2	149	15	24	60	62	30	59	10	1	93	32	20	3	0	1	35	8	0	83	0	9	21	68	8	1	69	47	1	70	26	1	1
			X	23	100	0	0	83	65	35	0	0	100	35	22	0	0	0	26	13	0	100	0	0	17	87	17	0	70	39	0	57	17	0	4
	62	Establishment in Japan of a wide-area integrated water management technique covering rivers, dammed reservoirs, etc., leading to widespread use of efficient water resource utilization systems in major urban zones.	1	141	18	23	59	80	62	32	6	0	57	70	57	1	3	7	22	16	1	52	1	28	28	40	13	9	49	39	4	38	12	13	1
			2	133	15	20	65	83	67	30	2	0	59	70	59	1	5	2	21	14	0	67	1	22	20	53	9	5	66	45	0	58	14	6	0
			X	20	100	0	0	88	75	25	0	0	70	65	55	0	0	0	30	25	0	85	0	0	30	50	15	5	80	30	0	40	10	5	0
	63	Widespread use in Japan of new joint-use duct systems in cities to contain housing cable for wire broadcasting, vacuum garbage collection pipelines, distribution pipelines, and regional heating and cooling pipes.	1	172	13	24	63	58	27	52	20	1	76	30	69	2	3	8	37	39	1	36	0	24	15	46	15	1	37	62	4	14	28	12	4
			2	154	10	26	64	55	19	63	18	0	80	15	71	1	3	3	43	55	1	45	0	16	12	62	8	1	44	68	1	15	40	6	3
			X	16	100	0	0	73	50	44	6	0	88	19	75	6	0	0	69	50	0	81	0	6	25	81	0	0	50	56	6	13	31	19	0
	64	Realization in Japan of the decentralization of various city functions currently concentrated in large cities through significant advancements in telecommunications and transportation systems.	1	176	15	23	63	74	52	42	6	1	84	33	62	3	19	13	44	27	0	15	2	26	13	40	11	5	32	57	5	16	13	30	3
			2	160	11	23	66	78	57	38	4	0	86	21	61	2	16	8	63	29	0	12	1	21	8	50	6	6	34	66	3	14	7	41	2
			X	18	100	0	0	85	72	22	6	0	94	17	72	11	0	6	61	33	0	28	6	11	6	61	6	6	44	94	11	6	6	33	0
	65	Practical use in Japan of technologies for surveying existing embedded objects and ground properties lying deeper than 5 meters from the surface, in response to increasing use of underground space.	1	153	14	29	57	50	18	51	28	3	63	13	44	11	5	7	33	19	3	42	1	34	41	50	20	8	34	9	3	8	18	3	4
			2	141	11	28	61	48	12	58	27	2	80	6	43	6	2	5	43	15	1	60	1	23	40	72	16	1	36	6	1	7	30	3	1
			X	16	100	0	0	69	44	44	13	0	94	0	56	13	13	6	56	25	0	69	0	13	50	69	38	0	44	0	6	13	31	0	0
	66	Practical use in Japan of the technology to utilize long service-life concrete and steel (at least 100 years) aiming at improving the durability of buildings and civil structures.	1	195	30	31	39	62	33	53	13	2	72	54	35	4	2	11	30	25	2	56	1	26	39	48	24	3	43	19	3	10	13	10	5
			2	167	29	33	38	61	28	63	9	1	86	51	29	1	2	7	34	23	1	69	1	20	38	69	19	1	52	15	1	15	22	10	3
			X	49	100	0	0	74	49	49	2	0	98	53	33	2	2	0	47	31	2	92	0	2	49	71	16	0	57	14	0	8	31	6	6
Effective use of new frontier spaces	67	Realization of deep underground cities where people can reside.	1	174	17	27	56	28	6	20	47	27	61	20	30	7	45	9	21	25	10	21	2	30	20	32	13	1	25	41	2	25	39	33	3
			2	160	14	25	61	25	3	19	53	26	71	13	21	4	47	7	21	30	8	19	3	40	19	38	12	1	25	46	1	26	50	29	3
			X	23	100	0	0	34	4	35	48	13	65	9	39	9	57	4	35	57	17	22	4	13	13	48	4	0	17	65	0	26	39	30	0
	68	Realization of marine cities by progress in offshore engineering.	1	156	12	29	58	39	11	34	45	10	79	31	30	6	20	10	21	13	0	38	2	36	29	44	17	1	40	40	1	46	31	19	3
			2	143	8	24	68	37	9	29	51	11	85	21	17	4	25	8	20	10	0	44	1	38	20	52	9	1	45	48	1	57	34	11	3
			X	12	100	0	0	52	25	42	25	8	100	25	33	8	33	8	17	0	0	75	8	17	25	67	0	0	58	42	0	67	42	8	0
	69	Practical use of technology system needed to systematically build cities in remote areas such as deserts and polar regions.	1	130	8	18	74	28	7	15	53	25	50	55	14	8	16	18	40	10	10	9	4	34	45	38	12	3	34	5	3	52	7	12	2
			2	119	7	12	82	25	2	14	66	18	50	68	7	8	18	13	61	9	8	8	3	32	58	43	7	2	42	3	1	70	6	13	0
			X	8	100	0	0	25	0	25	50	25	25	75	13	13	38	13	75	13	0	13	0	25	75	50	0	0	38	13	0	50	0	25	0
	70	Practical use in Japan of a technology to construct super high-rise buildings (around 1,000 m tall) with living spaces.	1	191	18	34	48	27	3	23	51	23	73	18	27	12	30	9	48	4	0	58	1	15	29	47	17	1	23	43	5	36	50	30	3
			2	171	16	34	50	27	2	22	53	22	84	10	19	9	32	6	54	0	0	70	1	15	25	60	8	0	21	56	2	36	62	26	4
			X	27	100	0	0	26	4	15	59	22	89	11	30	11	30	7	59	0	0	93	0	4	11	70	7	0	30	63	0	41	52	37	4



(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time			Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001 2006 2011 2016 2021 2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Effective use of new frontier spaces	71	Elucidation of the impact of living in a super high-rise building (around 1,000 m tall) on human physiology and psychology.	1	149	10	26	64	34	6	30	50	14	36	7	58	23		13	12	39	10	1	27	0	36	46	48	13	6	29	11	1	9	28	34	1
			2	129	8	22	70	32	4	27	59	11	33	2	64	21		12	9	50	6	0	35	1	35	52	60	8	3	27	8	1	9	36	43	4
			X	10	100	0	0	25	0	10	80	10	20	0	70	20		30	0	30	10	0	40	0	40	40	80	0	0	40	10	0	10	30	40	0
	72	Realization of facilities in the outer space where people in general can live in long period.(at least one year)	1	98	4	7	89	31	3	34	43	20	49	33	8	57		10	14	88	9	39	10	0	4	52	38	26	2	58	2	2	9	21	39	5
			2	94	2	6	91	30	2	29	52	17	43	21	4	66		15	11	98	4	43	5	0	1	68	34	17	2	71	1	1	6	26	53	4
			X	2	100	0	0	75	50	50	0	0	50	50	50	100		0	0	100	0	50	0	0	0	100	50	100	0	50	0	0	0	0	50	0
	73	Realization of manned laboratories on Mars.	1	65	3	6	91	25	3	17	52	28	38	29	2	65		14	18	89	6	32	6	0	3	52	32	25	3	52	0	3	6	17	25	6
			2	72	1	4	94	23	0	18	54	28	25	17	0	76		17	15	97	0	32	3	0	1	65	29	21	1	58	0	3	4	18	47	4
			X	1	100	0	0	25	0	0	100	0	0	0	0	100		0	0	100	0	100	0	0	0	0	0	100	0	100	0	0	0	0	0	0

(Note) See page 7 for the interpretation of the graphs.

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12. Survey Results in “Communication”

12.1. Trends in areas of attention

12.1.1. Digital broadcasting

In October 1996, multi-channel digital broadcasting began in Japan using a CS communications satellite. In December 1996, the Study Group on Satellite Digital Broadcasting Technology of the Ministry of Posts and Telecommunications reported that two-channel digital HDTV broadcasting would become technically possible using a repeater mounted on a BS broadcasting satellite around the year 2000. On the heels of this, the Study Group on the BS-4b Satellite reported in February 1997 that the BS-4b broadcasting satellite to be launched around 2000 should center around digital HDTV. In consideration of the need for a smooth transition from analog to digital, the study groups report recommended that the analog-to-digital transition channel based on analog-digital simultaneous broadcasting be incorporated and that the reception of digital broadcasts using existing analog receiver be made possible through the attachment of an adapter. These studies have paved the way for the dawn of an era of full-fledged digital broadcasting in Japan.

Regarding terrestrial digital broadcasting, the Ministry of Posts and Telecommunications Communications Research Laboratory, the NHK Science and Technical Research Laboratories and the Next-generation Digital Television Broadcasting System Laboratory announced in January 1997 that they would undertake a joint research project on terrestrial digital transmission methods. In March of the same year, the Ministry of Posts and Telecommunications announced that it would carry out the adoption of a broadcasting method and preparation of a channel allocation plan, development of a regulatory framework, etc. so that terrestrial digital broadcasts could begin by the year 2000.

While the current CS digital broadcasting service centers on the multi-channel broadcasting of standard TV programs, BS digital broadcasting is expected to revolve around HDTV, and provides a high-image-quality high-functionality integrated digital broadcasting service incorporating various data transmission services.

The forecasted realization time for “35: Widespread use of integrated digital broadcasts based on ground or satellite waves” was 2009. At the time the survey was conducted, the announcement on the use of the BS-4b satellite had not been made. Taking this into consideration, it is possible that services based on satellite waves will spread more quickly. As part of the topic “14: Practical use of waveform equalizers and Orthogonal Frequency Division Multiplexing (OFDM) for mobile TV reception”, the realization time for OFDM, a modulation method considered promising for terrestrial digital broadcasting, was forecasted as 2006.

The following topics are expected to be realized before the forecasted realization time for the widespread use of an integrated digital broadcasting service “42: Development of a home TV set capable of automatic search, recording and replay of up to several hundred programs” (an important technology for the realization of an integrated digital forecasting service) and “30. Practical use of information filters that automatically sort large amounts of information and selectively choose only those items needed” (to allow viewers to selectively record and replay TV programs that they wish to watch). The survey results confirmed that a suitable environment for the realization of a high-image-quality high-functionality integrated digital broadcasting service was developing.

The integrated digital broadcasting service is an evolving one. New features, which have not even been conceived at the present time, will gradually be introduced. To address this, “54: Development of a digital broadcasting technology that allows flexible changes in the broadcasting mode” (forecasted realization time 2007) is desired. With image pickup and display, “27: Development of a 4,000 × 4,000 pixel high-definition display, image sensor, etc.” is forecasted to be realized by 2005, and R&D efforts are expected to make further progress towards superior image quality in the future. At present, a project aimed at commercializing a 40 in.-class high-definition display by the Nagano Winter Olympics in 1998 is in progress, while the realization time for “28: Practical use of 90 in. large wall-mountable high-definition flat color displays” was forecasted as 2005. Thus, there are great expectations for large wall-hung TVs.

The forecasted realization times for some topics including the following were in the 2009~2011 range "40: Development of a 3-D TV system capable of displaying hidden portions of an object in response to a shift in the focus of the eye" "41: Widespread use of binocular stereoscopic TV broadcasts that can be enjoyed at home" and "44: Practical use of an ultra-low bit rate encoding method for high quality image and sound signals." It is expected that, if these technologies are realized, digital broadcasting services will be further expanded and enhanced.

To enhance the content of broadcasting services, it is essential to bolster the content production structure. R&D on desktop program production (DTPP), which allows diverse images, such as high-definition images and 3-D images, to be created, composed and processed freely, has already begun. The realization times for topics relating to some component technologies for this system are as follows "47: Practical use of virtual studio technology capable of taking images of an object from difficult angles" (2008); and "46: Development of a TV program production technology capable of converting a scenario to an actual visual format" (2014).

In the face of an approaching aging society, R&D on the receiver human interface as part of the implementation of easy-to-use broadcast receivers will become an important task. The following technologies will also be incorporated in future broadcasting services "31: Practical use of information media conversion technologies such as a sign language interpretation communication system" and "32: Practical use of a support system for visually-impaired persons that converts visual images into audible sounds etc.."

(Keiichi Kubota)

12.1.2. Move towards ultrafast intelligent networks

Since the announcement of the GII (Global Information Infrastructure) concept by the US Vice President in March 1994, the development of information superhighways on a global-scale, including developing countries, has been making a steady progress. In Japan, a shared multimedia use experiment was conducted by NTT over two and a half years starting in September 1994 using a 10 Gb/s backbone network and 156 Mb/s access circuits, and technological know-how for the development and utilization of ultrafast high-capacity networks etc. is being accumulated. With definite needs for services such as telemedicine and telelectures or VOD (Video on Demand) emerging, the importance of R&D for ultrafast intelligent networks aimed at further reducing communications costs is increasing.

Around 1993, Internet use became easier and more common as information supply via WWW (World Wide Web) and information retrieval using WWW browsers started to spread rapidly. In 1994, services by commercial Internet access providers began, thus expanding the Internet, which was until then academically oriented, to include private companies and individuals as users. This has resulted in the Internet share of the combined capacity of Japan-US communications circuits exceeding the telephone share in 1996. Through the establishment of security technologies, the Internet will be also be used for electronic commerce in the future.

(1) Ultra high-speed high-capacity network configuration technologies

"03: Practical use of modes of transmission over extremely long distances without repeaters based on an ultra low loss optical fiber cable" (forecasted realization time 2009) is expected to contribute to cost reductions in international information highway, while "05: Development of an optical fiber communication method based on the manipulation of the quantum state of photons" (forecasted realization time 2013) may possibly bring about a dramatic increase in the capacity of optical communications. The realization times for "10: Practical use of optical switching equipment that directly switches light signals" (aimed at ultra high-speed signal switching) and "11: Development of high-speed switching devices using high-temperature superconductors" are forecasted to be 2009 and 2012, respectively. In the application area, "08: Development of a super high-speed communications protocol capable of achieving a throughput of hundreds of Mbps" is forecasted to be realized by 2003.

(2) Intelligent network technologies

There are high expectations for networks to make advanced services possible, with "61: Widespread use of ambulance-hospital data communication systems for the transmission of images etc. for emergency medical care" "62: Practical use of a technology that ensures a crash-proof network" and "63: Practical use of integrated building management systems etc." which are linked to an earthquake detection system forecasted to be realized by 2006, 2008 and 2011, respectively.

(3) Security technologies

As a large number of unspecified persons try to conduct business and carry out commercial transactions via networks such as the Internet, the establishment of security technologies, such as authentication and encryption, become very important. The realization times for "67: Widespread use of electronic commerce carried out via a network" "66. Widespread use of on-line seal-less document preparation services for various official documents such as contract documents" and "68: Widespread use of a security technology that automatically monitors illicit activities involving info-communications ethics are forecasted 2006, 2008 and 2009, respectively.

(Toyomichi Yamada)

12.1.3. Mobile communication

Since the early 1990s, mobile communication has spread at a remarkable rate following an easing in government regulations in this area, with other possible factors involving advances in equipment performance and increased mobility in people's lives. While the term personal communication in many cases refers to mobile communication, it is also very much a reflection of the ongoing shift in the identities of the information sources from companies and governments to individuals. The sight of female senior high school students carrying around paging terminals (beepers), PHS (Personal Handyphone System) receivers or mobile phones has become common place. This demand has arisen from independent-minded teenagers needs to keep personal information among themselves without being intruded on by parents and teachers. The business sector is in the process of undergoing a major change. For example, mobile phones provide each sales representative with a mobile office, while navigation systems, such as the GPS (Global Positioning System), supply drivers with traffic information relating to fuel efficiency and safety.

The widespread use of mobile communication is a phenomenon that has inevitably arisen from the convergence of the following two social trends: the information age and the mobile age. Information entices people to move, people need information to move, people exchange information, while they are on the move, and so on. Some selected topics from the 6th technological forecast survey will be discussed below to predict the future direction of this field.

(1) Development of millimeter wave devices

Millimeter waves, which have the shortest wavelengths among all radio waves, not only make high-speed telecommunication possible but are also suitable for distance measurement as in the case of radar. As such, they play a central role in ITS (Intelligent Transport Systems), with strong expectations expressed for the development of devices based on them.

(2) Subminiature variable directional planar antennas for mobile stations

Antennas that receive and transmit radio waves, particularly small antennas that save space, are indispensable for mobile communication. Directivity is a powerful property in avoiding the emission or reception of unwanted radio waves, and variable directivity is also indispensable for mobile communication. R&D aimed at obtaining superior characteristics than are possible from the current lines of development, which depend on modulation, coding and diversity, is required.

(3) Mobile communication at speeds greater than 10 Mbps

Mobile communication is not limited to voice transmission. Todays widespread use of notebook PCs or PDAs (Personal Digital Assistants) has given rise to expectations for an integration of these devices with radio communication. The devices handle digital data and images, which necessitate the transmission of large volumes of data. Multimedia has penetrated the area of mobile communication.

(4) Practical use of low earth orbit satellite communication

This is a type of mobile communication that reaches anywhere on earth, including blind spots of terrestrial mobile communication. As it has a position determining function similar to that of GPS, feature-rich services will be possible.

(5) Emergency mobile communication for distress situations

In light of the fact that mishaps could happen anytime anywhere, mobile communications capability to determine locations and establish radio contact is a particularly great asset. Satellite use is a possibility.

(6) Development of small-size light-weight batteries for portable communications terminals

The promotion of the widespread use of mobile communication boils down to the advancement of battery development. As discussed in 12.1.3. (3), with high-speed large-volume data communication being the central feature of mobile communication, high capacity batteries are essential, as the high-speed transmission of a large volume of data would result in a large energy consumption.

In summary, there are expectations for the development of devices that support high-speed large-volume data transmission, as a consequence of the evolution from voice communication to multimedia communication, including batteries, as well as that of additional mobile communication features, such as a truly global communication coverage, instead of limited area coverage, and the determination of the locations of mobile stations.

(Masao Nakagawa)

12.1.4. Advances in multimedia communication

One of the typical examples of technological innovation this century is computer technology. A few years ago, computers reached the level of sophistication where they are capable of handling a wide range of data, including human languages, voices, still images, animation and full-motion videos, apart from numerical data ó giving rise to the advent of multimedia, a symbolic event for the 1990s. Compared to a previous-generation technology known as new media, which was a buzz word of the 1980s, computer and computer-related technologies have come a long way. For example, the introduction of ISDN in the 1980s resulted in a dramatic increase in data transmission speed from the previous 1.2~9.6 Kbps range based on analog telephone networks to the 64 Kbpsñ1.5 Mbps range, and this has now been further increased to the 100~600 Mbps range, which represents a nearly 10,000 fold performance improvement. Alongside this, data compression technologies based on digitization, combined with fast computer processing speeds, have made the transmission of animation and full-motion videos possible, thus setting a technological foundation on which multimedia technology can flourish. Through computer chip downsizing (fruit of micromachining technology), the operating frequencies of PCs have surpassed 100 MHz, paving the way for the comfortable handling of voice and animation/full-motion videos, and this has made multimedia suddenly accessible to everyone.

As well as mixed-media presentation, the concrete goals of multimedia technology include real-time response and bidirectional communication. In this regard, the Internet, which has shown rapid growth over the last couple of years, can be taken as embodying the essence of multimedia, for it is capable of transmitting different types of data encompassing most forms of expression used in human communication ó such as hand-written characters, printed characters, illustrations, maps, photos, still images, animation/full-motion videos, speeches/conversations, and musical sound as well as bidirectional communication, although it has limited abilities regarding real-time response. Tasks that remain include improving content quality and the price/performance ratio, as well as general performance enhancement, encompassing transmission capacity, transmission speed, processing speed, storage capacity, and the like through a synergy of improvements in multimedia compnent technologies.

One area of expectation relating to multimedia communication is video-on-demand (VOD) services, which cater for the needs for customized information supply, as opposed to the conventional distribution of uniform information via broadcasting. The forecasted realization times for “30: Practical use of information filters that automatically select desired data only” and “48: Widespread use of a motion video image replay/transmission and home reception/recording system which is 10 times as fast as the normal speed” were 2005 and 2009, respectively.

In further advancing multimedia communication, the importance of video compression technologies, such as MPEG2 (Moving Picture Expert Group phase 2) and MPEG4, will increase in the future. The forecasted realization times for “45: Development of an encoding technique that can compress motion video image information to about 1/250 of the original size” and “44: Practical use of an ultra-low bit rate encoding method for high quality image and sound signals” were 2008 and 2009, respectively. On the other hand, the forecasted realization time for both “36: Widespread use of communication systems for retrieval of still or motion video information from electronic libraries” and “39: Widespread use of a multimedia protocol that handles different media protocols” was 2008.

With advances in multimedia, the importance of computer intelligence and human interface will increase in the future. The forecasted realization times for “38: Development of an automatic Japanese-English, English-Japanese speech translation telephone system comparable to human simultaneous interpretation in service quality” and “31: Practical use of information media conversion technologies such as a sign language interpretation communication system” were 2012 an 2009, respectively. On the other hand, the forecasted realization times for “51: Widespread use of character recognition technologies which enable a recognition rate with handwritten Chinese character of 99% or more” “52: Practical use of technologies capable of automatically turning written information into speech of a quality level nearly equal to that of human speech” and “55: Widespread use of multi-modal environments as a common means of human-computer interface” topics all relating to human interface, were 2008, 2007 and 2009, respectively, i.e. basically the same period.

While computer processing power is tied closely to the transmission capacity of multimedia communication, there are numerous instances of purpose-specific computer processing power making headway regardless of progress in communication technology. A typical example is virtual reality (VR), a cutting-edge multimedia area where ultra high-speed image processing and real-time response are pursued to the limit. The forecasted realization time for “57: Widespread use of image communication systems designed to closely interconnect satellite offices” was 2009. Other examples of cutting-edge multimedia communication include a high-quality teleconferencing system via a 156 Mbps transmission line based on MPEG2 video compression technology and the ATM (Asynchronous Transfer Mode) protocol, ultra high-speed computer-to-computer communication taking place at a data rate of 622 Mbps, and the creation of an imaginary space called cyberspace. Days when physical distribution and commercial transactions (electronic settlement of accounts) are carried out electronically, in addition to information exchange, will not be so far away. Indeed, once reliable security technologies are in place, they will spread like wildfire.

(Shigeru Ueda)

12.2. Forecast topic framework

In the course of compiling forecast topics, a framework representing the organization of technologies in tabulated matrix form was drawn up for each field, with objectives and technological domains defining the rows and columns of the table, respectively. The framework is designed to present an overall picture of technological development in each field in terms of future prospects, importance, etc. as seen from the present perspective, and is also used as a working framework for future reviews of forecast topics.

Table 12.2-1 Forecast Topic Framework for Communication Field

Domain / Objective	Transmission technology	Switching technology	Satellite and mobile communication technology	Broadcasting, multimedia communication and intelligent system technology	Networking technology	Security technology	Common element technologies
Pursuit of human touch, culture and comfort and enhancement of measures to cope with aging of population			14	27 28 29 30 31 32 33 34 35 36 37			71
Pursuit of personalized/privatized information and convenience	01 02		15 16 17 18 19	38 39 40 41 42 43	58 59 60	66 67	72 73
Pursuit of greater efficiency and cost cutting	03 04 05 06 07 08	10 11 12 13	20 21 22 23	44 45 46 47 48 49 50			74
Environmental protection, recycling, improvement of social environment and problem solving			24 25		61		75 76 77
Provision of sense of security and reliability (disaster preparedness, safety, privacy protection, etc.)			26		62 63 64 65	68 69 70	78
Greater user-friendliness (improved ease of use and interaction)	09			51 52 53 54 55 56 57			

* Figures appearing in the table represent topic numbers.

12.3. Topics with high degree of importance

Degree of importance index scores (Note 1) averaged at 62.5 for topics in the communication field as a whole. Topics considered of particular importance to Japan (top 20 topics in terms of degree of importance index score) are listed in the table below. 01. Practical use of a highly secure next-generation Internet that allows the transmission of real-time information was rated most important (92 points), while 37. Realization of electronic courts based on a teleconferencing system and electronic filing system was rated least important (37 points). As many as 7 topics featuring in the top 20, including No. 1 and No. 2, related to pursuit of personalized/privatized information and convenience.

Table 12.3-1 Top 20 Topics in Terms of Degree of Importance Index

Topic	Degree of importance index	Forecasted realization time (year)
01 Practical use of a highly secure next-generation internet that allows the transmission of real-time information, leading to the implementation of internet-based telephone services and motion video broadcasts.	92	2003
72 Development of high performance batteries with an energy density of about 500 Wh/Kg, capable of miniaturizing mobile phones in terms of both size and weight.	87	2009
63 Practical use of integrated building management systems and home security systems which are linked to an earthquake detection system and take the necessary safety measures to protect human lives in the event of a non-direct-hit earthquake, taking advantage of the time lag to the arrival of seismic waves.	86	2011
67 Widespread use of electronic commerce carried out via a network based on an electronic funds transfer system and electronic money system.	85	2006
08 Development of a super high-speed computer communication protocol capable	84	2003

Topic	Degree of importance index	Forecasted realization time (year)
of achieving a throughput of hundreds of Mbps.		
09 Widespread use of integrated information wiring and plug socket that incorporate services such as the telephone, Internet, VOD and high-definition TV in homes and offices.	83	2007
74 Practical use of biochip devices that have a memory density (10^{12} bit/cm^2) 1,000 times that of current semiconductor devices (10^9 bits/cm^2).	82	2015
68 Widespread use of a security technology that automatically monitors illicit activities involving network ethics, such as copyright infringement concerning multimedia software use over a network and the violation of privacy.	81	2009
38 Development of an automatic Japanese-English, English-Japanese speech translation telephone system comparable to human simultaneous interpretation in service quality.	81	2012
66 Widespread use of on-line seal-less document preparation services for various official documents such as contract documents which are provided via a network based on security technology capable of achieving both privacy protection and verification.	79	2008
19 Practical use of a personal mobile communication system that enables communication with anyone anywhere in the world through advances in distributed databases and personal ID technology.	79	2008
62 Advancements in the autonomous distributed control of wide-area communication network management, leading to the practical use of a technology that ensures a crash-proof network.	79	2008
18 Practical use of a personal mobile communication system with a bandwidth of at least 10 Mbps capable of providing multimedia services.	74	2006
35 Widespread use of integrated digital broadcasts based on ground or satellite waves (a service that dynamically combines standard TV, HDTV, and voice and data communication).	73	2009
30 Practical use of information filters that automatically sort large amounts of information and selectively choose only those items needed.	72	2005
51 Widespread use of character recognition technologies which enable a recognition rate with handwritten Chinese character of 99% or more.	72	2008
12 Practical use of automatic protocol conversion technology, enabling easy interconnection of various communications networks.	72	2006
61 Widespread use of ambulance-hospital data communication systems for the transmission of images and emergency medical care instructions.	72	2006
06 Development of millimeter wave semiconductor devices for use in wireless LANs, radar for vehicle collision prevention systems, etc.	71	2003
69 Widespread use of security systems capable of identifying individuals based on the recognition of distinguished features of a person such as finger prints, hand writing, voice and face.	71	2009

Note 1: Degree of importance index = (number of “high” responses × 100 + number of “medium” responses × 50 + number of “low” responses × 25 + number of “unnecessary” responses × 0) ÷ total number of degree of importance responses

12.4. Forecasted realization times

Forecasted realization times were distributed as shown in the diagram below. With 60% of the topics in the communication field forecasted to be realized between 2006 and 2010, forecasted realization times were generally earlier than the general trend covering all topics.

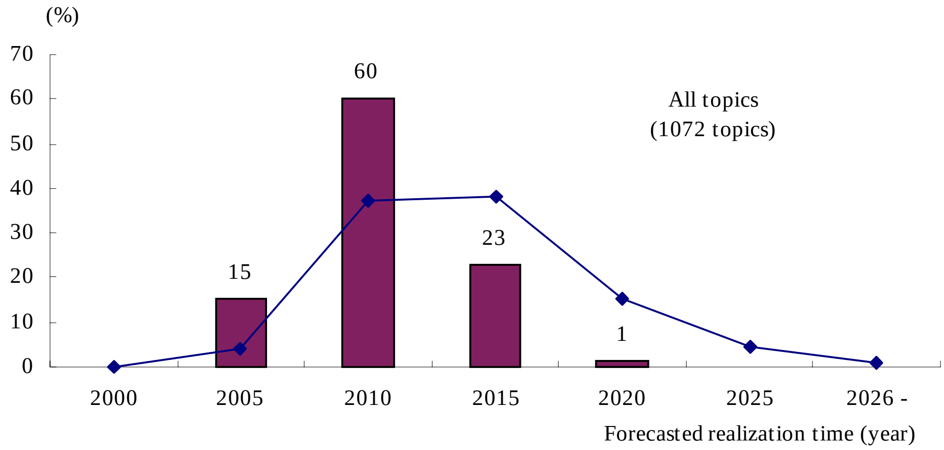

Fig. 12.4-1 Trends in Forecasted Realization Times

12.5. Current leading countries etc.

Responses to the question concerning current leading countries etc. were as shown in the diagram below. Although the U.S. was named by the greatest number of respondents in the communication field as a whole, Japan followed fairly closely, highlighting the leadership role played by the two countries in technological development. In contrast, the third-placed EU and other countries/regions were rated extremely low.

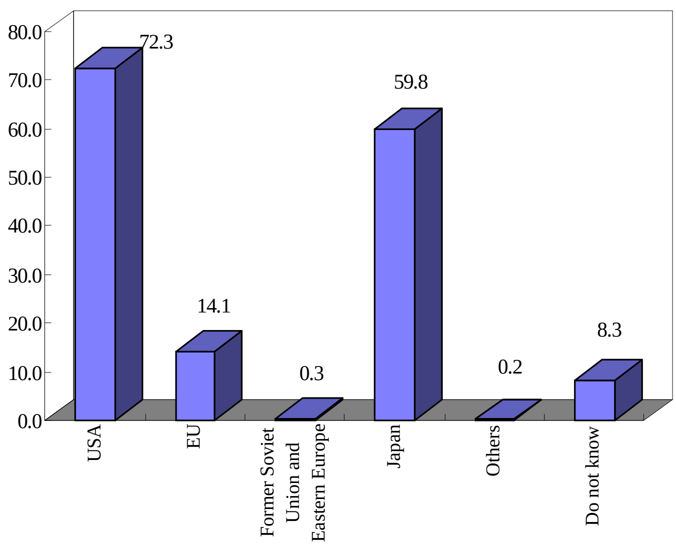

Fig. 12.5-1 Current Leading Countries etc. (%)

12.6. Comparison with the 5th Survey (previous survey)

Of the 78 topics included in the latest survey, 19 (24%) were identical to the previous survey, 16 (21%) were modified, and 43 (55%) were newly introduced. For identical topics, the results of the latest survey were compared with those of the previous survey in terms of degree of importance index scores and forecasted realization times, as shown in the table below.

Degree of importance index scores rose for 9 topics and fell for 10. 04. Development of non-linear optical fiber transmission methods applying non-linear effects saw the greatest jump, up 11 points, while 03. Practical use of modes of transmission over extremely long distance without repeaters based on realization of optical fiber with ultra low rate of transmission loss saw the greatest drop, down 13 points.

Forecasted realization times were pushed further into the future for all topics, by 1 to 7 years. The topics whose forecasted realization times were pushed back 7 years were 20. Development of ultra-high sensitivity receiving technologies of terahertz-band electromagnetic waves based on high-temperature superconductive Josephson devices and 21. Practical use of high-output semiconductor microwave amplifiers in broadcasting satellite etc.

Table 12.6-1 Comparison with 5th Survey for Identical Topics

Topic	Degree of importance index / forecasted realization time	
	6th survey	5th survey
03 <u>Practical use</u> of modes of transmission ever extremely long distance without repeaters based on realization of <u>optical fiber with ultra low rate of transmission loss</u> (less than 0.01 dB/Km), enabling installation of Japan-Hawaii optical trunk ine without repeateers.	71/2009	84/2003
04 <u>Development</u> of <u>non-linear</u> optical fiber transmission methods applying solitons, induced Raman effect, and other non-linear effects.	59/2007	48/2005
05 <u>Development</u> of an optical fiber communication method capable of reducing the impact of quantum noise through the manipulation of <u>the quantum state of photons</u>.	54/2013	48/2012
07 <u>Development</u> of communications systems based on electromagnetic waves outside the visible to infrared light spectrum and <u>radio wave</u> (e.g., applying far infrared light or ultraviolet light).	48/2010	45/2006
10 <u>Practical use</u> of optical switching equipment that switches <u>light signals without converting into electrical signals.</u>	71/2009	81/2007
11 <u>Development</u> of A/D converters and high-speed switching devices using high-temperature superconductors.	49/2012	54/2007
12 <u>Practical use</u> of automatic protocol conversion technology, enabling easy interconnection of various communications networks.	72/2006	79/2002
13 <u>Practical use</u> of satellite systems capable of switching multiplexed signals transmitted from numerous ground stations.	60/2007	63/2003
15 <u>Practical use</u> of subminiature variable directional planar antennas for mobile objects.	59/2005	63/2001
20 Realization of high-temperature superconductive Josephson devices, leading to the <u>development</u> of ultra-high sensitivity receiving technologies of terahertz-band electromagnetic waves which use harmonics mixing mechanisms.	45/2013	55/2006
21 <u>Practical use</u> of semiconductor microwave amplifiers with high outputs comparable to those of TWTs (Traveling Wave Tubes), leading to its application to broadcasting satellite etc.	58/2009	64/2002
36 <u>Widespread use</u> of communication systems for retrieval of still or motion video information from electronic libraries (containing character data, books, still videos, movies, TV, documentary films, etc.) through broad-band lines.	66/2008	60/2005
44 <u>Practical use</u> of an ultra-low bit rate encoding method for high quality image and sound signals, which are almost indistinguishable to original signals (at 10 Mbps or less for HDTV-class images with a 1/100 data compression, and 64 kbps or less for CD-class sounds).	63/2009	67/2003

Topic	Degree of importance index / forecasted realization time	
	6th survey	5th survey
51 Widespread use of character recognition technologies which enable a recognition rate with handwritten Chinese character of 99% or more.	72/2008	63/2003
52 Practical use of high-quality speech synthesizing technologies for automatically turning written information into speech of a quality level nearly equal to that of human speech.	60/2007	58/2003
53 Practical use of large-scale adaptive digital filters., eliminating howling caused by interference between microphones and speakers and deterioration in sound quality.	45/2006	50/2000
56 Widespread use of 3-D teleconferencing based on highly realistic 3-D imaging devices.	44/2013	43/2011
61 Widespread use of ambulance-hospital data communication systems for the transmission of images and emergency medical care instructions.	72/2006	67/2003
65 Widespread use of interconnected home security systems with functions such as crime and disaster prevention as a community-wide security system.	59/2010	54/2006

Note: Up until the 5th Survey, realization meant realization in Japan unless otherwise specified. However, this was changed to mean realization somewhere in the world in the 6th Survey. Therefore, care should be taken when comparing forecasted realization times from the two surveys.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time			Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001 2006 2011 2016 2021 2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Transmission technology	1	Practical use of a highly secure next-generation internet that allows the transmission of real-time information, leading to the implementation of internet-based telephone services and motion video broadcasts.	1	269	32	42	26	89	78	20	2	0	94	20	69	16		0	1	98	8	0	21	0	1	40	35	19	2	25	66	6	0	67	68	2
			2	232	29	46	25	92	84	16	0	0	93	14	71	12		0	1	98	6	0	19	1	1	43	33	15	1	21	75	3	0	63	73	0
			X	68	100	0	0	95	90	10	0	0	96	25	68	15		1	0	97	4	0	25	1	0	43	25	18	0	24	72	6	1	53	71	1
	2	Widespread use of indoor broadband optical wireless communication via indirect or scattered light that enables PCs and graphics terminals to make wireless connection to a network.	1	239	23	40	37	53	21	53	24	3	64	4	54	3		4	4	74	4	0	56	0	15	35	22	13	1	16	31	6	6	47	13	5
			2	210	19	41	40	54	17	64	18	0	63	1	62	1		4	2	78	1	0	64	0	10	40	22	11	0	14	40	3	4	59	9	2
			X	39	100	0	0	70	45	47	8	0	69	3	72	0		8	3	82	0	0	79	0	5	38	26	10	0	21	26	10	5	56	15	5
	3	Practical use of modes of transmission ever extremely long distance without repeaters based on realization of optical fiber with ultra low rate of transmission loss (less than 0.01 dB/Km), enabling installation of Japan-Hawaii optical trunk ine without repeateers.	1	198	19	33	48	68	44	42	13	1	78	23	18	11		10	8	55	9	1	84	1	7	42	20	26	2	36	3	3	2	5	9	3
			2	169	18	33	49	71	46	46	7	1	89	20	17	7		11	6	58	4	1	88	0	5	51	16	28	0	47	2	3	2	4	6	1
			X	30	100	0	0	73	53	37	7	3	83	17	20	7		30	7	53	0	3	83	0	0	40	20	27	0	57	0	10	3	7	10	7
	4	Development of non-linear optical fiber transmission methods applying solitons, induced Raman effect, and other non-linear effects.	1	154	22	23	55	62	32	52	15	1	79	16	12	17		4	5	73	16	1	82	1	6	46	24	21	1	38	2	3	3	4	7	5
			2	138	18	22	59	59	26	58	15	1	84	11	8	13		6	5	72	9	1	86	1	5	56	25	17	0	45	3	1	1	1	7	1
			X	25	100	0	0	74	52	40	8	0	96	16	8	12		12	0	84	12	0	88	4	0	40	32	32	0	60	4	4	0	4	8	4
	5	Development of an optical fiber communication method capable of reducing the impact of quantum noise through the manipulation of the quantum state of photons.	1	110	13	29	58	54	21	54	21	4	66	15	13	34		10	10	71	16	2	63	0	14	48	26	18	0	36	1	3	1	3	6	5
			2	98	11	26	63	54	20	60	17	3	78	12	6	29		9	6	76	9	0	69	0	6	60	21	16	0	52	0	2	0	2	5	3
			X	11	100	0	0	52	9	82	9	0	82	18	9	55		27	0	73	0	0	82	0	9	36	36	18	0	55	0	9	0	9	9	0
	6	Development of millimeter wave semiconductor devices for use in wireless LANs, radar for vehicle collision prevention systems, etc.	1	183	19	33	49	70	44	49	6	1	75	8	66	5		1	2	73	22	2	75	1	9	37	29	20	0	38	22	2	8	26	8	5
			2	159	15	36	49	71	46	48	6	0	77	4	70	1		1	1	76	16	0	80	0	5	46	26	17	0	47	21	1	6	37	4	1
			X	24	100	0	0	85	71	29	0	0	83	4	58	0		0	0	71	17	0	75	0	4	33	38	29	0	58	42	0	0	38	4	0
	7	Development of communications systems based on electromagnetic waves outside the visible to infrared light spectrum and radio wave (e.g., applying far infrared light or ultraviolet light).	1	158	13	32	56	46	16	42	35	6	60	9	27	24		6	15	54	12	3	34	0	35	45	20	20	1	32	8	4	14	20	6	5
			2	135	12	31	57	48	14	53	30	3	73	6	29	16		7	8	65	8	1	38	0	29	58	17	15	0	39	7	3	11	32	1	2
			X	16	100	0	0	67	44	38	19	0	81	0	19	19		6	0	75	19	0	63	0	25	56	19	38	0	63	13	6	6	19	0	0
	8	Development of a super high-speed computer communication protocol capable of achieving a throughput of hundreds of Mbps.	1	205	25	37	39	78	58	36	6	0	90	12	29	16		0	1	91	16	0	42	0	2	49	33	18	1	37	8	3	1	19	14	1
			2	178	21	35	43	84	70	28	2	0	95	7	26	9		1	0	94	7	0	43	0	1	61	38	14	1	43	8	3	0	23	13	1
			X	38	100	0	0	85	71	26	3	0	95	3	45	11		0	0	97	3	0	58	0	0	68	26	24	0	47	13	3	0	21	13	0
	9	Widespread use of integrated information wiring and plug socket that incorporate services such as the telephone, Internet, VOD and high-definition TV in homes and offices.	1	260	33	37	30	77	58	35	7	0	77	7	81	7		1	2	81	23	0	56	0	7	22	36	11	1	26	57	4	0	33	30	2
			2	228	31	37	32	83	68	28	5	0	74	3	83	4		0	0	87	17	0	59	0	3	22	38	9	0	23	70	2	0	33	30	1
			X	70	100	0	0	91	83	16	1	0	80	4	87	6		0	0	89	16	0	73	0	3	23	37	11	1	29	66	3	0	33	31	0
Switching technology	10	Practical use of optical switching equipment that switches light signals without converting into electrical signals.	1	208	20	36	45	70	45	45	10	0	85	10	21	17		4	2	66	24	0	77	0	8	57	27	19	0	41	2	2	0	6	6	4
			2	186	18	32	50	71	45	48	7	1	90	7	16	12		3	1	66	17	0	82	0	5	66	26	17	0	48	2	2	0	7	6	3
			X	33	100	0	0	86	73	27	0	0	91	6	21	21		6	0	67	30	0	88	0	0	61	33	27	0	58	3	3	0	9	9	0

(Note) See page 7 for the interpretation of the graphs.

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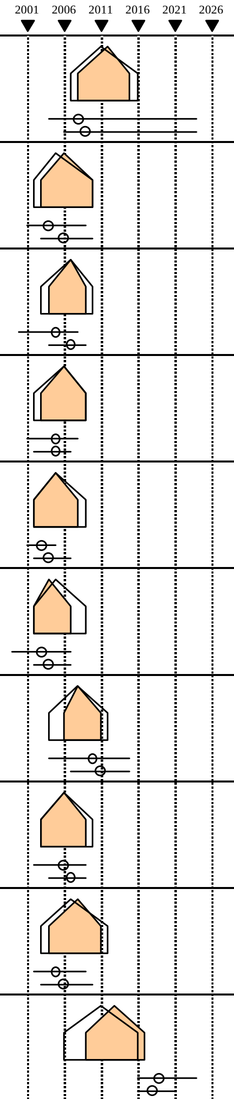
Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Medium	Low	Importance (index, %): Index	High	Medium	Low	Unnecessary	Expected effect (%): Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Switching technology	11	Development of A/D converters and high-speed switching devices using high-temperature superconductors.	1	125	4	18	78	53	20	54	23	2	66	13	9	28		8	13	65	23	1	52	2	17	45	30	20	0	42	0	0	2	3	6	4
			2	114	4	18	77	49	12	64	22	3	77	11	4	25		8	5	75	20	1	58	1	11	55	29	16	2	48	0	1	2	3	4	2
			X	5	100	0	0	63	25	75	0	0	80	0	0	0		0	0	100	20	0	40	0	0	100	0	0	0	40	0	0	0	0	20	0
	12	Practical use of automatic protocol conversion technology, enabling easy interconnection of various communications networks.	1	208	17	35	48	70	45	44	10	1	86	4	35	9		4	6	80	17	0	35	0	12	42	36	16	3	29	18	1	0	31	13	2
			2	184	19	33	48	72	48	47	6	0	90	2	35	5		2	3	86	11	0	32	0	7	52	34	13	1	32	18	2	1	32	10	1
			X	35	100	0	0	77	56	41	3	0	91	0	37	3		3	6	89	11	0	34	0	3	37	37	14	0	29	23	3	0	43	11	0
	13	Practical use of satellite systems capable of switching multiplexed signals transmitted from numerous ground stations.	1	199	13	36	51	61	32	48	20	1	78	20	31	5		3	5	82	22	3	44	0	8	39	23	21	2	43	19	1	2	20	10	3
			2	172	13	34	53	60	27	59	14	0	84	15	28	3		2	3	89	17	1	52	0	5	42	21	21	0	53	14	2	1	23	7	1
			X	22	100	0	0	63	33	52	14	0	77	18	27	9		5	9	95	32	0	64	0	5	41	27	27	0	64	14	0	0	14	9	0
Satellite and mobile communication technology	14	Practical use of waveform equalizers, Orthogonal Frequency Division Multiplexing (OFDM), etc. capable of adapting to rapidly fluctuating radio reception conditions, making high-quality TV reception possible even in traveling motor vehicles or trains.	1	170	25	32	43	61	30	53	16	1	77	1	67	4		2	4	59	45	1	54	0	11	48	31	22	1	36	18	1	2	19	17	4
			2	146	24	34	42	62	30	59	10	1	81	1	72	1		1	1	66	49	0	64	0	8	53	29	18	0	39	20	2	2	23	15	2
			X	35	100	0	0	79	62	32	6	0	91	0	77	3		0	0	57	69	0	57	0	0	60	26	20	0	63	20	0	3	17	17	0
	15	Practical use of subminiature variable directional planar antennas for mobile objects.	1	159	13	38	48	57	24	59	16	1	74	3	56	4		1	7	67	26	1	69	1	13	42	23	17	1	31	10	1	1	18	9	3
			2	140	14	37	49	59	23	66	10	1	83	0	62	1		0	4	75	21	0	78	0	8	51	24	14	1	33	10	1	0	18	4	1
			X	20	100	0	0	68	42	47	11	0	80	0	65	5		0	0	75	30	0	85	0	0	45	35	25	0	25	0	5	0	20	5	0
	16	Widespread use of battery-free wireless cards in automatic train ticket inspection and physical distribution systems.	1	181	10	29	60	69	43	47	9	1	81	7	73	3		1	3	64	33	0	65	1	10	29	37	12	2	25	35	3	1	47	18	2
			2	159	10	23	67	70	42	53	4	1	81	4	75	1		0	3	70	31	0	76	0	7	31	39	8	0	22	45	3	2	52	16	1
			X	16	100	0	0	80	60	40	0	0	88	0	63	6		0	0	63	50	0	81	0	0	31	38	31	0	25	25	0	0	50	13	0
	17	Practical use of super high-speed wireless LANs capable of a bit rate of 600 Mbps, and advances in the shift towards wireless communication with office and home information systems.	1	225	17	40	44	59	29	52	17	2	80	4	64	4		1	5	81	18	1	59	0	7	42	28	20	1	28	34	1	7	40	10	4
			2	191	17	39	45	61	28	61	11	0	85	3	66	2		1	1	86	12	0	61	0	5	48	21	15	0	25	42	2	3	48	10	2
			X	32	100	0	0	66	35	58	6	0	84	3	59	6		0	0	91	19	0	59	0	0	47	19	34	0	31	38	3	0	47	6	0
	18	Practical use of a personal mobile communication system with a bandwidth of at least 10 Mbps capable of providing multimedia services.	1	237	24	34	42	72	48	44	8	0	87	5	73	4		3	1	80	33	0	64	0	7	43	29	14	0	31	44	1	4	41	21	3
			2	205	21	34	44	74	50	46	5	0	83	2	78	0		1	0	83	32	0	71	0	4	46	27	9	0	28	54	1	2	47	17	1
			X	44	100	0	0	85	72	26	2	0	89	0	73	0		0	0	82	50	0	77	0	0	55	32	25	0	43	39	5	5	48	7	0
	19	Practical use of a personal mobile communication system that enables communication with anyone anywhere in the world through advances in distributed databases and personal ID technology.	1	242	22	38	40	77	57	39	4	0	85	15	74	6		0	1	87	46	1	54	0	3	39	35	12	2	34	48	3	0	52	26	2
			2	208	21	39	40	79	60	38	2	0	88	7	77	3		0	0	92	50	0	59	0	2	45	31	10	1	32	56	2	0	59	29	0
			X	43	100	0	0	87	74	26	0	0	91	9	70	2		0	0	88	58	0	60	0	0	42	35	19	2	37	40	0	2	67	23	0
	20	Realization of high-temperature superconductive Josephson devices, leading to the development of ultra-high sensitivity receiving technologies of terahertz-band electromagnetic waves which use harmonics mixing mechanisms.	1	95	5	26	68	45	11	49	38	1	65	9	20	32		8	21	66	16	2	51	1	19	49	24	20	0	48	1	1	3	6	4	5
			2	83	5	22	73	45	12	47	37	4	71	4	12	24		10	8	72	12	2	53	1	14	61	24	13	0	57	0	1	1	6	4	2
			X	4	100	0	0	75	50	50	0	0	75	0	25	0		0	0	25	0	0	25	0	50	75	25	0	0	50	0	0	0	0	0	0



(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic development	Expected effect: Resolution of global problems	Expected effect: People's needs	Expected effect: Expansion of intellectual resources	Forecasted realization time (2001 2006 2011 2016 2021 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Satellite and mobile communication technology	21	Practical use of semiconductor microwave amplifiers with high outputs comparable to those of TWTs (Traveling Wave Tubes), leading to its application to broadcasting satellite etc.	1	112	14	31	54	59	25	60	14	0	84	17	25	10		1	7	67	15	1	69	1	13	45	24	25	2	43	2	1	8	9	9	4
			2	100	14	34	52	58	20	72	8	0	92	9	21	6		0	3	74	13	0	80	0	8	53	19	20	0	52	0	2	6	7	6	3
			X	14	100	0	0	50	7	79	14	0	86	7	7	0		0	0	64	14	0	93	0	0	50	21	14	0	50	0	0	0	0	7	0
	22	Development of satellite communication technology incorporating ultra-broadband transponders etc. with a transmission capacity of at least 1 Gbps per transponder.	1	137	14	30	56	59	26	61	13	1	89	14	29	4		2	3	78	19	4	58	1	9	47	26	20	1	52	10	2	2	9	9	4
			2	118	13	32	55	60	24	68	8	1	96	10	26	1		3	2	85	12	1	63	0	6	54	23	15	0	62	5	3	0	7	6	1
			X	15	100	0	0	63	33	53	13	0	93	7	33	7		0	7	87	7	0	93	0	0	53	27	20	0	47	7	7	0	7	7	0
	23	Practical use of low earth orbit satellite communication systems, leading to their application to mobile communication involving motor vehicles, vessels and aircrafts, as well as personal communication.	1	194	18	29	53	71	45	49	6	0	91	16	60	2		1	1	95	21	1	22	0	1	38	26	19	0	32	39	3	5	25	18	4
			2	174	19	29	52	71	43	54	3	0	91	8	63	0		1	1	95	15	1	22	0	1	44	23	10	0	33	48	1	3	30	17	2
			X	33	100	0	0	79	61	33	6	0	91	6	70	0		0	0	97	21	3	24	0	0	42	21	12	0	30	39	3	0	24	15	3
	24	Development of laser-based space-earth communication technology capable of a bit rate of around 10 Gbps.	1	129	11	31	58	47	14	48	36	2	71	21	10	15		5	7	72	15	3	40	0	13	49	18	24	0	47	7	1	8	9	6	6
			2	116	9	30	60	47	10	58	30	2	80	22	7	9		4	4	84	12	1	46	0	5	56	16	20	0	60	3	2	7	8	3	3
			X	11	100	0	0	57	27	45	27	0	82	0	18	9		9	9	91	18	0	64	0	0	45	18	18	0	64	0	9	0	18	0	0
	25	Widespread use of a system that collects various information from an intensive nationwide network of telemeters for meteorological observation, environmental monitoring and road traffic control, and distributes it to ground stations via satellite.	1	168	9	25	66	65	38	46	13	2	61	43	65	2		3	3	64	21	2	52	1	18	26	31	18	1	45	24	2	5	19	13	2
			2	146	8	22	71	67	38	55	6	1	64	31	73	1		2	2	74	17	0	62	0	12	30	33	11	0	55	29	1	3	22	8	1
			X	11	100	0	0	86	73	27	0	0	73	36	73	0		0	0	73	36	0	82	0	0	18	27	36	0	82	27	0	0	18	9	0
	26	Widespread use of two-way portable communication equipment capable of locating the point of distress signal transmission in an emergency situation.	1	172	10	24	66	60	31	46	22	1	34	5	91	1		2	3	67	19	2	46	0	19	31	22	19	1	36	28	2	0	28	12	1
			2	147	9	22	69	58	24	62	15	0	26	2	92	1		0	1	76	14	0	61	0	15	39	19	14	1	47	29	1	0	39	9	1
			X	13	100	0	0	81	62	38	0	0	38	0	92	8		0	0	92	0	0	54	0	8	38	23	38	0	62	23	0	0	38	8	0
Broadcasting, multimedia communication and intelligent system technology	27	Development of a 4,000×4,000 pixel high-definition display, image sensor, and signal processing technique.	1	167	17	30	53	64	37	48	15	0	80	4	56	13		1	2	43	7	0	93	0	2	43	35	23	1	40	4	4	1	5	13	3
			2	142	15	29	56	64	35	51	13	0	84	3	61	9		1	1	38	3	0	96	0	1	51	32	18	1	42	1	5	1	4	11	1
			X	21	100	0	0	75	52	43	5	0	81	0	62	19		0	0	29	0	0	100	0	0	43	29	24	5	43	0	10	0	5	14	5
	28	Practical use of 90 in. large wall-mountable high-definition flat color displays.	1	172	14	28	58	67	42	43	15	0	74	1	66	4		0	2	29	4	0	94	0	1	37	26	19	1	31	2	3	0	5	16	3
			2	151	11	26	62	66	38	49	13	0	75	1	70	3		0	1	23	1	0	96	0	1	45	23	17	1	32	2	3	0	2	13	2
			X	17	100	0	0	88	75	25	0	0	94	0	88	6		0	0	12	0	0	94	0	0	53	29	24	0	41	0	6	0	6	18	6
	29	Widespread use of a control technique to fix an acoustic image at any desired location in space.	1	127	17	20	63	40	6	45	46	2	45	0	66	10		4	6	53	18	1	61	0	14	43	26	18	0	20	0	3	0	7	15	3
			2	107	17	19	64	42	7	47	47	0	41	0	75	6		3	2	63	16	0	79	0	9	56	25	15	0	23	0	3	0	5	14	3
			X	18	100	0	0	58	22	67	11	0	56	0	67	17		0	0	61	28	0	94	0	0	67	44	17	0	28	0	6	0	6	28	11
	30	Practical use of information filters that automatically sort large amounts of information and selectively choose only those items needed.	1	177	16	31	54	73	50	43	7	0	77	12	66	19		3	4	86	18	1	45	0	7	44	33	15	11	34	12	2	0	36	31	2
			2	155	15	26	59	72	48	46	6	0	78	7	73	9		0	4	93	12	0	53	0	4	54	33	12	7	35	8	2	0	38	30	1
			X	23	100	0	0	78	57	43	0	0	74	17	83	4		0	4	87	13	0	57	0	4	48	30	13	9	43	9	0	0	43	48	0

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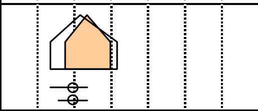
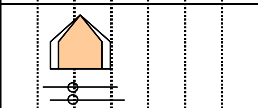
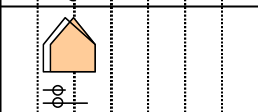
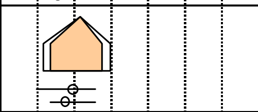
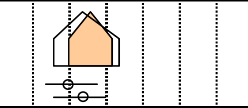
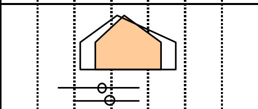
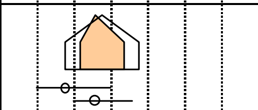
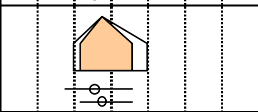
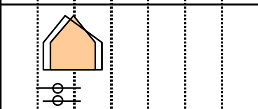
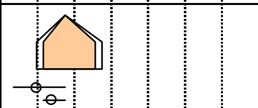
Broadcasting, multimedia communication and intelligent system technology	31	Practical use of information media conversion technologies such as a sign language interpretation communication system enabling a hearing-impaired person and a healthy person to communicate with each other at a great distance apart.	1	168	11	21	68	58	27	48	24	0	26	0	98	8		2	2	54	22	0	42	1	29	47	38	21	1	61	3	2	0	13	28	2
			2	146	10	23	68	58	26	55	19	0	22	0	99	4		2	1	60	18	0	47	1	24	54	37	16	1	70	3	2	0	12	27	1
			X	14	100	0	0	86	71	29	0	0	36	0	100	14		0	0	86	21	0	64	0	0	86	36	7	0	64	7	0	0	7	57	7
	32	Practical use of a support system for visually-impaired persons that converts visual images into audible sounds based on image recognition technology.	1	152	10	26	64	54	24	46	29	1	27	0	97	11		7	11	57	18	0	37	0	29	52	37	20	3	54	1	2	0	7	19	2
			2	136	8	26	66	54	20	58	21	1	22	0	97	7		7	4	64	15	0	41	0	24	62	32	18	1	64	1	1	0	4	21	1
			X	11	100	0	0	73	45	55	0	0	18	0	100	0		9	0	91	9	0	64	0	0	91	27	18	0	64	18	0	0	0	27	0
	33	Development of household TV sets featuring a real-time language translation function.	1	203	11	23	66	59	32	43	24	2	51	9	83	17		11	4	43	25	1	68	0	17	49	34	16	5	45	2	1	0	6	29	1
			2	176	10	22	68	60	29	53	17	1	56	5	88	9		9	3	42	22	1	78	0	13	61	34	11	2	52	1	2	0	3	32	1
			X	17	100	0	0	82	65	35	0	0	82	6	94	12		24	0	71	24	0	94	0	0	82	35	18	0	65	6	0	0	0	29	0
	34	Widespread use of robots that have a tactile sense and work at locations inaccessible to humans via remote control.	1	145	4	19	77	66	38	49	14	0	66	44	55	10		0	5	63	16	3	57	1	17	42	43	23	1	48	2	1	6	16	15	2
			2	123	2	20	77	61	30	57	13	0	68	44	52	6		1	3	76	9	1	65	0	11	43	46	17	1	62	2	1	6	16	11	2
			X	3	100	0	0	67	33	67	0	0	67	67	67	0		0	0	100	0	0	0	0	0	33	33	0	0	33	33	0	0	0	33	0
	35	Widespread use of integrated digital broadcasts based on ground or satellite waves (a service that dynamically combines standard TV, HDTV, and voice and data communication).	1	226	20	34	46	71	47	42	10	0	85	5	68	5		2	2	76	35	0	63	0	5	34	37	19	2	31	46	3	0	11	23	2
			2	196	19	31	49	73	51	41	8	1	88	3	73	1		2	1	82	34	1	66	0	4	35	33	13	1	29	57	3	0	8	29	1
			X	38	100	0	0	87	76	22	3	0	95	0	92	3		0	0	63	21	0	87	0	0	34	34	21	0	29	55	3	0	3	26	0
	36	Widespread use of communication systems for retrieval of still or motion video information from electronic libraries (containing character data, books, still videos, movies, TV, documentary films, etc.) through broad-band lines.	1	254	20	35	45	69	42	48	10	0	72	13	76	20		1	1	87	20	0	54	0	6	26	35	26	12	38	32	5	0	22	33	2
			2	216	18	36	46	66	35	60	5	0	70	8	79	14		1	0	92	17	0	54	0	5	26	35	21	6	45	37	3	0	21	38	1
			X	38	100	0	0	80	61	37	3	0	76	13	82	16		0	0	92	16	0	68	0	0	26	37	34	5	47	32	8	0	18	39	0
	37	Realization of electronic courts based on a teleconferencing system and electronic filing system.	1	162	8	20	72	39	11	38	37	13	39	2	58	6		22	12	48	7	1	16	1	35	12	18	7	7	22	56	4	0	43	57	1
			2	146	5	21	73	37	8	38	41	13	40	1	66	2		21	7	60	4	0	12	0	29	12	15	5	5	19	67	1	0	40	64	0
			X	8	100	0	0	72	63	0	38	0	50	0	75	0		0	13	100	0	0	0	0	0	13	0	0	0	38	75	13	0	38	50	0
	38	Development of an automatic Japanese-English, English-Japanese speech translation telephone system comparable to human simultaneous interpretation in service quality.	1	206	10	22	67	77	58	34	7	0	73	10	78	17		9	4	42	18	0	81	1	9	53	34	14	6	47	2	1	0	9	26	2
			2	176	9	20	72	81	63	34	3	0	73	8	86	10		9	3	39	13	1	84	1	5	63	34	10	3	57	2	2	0	6	34	1
			X	15	100	0	0	100	100	0	0	0	93	13	93	7		27	7	60	27	0	93	0	0	80	47	13	0	67	7	7	0	0	53	0
	39	Widespread use of a multimedia protocol that handles all different communication, broadcasting and package protocols in an integrated manner.	1	201	20	34	46	69	43	46	10	1	83	6	45	10		3	5	87	16	1	31	0	7	45	29	10	1	35	10	3	0	15	15	2
			2	178	16	35	49	69	41	55	5	0	88	3	48	4		3	2	92	11	1	34	0	5	59	25	6	2	39	12	3	0	16	19	2
			X	28	100	0	0	79	61	36	4	0	86	7	36	4		0	4	96	14	0	36	0	0	71	25	4	0	39	11	7	0	21	25	4
	40	Development of a 3-D TV system capable of displaying hidden portions of an object in response to a shift in the focus of the eye.	1	168	10	27	63	47	16	45	35	4	53	3	64	10		5	6	58	14	1	60	0	14	44	30	17	1	31	4	1	0	8	13	3
			2	146	8	25	66	46	11	52	36	1	49	1	74	6		5	1	62	11	1	71	0	10	55	29	15	0	33	3	1	0	5	14	3
			X	12	100	0	0	60	33	42	25	0	58	0	75	0		8	0	58	25	0	92	0	0	50	25	25	0	42	8	0	0	0	17	8

(Note) See page 7 for the interpretation of the graphs.

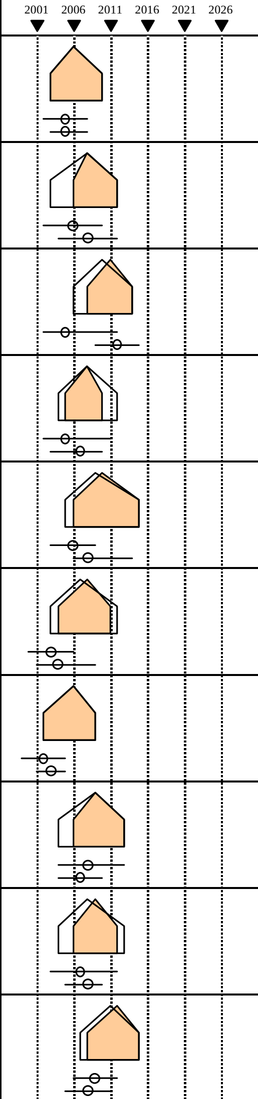
Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time			Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001 2006 2011 2016 2021 2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Broadcasting, multimedia communication and intelligent system technology	41	Widespread use of binocular stereoscopic TV broadcasts that can be enjoyed at home.	1	175	14	25	61	42	13	36	46	6	47	1	63	6		15	15	45	14	0	64	1	15	34	23	10	0	23	5	5	0	5	17	6
			2	155	12	22	66	39	9	34	52	5	43	0	74	3		14	10	45	9	0	72	1	12	46	22	7	0	21	3	5	0	3	19	3
			X	19	100	0	0	54	26	42	26	5	47	0	58	5		21	0	42	16	0	95	0	0	42	16	5	0	37	5	16	0	0	16	16
	42	Development of a home TV set capable of automatic search, recording and replay of up to several hundred programs.	1	199	20	26	54	50	15	58	26	2	64	1	71	10		3	3	70	13	0	58	1	10	26	27	13	4	21	23	3	0	8	26	2
			2	175	18	22	60	49	10	66	24	1	61	0	82	5		2	1	76	9	0	62	0	9	33	30	8	1	18	29	2	0	2	27	1
			X	31	100	0	0	60	29	52	19	0	74	0	94	0		3	0	81	6	0	77	0	0	26	32	6	0	32	42	3	0	6	35	0
	43	Practical use of portable information terminals approximately of the size of a watch which are capable of transmitting/receiving images, sound and data worldwide.	1	231	16	33	51	64	36	49	14	0	76	7	72	6		7	5	66	15	0	74	1	8	38	29	16	1	32	20	2	1	24	24	2
			2	202	15	30	55	61	28	60	11	0	72	3	78	2		6	2	70	14	0	86	0	2	42	28	12	0	35	22	2	1	23	27	1
			X	31	100	0	0	77	55	42	3	0	77	3	77	0		10	0	84	13	0	87	0	0	48	35	16	0	42	26	3	3	19	32	0
	44	Practical use of an ultra-low bit rate encoding method for high quality image and sound signals, which are almost indistinguishable to original signals (at 10 Mbps or less for HDTV-class images with a 1/100 data compression, and 64 Kbps or less for CD-class sounds).	1	200	20	27	53	64	35	54	9	2	73	8	56	13		8	7	74	29	0	70	1	9	51	25	12	3	31	6	3	0	5	13	3
			2	174	21	25	55	63	30	66	3	1	79	5	59	7		7	4	80	21	0	76	0	7	58	20	9	1	32	5	3	0	2	13	2
			X	36	100	0	0	75	53	44	0	3	78	3	64	11		11	3	78	19	0	89	0	3	61	22	14	0	39	8	3	0	3	11	6
	45	Development of an encoding technique that can compress motion video image information to about 1/250 of the original size.	1	186	19	26	55	63	34	53	12	1	73	4	52	11		2	9	76	31	1	63	1	9	51	22	12	1	33	3	3	0	4	11	4
			2	162	17	27	57	60	25	67	7	1	79	2	52	6		2	8	83	24	1	70	0	7	61	15	9	0	36	2	2	1	2	8	2
			X	27	100	0	0	69	41	56	4	0	78	0	67	7		0	7	81	30	4	85	0	4	70	15	11	0	48	4	0	4	0	7	7
	46	Development of a TV program production technology capable of converting a scenario to an actual visual format.	1	102	19	21	61	42	13	39	40	9	57	3	41	19		19	15	44	4	0	30	0	25	40	25	9	3	23	5	3	0	5	24	1
			2	88	15	24	61	41	9	41	46	4	65	0	40	17		18	11	57	1	0	30	0	20	48	23	7	1	26	3	3	0	1	24	1
			X	13	100	0	0	73	50	42	8	0	62	0	62	23		8	15	85	0	0	69	0	0	54	31	15	0	54	8	8	0	0	46	0
	47	Practical use of virtual studio technology capable of taking images of an object from difficult angles.	1	113	15	22	63	45	11	50	35	4	56	5	44	12		3	5	69	9	0	42	2	8	39	29	16	0	23	3	4	1	7	16	4
			2	104	13	17	69	42	8	49	42	2	65	3	40	11		3	2	73	4	0	46	2	7	45	26	14	0	17	2	2	1	4	16	2
			X	14	100	0	0	68	43	43	14	0	71	14	50	14		0	7	71	7	0	79	0	7	43	29	14	0	36	7	0	7	14	29	7
	48	Widespread use of a motion video image replay/transmission and home reception/recording system which is 10 times as fast as the normal speed, leading to the introduction of video-on-demand services based on broadband ISDN communication, etc.	1	212	17	30	52	55	24	51	22	2	73	2	65	3		6	2	74	16	0	64	0	6	32	29	14	1	25	19	2	0	8	23	2
			2	181	14	31	54	53	17	62	20	2	75	1	73	1		6	1	83	10	0	69	0	4	41	29	12	0	27	20	3	0	3	25	1
			X	26	100	0	0	71	50	38	8	4	81	0	85	0		4	0	85	15	0	81	0	0	46	27	23	0	35	23	4	0	8	35	0
	49	Practical use of "electronic secretary" terminals featuring an information agent function for schedule management and database access via a network, as well as voice recognition and fuzzy search functions.	1	224	17	24	60	58	27	53	19	2	78	4	71	9		3	4	81	16	0	50	0	8	40	28	13	4	26	10	3	0	27	24	3
			2	195	16	19	65	55	20	64	15	2	77	1	75	4		2	2	87	11	0	49	0	5	54	29	8	2	25	8	2	0	22	22	3
			X	31	100	0	0	74	50	47	3	0	77	3	77	6		0	0	87	10	0	65	0	0	65	35	13	0	42	10	6	0	13	35	0
	50	Spread of various multimedia networks, leading to the practical use of a system that automatically chooses the most suitable network in terms of communication medium and service quality relative to the cost according to the intended purpose of the user.	1	206	26	27	47	59	29	50	21	1	68	2	67	4		1	4	73	13	0	42	0	15	32	22	10	1	20	21	3	0	17	17	3
			2	177	20	29	51	54	17	66	17	0	68	1	76	2		1	3	82	7	0	43	0	10	44	24	5	0	21	22	3	0	14	16	1
			X	35	100	0	0	68	38	59	3	0	69	0	74	3		0	3	91	9	0	51	0	0	49	31	3	0	26	26	6	0	14	26	0

(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%) High	Degree of expertise (%) Medium	Degree of expertise (%) Low	Importance (index, %) Index	Importance High	Importance Medium	Importance Low	Importance Unnecessary	Expected effect (%) Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Forecasted realization time (2001 2006 2011 2016 2021 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%) USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%) Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%) Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Broadcasting, multimedia communication and intelligent system technology	51	Widespread use of character recognition technologies which enable a recognition rate with handwritten Chinese character of 99% or more.	1	169	9	27	64	70	45	43	11	0	75	1	76	9		8	5	20	8	0	95	0	2	46	31	12	6	40	4	3	0	11	20	3
			2	143	8	25	67	72	48	45	7	0	79	1	83	3		8	2	12	2	0	95	0	1	54	30	8	2	43	3	3	0	8	20	1
			X	11	100	0	0	100	100	0	0	0	100	0	73	0		9	0	0	9	0	100	0	0	55	0	9	9	64	9	0	0	0	27	9
	52	Practical use of high-quality speech synthesizing technologies for automatically turning written information into speech of a quality level nearly equal to that of human speech.	1	179	10	25	65	63	34	49	17	0	61	1	89	8		2	4	56	17	0	80	0	9	45	31	15	7	37	2	2	1	10	25	2
			2	157	9	21	70	60	25	64	11	0	59	1	92	1		1	3	51	13	0	88	0	6	60	27	11	4	41	1	2	1	10	25	1
			X	14	100	0	0	86	71	29	0	0	71	0	100	0		0	0	50	14	0	100	0	0	86	29	0	7	50	7	0	0	7	29	7
	53	Practical use of large-scale adaptive digital filters., eliminating howling caused by interference between microphones and speakers and deterioration in sound quality.	1	125	18	18	63	46	14	44	40	2	52	1	61	5		2	3	50	18	1	68	0	17	37	18	14	0	23	2	6	1	5	10	6
			2	114	18	16	66	45	11	49	39	1	49	0	72	2		0	1	49	14	0	77	0	14	45	15	7	0	29	0	4	0	4	10	2
			X	21	100	0	0	61	29	57	14	0	67	0	76	0		0	0	38	14	0	100	0	0	71	29	5	0	38	0	5	0	5	29	5
	54	Development of a digital broadcasting technology that allows flexible changes in the broadcasting mode via downloaded decoding software.	1	137	18	29	53	56	25	51	22	2	73	3	56	6		3	7	66	23	0	50	0	15	40	23	15	1	26	20	2	0	9	14	2
			2	124	15	29	56	54	18	61	20	1	73	2	61	4		2	2	77	19	0	53	0	10	50	19	10	0	23	22	2	0	4	15	0
			X	19	100	0	0	72	47	47	5	0	79	0	74	0		0	0	84	16	0	53	0	0	58	32	11	0	32	16	5	0	5	21	0
	55	Widespread use of multi-modal environments that allow the coordinated use of various input media including a keyboard, mouse, and voice and image recognition devices, as a common means of human-computer interface.	1	167	16	25	59	65	40	40	18	1	67	2	83	7		2	5	86	20	0	50	0	5	40	35	13	1	29	4	2	1	5	12	2
			2	142	14	23	63	63	34	51	14	1	62	1	86	3		2	3	86	15	0	53	0	4	52	39	8	1	28	4	4	1	4	13	1
			X	20	100	0	0	83	65	35	0	0	80	5	100	0		5	0	85	20	0	90	0	0	75	50	20	0	50	10	0	0	5	25	5
	56	Widespread use of 3-D teleconferencing based on highly realistic 3-D imaging devices.	1	187	12	23	65	45	13	41	44	2	66	10	50	6		5	11	52	17	1	63	0	16	36	22	19	0	33	4	3	0	7	16	3
			2	162	10	20	69	44	12	43	44	2	72	4	57	2		6	4	59	10	1	72	0	8	46	23	12	0	36	1	4	0	4	14	1
			X	17	100	0	0	65	41	35	24	0	76	0	53	6		0	0	35	12	0	94	0	0	53	18	24	0	41	0	6	0	6	24	6
	57	Widespread use of communication systems designed to closely interconnect satellite offices via a network through, for example, an image display covering an entire wall for a super-realistic visual effect.	1	187	12	33	55	52	20	49	29	2	75	16	56	4		5	4	65	11	0	67	0	10	33	32	16	1	29	10	3	1	10	24	3
			2	163	9	34	57	52	17	59	22	2	79	10	57	2		6	4	69	5	0	73	0	5	42	32	11	0	28	10	4	0	7	21	1
			X	15	100	0	0	78	60	33	7	0	73	0	60	7		0	0	60	0	0	93	0	0	33	33	13	0	33	13	13	0	7	40	7
Networking technology	58	Practical use of a seamless broadband access that makes broadband services capable of a bit rate of at least 100 Mbps accessible from outdoor portable information terminals and mobile systems, as well as indoor terminals such as those in offices.	1	225	22	41	37	67	39	50	10	1	89	6	59	6		4	3	81	27	0	63	0	6	43	28	20	0	37	32	2	2	22	18	3
			2	198	21	39	40	65	35	59	6	1	93	4	64	2		3	3	88	24	0	66	0	4	54	26	17	0	41	33	2	1	26	17	1
			X	41	100	0	0	79	59	41	0	0	100	2	61	2		2	2	90	34	0	76	0	0	73	29	24	0	39	29	0	2	22	22	0
	59	Development of collaboration support technology designed to assist in the operation of virtual companies in terms of carrying out tasks such as planning, designing, manufacturing and marketing, through the integration of their facilities, functions and human resources that are scattered over different locations and organizations, via a network.	1	178	15	31	54	65	37	50	13	1	90	20	40	11		1	2	84	17	0	43	0	6	35	40	13	1	29	24	3	1	22	30	1
			2	155	11	32	57	62	28	63	8	1	94	11	34	7		0	1	90	10	0	37	0	3	44	41	8	0	25	28	2	0	20	31	0
			X	17	100	0	0	90	82	12	6	0	94	24	35	6		0	0	94	6	0	59	0	0	41	35	0	0	41	18	6	0	18	41	0
	60	Practical use of a LAN configuration technique that enables individuals to make virtual connection to the respective networks to which they belong (logical LANs), regardless of the actual location of network connection and physical network involved.	1	199	17	30	53	68	39	54	7	0	77	8	54	7		1	3	88	16	0	42	0	6	40	24	16	1	25	17	3	0	31	19	1
			2	173	14	33	53	64	29	67	3	1	84	4	54	2		1	0	93	12	0	41	0	5	49	24	10	0	27	18	3	0	32	16	0
			X	25	100	0	0	78	56	44	0	0	84	0	64	4		4	0	96	20	0	68	0	0	56	28	8	0	36	20	4	0	28	32	0

(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Medium	Low	Importance (index, %): Index	High	Medium	Low	Unnecessary	Expected effect (%): Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Networking technology	61	Widespread use of ambulance-hospital data communication systems for the transmission of images and emergency medical care instructions.	1	195	11	29	61	71	48	42	10	1	37	2	98	2		0	1	72	18	0	46	1	16	27	35	16	7	48	31	4	0	29	18	2
			2	173	9	27	65	72	47	44	9	0	32	1	95	1		1	1	79	13	0	47	0	13	29	39	11	5	61	34	2	0	30	18	1
			X	15	100	0	0	87	73	27	0	0	33	0	93	0		0	0	80	13	0	80	0	0	33	40	27	0	73	47	0	0	40	40	0
	62	Advancements in the autonomous distributed control of wide-area communication network management, leading to the practical use of a technology that ensures a crash-proof network.	1	188	22	36	41	76	56	37	6	1	78	6	49	6		3	3	81	21	0	60	0	7	46	22	20	1	28	8	2	0	15	7	2
			2	162	20	38	42	79	60	36	3	0	86	4	49	2		0	1	88	15	0	68	0	3	58	20	15	1	31	6	1	0	14	5	1
			X	33	100	0	0	89	79	18	3	0	76	6	45	3		0	0	91	15	0	76	0	3	55	9	27	0	30	6	3	0	12	9	0
	63	Practical use of integrated building management systems and home security systems which are linked to an earthquake detection system and take the necessary safety measures to protect human lives in the event of a non-direct-hit earthquake, taking advantage of the time lag to the arrival of seismic waves.	1	125	10	16	74	83	69	25	4	2	43	26	87	4		7	3	29	5	2	64	0	18	36	41	22	3	65	10	1	1	27	10	1
			2	109	6	7	87	86	75	20	4	1	39	25	89	3		6	2	26	7	2	77	0	12	37	34	18	2	78	7	1	1	37	9	0
			X	6	100	0	0	83	67	33	0	0	50	33	67	0		0	0	50	33	0	67	0	17	33	17	33	17	100	17	0	0	17	33	0
	64	Practical use of communication networks allowing the easy control of the network service quality aimed at the efficient utilization of network resources and improvements in heavy-traffic robustness and reliability.	1	204	29	31	40	69	41	51	7	1	83	7	41	4		1	1	79	18	0	59	0	7	43	20	17	1	25	14	2	0	13	9	2
			2	178	26	32	42	68	38	59	3	0	89	2	38	1		0	0	85	13	0	62	0	4	54	20	11	1	29	10	1	0	11	7	0
			X	46	100	0	0	74	49	51	0	0	87	2	43	0		0	0	83	20	0	74	0	0	52	13	15	2	26	11	2	0	9	7	0
	65	Widespread use of interconnected home security systems with functions such as crime and disaster prevention as a community-wide security system.	1	168	8	20	71	63	34	49	15	2	48	6	95	2		6	6	61	15	0	48	0	23	23	35	12	3	34	39	2	0	49	28	1
			2	145	6	22	72	59	24	65	8	2	42	1	92	1		3	2	70	12	0	50	0	15	26	32	7	0	40	48	1	0	54	27	1
			X	9	100	0	0	69	44	44	11	0	78	0	89	0		0	0	100	44	0	67	0	0	22	22	22	0	44	67	11	0	44	22	0
Security technology	66	Widespread use of on-line seal-less document preparation services for various official documents such as contract documents which are provided via a network based on security technology capable of achieving both privacy protection and verification.	1	216	9	28	63	74	52	39	8	0	85	8	68	3		1	4	86	27	0	42	0	6	31	29	8	4	24	58	3	0	62	35	2
			2	182	8	27	65	79	62	33	5	1	88	5	70	2		1	2	90	22	0	44	1	4	37	28	7	2	24	74	2	0	66	40	0
			X	14	100	0	0	89	79	21	0	0	93	14	71	0		0	0	100	29	0	57	0	0	43	14	7	7	43	79	14	0	71	36	0
	67	Widespread use of electronic commerce carried out via a network based on an electronic funds transfer system and electronic money system.	1	225	10	30	60	81	64	32	3	0	89	8	69	4		1	3	92	44	0	40	0	2	29	34	10	5	24	62	3	0	66	38	1
			2	195	9	28	64	85	72	26	2	1	90	4	68	2		1	1	93	43	0	41	1	1	32	38	6	2	24	77	1	0	67	41	0
			X	17	100	0	0	91	82	18	0	0	94	12	59	0		0	0	100	29	0	41	0	0	35	35	6	6	29	82	12	0	59	53	0
	68	Widespread use of a security technology that automatically monitors illicit activities involving network ethics, such as copyright infringement concerning multimedia software use over a network and the violation of privacy.	1	186	11	21	68	75	54	35	10	0	75	5	57	12		10	11	79	20	0	25	1	13	35	31	10	3	27	45	2	0	54	37	1
			2	166	10	19	72	81	64	31	4	0	84	2	59	8		7	7	86	18	0	25	0	7	36	27	6	1	25	62	1	0	59	38	0
			X	16	100	0	0	88	75	25	0	0	88	6	69	6		0	0	94	19	0	44	0	0	50	31	13	6	31	56	13	0	44	38	0
	69	Widespread use of security systems capable of identifying individuals based on the recognition of distinguished features of a person such as finger prints, hand writing, voice and face.	1	187	16	17	67	67	43	43	14	1	73	3	72	6		2	4	75	19	1	61	1	10	43	33	11	4	29	29	2	0	60	34	1
			2	165	13	18	68	71	46	48	5	1	79	2	72	2		0	2	84	16	0	67	1	5	53	31	8	1	30	33	2	0	64	35	0
			X	22	100	0	0	84	73	23	0	5	82	0	64	0		0	0	95	9	0	82	5	0	45	59	0	5	50	41	0	0	64	45	0
	70	Realization of high-security communication, and widespread use of electronic secret ballots.	1	176	11	18	72	53	25	41	31	3	55	6	66	2		9	11	57	18	1	29	0	28	23	20	9	3	23	53	3	0	49	48	1
			2	159	8	15	77	53	21	52	26	2	57	2	75	2		9	6	69	14	0	29	0	22	26	18	7	1	18	71	1	0	57	53	0
			X	12	100	0	0	81	67	25	8	0	75	8	67	0		8	0	92	17	0	58	0	8	33	33	0	0	42	75	0	0	42	58	0



(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic development	Expected effect: Resolution of global problems	Expected effect: People's needs	Expected effect: Expansion of intellectual resources	Forecasted realization time (2001 2006 2011 2016 2021 2026)
Common element technologies	71	Practical use of low bit rate high quality video encoding technology capable of a bit rate of around 10 Kbps (with a 1/20,000 data compression) suitable for mobile communication and the Internet.	1	206	15	33	52	65	37	50	13	1	80	6	61	9	
			2	180	14	33	53	62	30	59	10	1	82	3	67	2	
			X	25	100	0	0	67	40	52	4	4	72	0	84	4	
	72	Development of high performance batteries with an energy density of about 500 Wh/Kg, capable of miniaturizing mobile phones in terms of both size and weight.	1	103	6	20	74	86	73	25	3	0	78	49	57	9	
			2	90	6	21	73	87	75	21	3	0	87	41	60	1	
			X	5	100	0	0	90	80	20	0	0	100	40	80	0	
	73	Development of light-reflecting liquid crystal color displays (no backlighting) with the advantage of low power consumption.	1	101	7	25	68	71	46	46	8	0	70	25	50	3	
			2	88	6	22	73	71	44	53	3	0	83	17	49	1	
			X	5	100	0	0	100	100	0	0	0	100	0	60	0	
	74	Practical use of biochip devices that have a memory density (10^{12} bit/cm^2) 1,000 times that of current semiconductor devices (10^9 bits/cm^2).	1	67	6	15	79	75	55	34	9	2	84	21	37	33	
			2	59	5	10	85	82	68	23	9	0	88	12	29	27	
			X	3	100	0	0	100	100	0	0	0	67	33	33	33	
	75	Practical use of a technology that makes power transmission between a space-based and earth-based sites and between space-based sites at microwave frequencies or higher possible.	1	117	3	22	74	57	27	52	17	4	56	68	9	9	
			2	103	4	20	76	53	17	65	16	3	52	77	5	4	
			X	4	100	0	0	75	75	0	0	25	50	50	0	0	
	76	Development of a satellite-borne ultra-high resolution spectroscope for the monitoring of the upper-atmosphere, capable of discerning the spectral distribution (far infrared to submillimeter range) to an accuracy level of one 10 millionth of the frequency used.	1	54	2	22	76	63	35	44	20	0	39	76	19	28	
			2	49	2	20	78	59	27	57	14	2	31	80	4	16	
			X	1	100	0	0	100	100	0	0	0	0	100	0	0	
	77	Practical use of an atomic frequency standard with stability and accuracy levels of 10^{-16}- 10^{-17}.	1	51	4	27	69	53	19	54	27	0	57	14	6	49	
			2	49	2	22	76	52	16	61	20	2	59	4	2	41	
			X	1	100	0	0	25	0	0	100	0	100	0	0	100	
	78	Development of a space environmental fluctuation prediction system involving radiation, high-energy particles, etc. that can cause such phenomena as the malfunctioning of satellite-borne equipment, degradation of solar cells, abnormal charging of satellites, etc.	1	49	2	31	67	52	18	53	29	0	45	43	10	24	
			2	47	2	30	68	51	15	62	21	2	57	40	4	19	
			X	1	100	0	0	50	0	100	0	0	100	0	0	0	

Topic serial No.	Questionnaire round	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
71	1	13	10	74	28	0	60	1	12	47	25	17	1	32	3	1	0	12	12	2
	2	13	7	82	27	0	67	1	8	59	24	11	1	34	1	2	1	11	10	1
	X	12	8	84	36	0	80	0	0	64	20	20	4	44	0	4	0	8	4	4
72	1	1	10	44	17	2	65	0	18	50	22	19	3	49	0	3	21	6	8	2
	2	1	7	44	7	0	79	0	11	59	22	19	1	59	0	2	27	4	7	1
	X	0	0	40	0	0	100	0	0	80	20	20	0	100	0	0	20	0	20	0
73	1	1	8	25	5	1	85	1	6	41	27	13	0	35	0	3	8	2	11	5
	2	0	5	27	1	0	89	1	3	55	22	6	0	39	0	5	7	1	7	3
	X	0	20	20	0	0	80	0	20	40	20	0	0	80	0	0	20	0	20	0
74	1	7	21	57	13	0	46	1	19	49	30	24	9	57	0	3	6	6	12	4
	2	8	14	68	2	0	63	3	14	61	25	14	5	58	0	2	5	5	12	5
	X	0	0	67	0	0	100	33	0	100	33	0	33	100	0	0	0	0	0	0
75	1	9	15	70	8	4	31	0	19	38	26	26	1	50	3	2	40	8	7	2
	2	8	15	82	5	3	33	0	12	46	22	20	0	63	1	2	46	11	3	1
	X	50	0	100	0	0	100	0	0	50	25	25	0	50	0	25	50	0	0	0
76	1	0	11	67	20	6	43	2	20	54	22	33	2	69	0	2	17	4	6	2
	2	2	12	76	14	0	47	0	14	59	6	27	0	73	0	2	12	0	2	0
	X	0	0	100	100	0	0	0	0	100	0	0	0	100	0	0	0	0	0	0
77	1	4	18	55	24	4	47	0	24	43	14	25	4	47	0	2	6	4	8	2
	2	4	10	59	8	0	49	0	16	55	6	24	0	63	0	2	0	0	10	0
	X	0	0	0	0	0	100	0	0	100	0	0	0	100	0	0	0	0	0	0
78	1	6	6	82	22	12	41	0	14	47	12	41	6	53	0	2	14	8	0	2
	2	6	6	85	11	2	34	0	9	60	9	30	4	66	0	2	15	0	2	0
	X	0	0	100	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0

(Note) See page 7 for the interpretation of the graphs.

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13. Survey Results in "Transportation"

13.1. Trends in areas of attention

13.1.1. Trends towards computerized and intelligent transportation systems

— Computer-based harmonized transportation systems and elimination of human factors —

In any industrial field, the sophistication of systems through the application of information technology is regarded as a priority issue. In the transportation field, efforts are being made to enhance transportation systems in terms of safety, speed, convenience, efficiency and environmentally friendliness, which are basic requirements for any transportation system, through, for example, an improvement in overall system efficiency via control and guidance and an improvement in safety and efficiency via the elimination of human error mainly by means of sensing and artificial intelligence technology.

In the transportation field, computerization or intelligent systems featured in 18 topics, which were broken down by type of transportation as follows: 3 out of 9 topics for rail and track transportation; 5 out of 23 topics for road transportation; 7 out of 13 topics for water and underwater transportation; 2 out of 11 topics for air transportation; and 1 out of 4 topics for other new transportation. This represents a slight fall from the previous survey.

It is interesting to note that the information technology share of topics was large in areas where hardware has matured, while it was relatively small in areas where there is still considerable room for further hardware development, ranging from more than half for water transportation, e.g. ships, to a mere 2 out of 11 for air transportation.

Although it is not clearly reflected in the topics in the latest survey, computerized systems for which technical feasibility has been fully investigated, such as a uniform fare collection system based on a smartcard, a bus operation information display system and a computerized physical distribution system, already exist, and the large-scale introduction of information technology is now on the agenda.

The three topics from the area of rail and track transportation were "01: Development of intelligent railway vehicles able to obtain improved riding comfort" (2006), "05: Inspection robots" (2008) and "06: Automatic train control system based on the detection of obstacles" (2005), which relate to intelligent systems and robotization centering on sensing. The four topics from the area of road transportation were "10: VR driving simulators" (2002), "14: City traffic control systems" (2007), "19: Motor vehicle driver support system" (2008), and "20: Automatic motor vehicle operation via guidance and control" (2015) and "24: Bridge fatigue monitoring" (2009) which aim to achieve efficient transportation by tackling road congestion via control and guidance, instead of allowing individual vehicles arbitrary operation. Motor vehicles represent highly convenient door-to-door means of transportation, and at present, this is achieved through the independent operation of individual vehicles. However, efforts are being made to develop a control and guidance system capable of bringing collective efficient operation to vehicles based on information technology as well. The seven topics from the area of water and underwater transportation were 36. Fully automatic ships (2014), "37: Autonomous, unmanned, underwater investigation vessels" (2009), "38: CIM for shipbuilding" (2006), "41: Fully automated container yards" (2007), "42: Marine traffic control systems" (2011), "43: Vessel collision avoidance systems" (2007) and "44: High-reliability vessels" (2008), which center on automation and intelligent systems aimed at replacing human judgment with computers to increase operation efficiency. This reflects the present state of shipbuilding and shipping industries. For a long time, ships and boats have been operated as self-contained systems, where the captain is held totally responsible for any accident involving his vessel, without instructions, monitoring or any other form of intervention from outside. Monitoring, control/guidance, full automation, etc., therefore, represent a complete turnaround from traditional practices, and this shows the significance of the impact of information technology and artificial intelligence.

The two topics from the area of air transportation were "53: Computerized air traffic control" (2009) and "54: All-weather fully automatic aircraft takeoff and landing" (2009), which aim to increase safety and reliability by having computers take over many complex procedures traditionally undertaken by humans. The only topic from the area of other transportation systems was “58: Intelligent wheel-chairs” (2008).

According to a rough classification, component technologies include robotics, sensing/monitoring, control/guidance, and autonomous operation/artificial intelligence application. In rail and track transportation, the systematic operation of trains and cars is a prerequisite. In contrast, the operation of transport vehicles is basically autonomous in road transportation, water and underwater transportation and air transportation, and efforts are focused on control/guidance aimed at the overall harmonized operation of individual vehicles to achieve congestion alleviation, environmental load reduction, efficient operation, etc. A reduction in human involvement in transport vehicle operation itself will lead to a reduction in human errors, which is said to be responsible for 80% of all accidents, and costs. The computerization of and robotization of design, manufacturing and maintenance processes will also lead to a reduction in costs and inspection errors.

In search of safe, efficient and highly-capable transportation systems, the application of information technology is under consideration, with efforts focused on establishing a technology which, while maintaining plenty of freedom and convenience for individual vehicles, increases overall efficiency, reduces tedious work associated with vehicle operation, and is comfortable for vehicle operators and very safe.

(Hiroyuki Yamato)

13.1.2. Sophistication of transportation functions (high speed, convenience and more sophisticated services)

Coinciding with the arrival of an information society, etc., the sophistication of transportation functions is being called for. Instead of single-mindedly evolving in the direction of reducing the movement of people, the information society has added a new meaning to meeting for people and actually increased its importance. For this reason, amid increased sophistication in people’s social lives, demands for faster and more convenient transportation systems are expected to intensify. As people’s leisure life becomes more substantial and their values change, demands for greater comfort during transit have begun to be voiced as an important element of transportation services in addition to simple conveyance. Meanwhile, advances in the aging of the population, etc. have led to consideration for disadvantaged people in transportation, with advanced services, such as the introduction of escalators and elevators at transportation terminals and special arrangements to accommodate wheelchairs, gradually spreading. In various transportation modes, technological development and improvements aimed at increasing the sophistication of transportation functions are taking place, with high expectations expressed in the latest survey.

First of all, in the area of rail and track transportation, the development of 0.4 Superconducting magnetically levitated railways with a maximum speed of 500 km per hour (2011) is under way in pursuit of high-speed transportation. Efforts are also being made to speed up existing wheel traction systems, with 08. Operation of Shinkansen bullet trains at a speed of 350 km/h with environmental protection measures expected to be realized relatively soon (2006). With road transportation systems, a call for environmental friendliness and safety was expressed more frequently than that for high-speed transportation due to their nature of being designed primarily for short-distance transportation. Nevertheless, there are expectations for the development of 15. Dual-mode motor vehicle transportation system in which vehicles travel at ultrahigh speeds along specified sections (2016). With water and underwater transportation systems, “33: Widespread use of sea traffic transportation network systems operating at speeds of 30 knots or faster carrying 300 passengers or more” was forecasted to be realized in the early 21 century (2010) to cater for the needs of commuters and business travelers around major cities. In water freight transportation, the modal shift concept geared towards encouraging a shift from motor vehicle transportation to water transportation has been proposed in view of the energy problems, with expectations expressed for the following topics: “34: Development of an ocean freight transportation facility based on technologies including superconductivity” (2017) and “35: Development of large high-speed boats about 500 tons in dead-weight, constructed entirely of non-steel new materials” (2008). However, regarding the development of an ocean freight transportation facility based on technologies including superconductivity, doubts about its realizability or at least the need for a long development period was raised, partly due to the numerousness of technical problems to be overcome. In air transportation, current systems are considered to have sufficient high-speed capabilities, compared to other types of transportation systems, with a further speed increase expected through “48: Development of a supersonic passenger capable of speeds up to Mach 3~4 with a maximum of 300 passengers on board” though its forecasted realization time is rather distant (2016).

Many of the forecast topics relating to improvements in convenience and sophistication in service, rather than high speed involve people’s needs. In rail and track transportation, inter-company mutual train operation arrangements have been established for various subway and suburban railway lines to improve user convenience. Although these arrangements are sometimes impossible, when connecting lines use different rail gauges, the early realization (2007) of “02: A system that enables railway vehicles mounted on motorized-trucks to roll onto tracks of different rail gauges” is expected. Rail freight transportation is important in view of global environmental problems etc., and the task ahead is believed to lie with connection on to road transportation, with “03: A system in which road trucks become railway vehicles” (2009) under development. In road transportation, hopes were pinned on “14: Widespread use of road traffic control systems for optimal control” (2007) and “16: Practical use of a shared connection-vehicle system with a re-location function” (2013) to address urban and local transportation needs, while expectations were raised for “18: Development of a construction method that can halve the time required for pavement repairs” (2006) for expressways as inter-city transportation facilities. In water and underwater transportation, the realization of “36: Development of fully automatic ships” (2014) and “40: Achievement of some 20% increase in propeller efficiency” (2009) were expected against a background of calls for greater safety and efficiency and shortages of specialists in freight transportation. In air transportation, expectations were raised for technological development aimed at service improvements through greater physical convenience and lower air fares. Examples include 46. Practical use of flying boats featuring new materials etc. for regular transportation services (2014), “49: Development of an ultra-large passenger aircraft” (2015) and “51: Reductions in direct aircraft operating costs to about half (2013). With new transportation systems, consideration for disadvantaged persons has become an important aspect of technological development, with expectations raised for “57: Practical use of robotic guidance systems for visually impaired people” (2006) and “58: Practical use of intelligent wheel-chairs capable of coping with stairs, slopes, etc.” (2008), along with “59: Practical use of cableways used in mountainous areas in urban transportation through technical sophistication and refinement”(2009) and “60: Practical use of vertical transportation systems for super high-rise buildings with a transporting capacity at least five times that of current elevators” (2011).

(Naoto Egawa)

13.1.3. Environment, energy and recycling

Environment, energy and recycling are issues that are at present a focus of keen attention.

In the 1970s, when this survey first began, environmental problems involving transportation systems were mainly of a local nature. Examples include air pollution by motor vehicle exhaust along major roads and the Shinkansen bullet train noise. As well as local problems, however, environmental problems have become recognized as global problems involving many different sources apart from transportation systems in recent years, and have expanded in scope to include socioenvironmental issues, such as global warming (caused by excessive carbon dioxide emissions and heat generation), the heat island phenomenon, depletion of the ozone layer, acid rain (and other secondary environmental problems), resource recycling, industrial waste problems and energy consumption reductions.

Against this background, topics relating to environmental protection and recycling were recognized as most important in the latest survey, accounting for 5 out of the 10 topics that had highest degree of importance index scores. There were 60 topics altogether including 14 from the environment-related area.

Regarding motor vehicle emissions, which were the No. 1 issue, there have recently been calls for the development of more advanced technologies geared toward meeting more stringent regulations, such as the introduction of an LEV regulation in the state of California, U.S.A., and the setting of short and long-term emission targets for diesel-powered vehicles in Japan. As a result, 26. Widespread use of electric vehicles

(2011) and 30. Emission control technologies for diesel-powered vehicles (2010), which are topics from this area, were ranked high among the 10 most important topics, and an increase in the government's funding for research, fostering of researchers and promotion of exchanges among industrial, academic and government sectors/different fields were called for as necessary measures for the realization of these technologies. Although there was no topic with direct reference to global warming, attributable to carbon dioxide emissions, great interest was shown in exhaust emission reduction measures in the context of energy problems, which are discussed below. It is anticipated that strong calls for the development of technologies that reduce the emission of pollutants from mobile emission sources other than motor vehicles also exist, although this was not included in the questionnaire.

Regarding traffic noise problems, efforts have been made to develop noise reduction technologies for the Shinkansen to address increases in its train operating speeds, while environmental quality standards for railway noise have been set as control guidelines, covering the Shinkansen as well as conventional railway lines. Against this social background, there is an urgent need to develop noise reduction technologies, and topics relating to this issue, such as "04: Superconducting magnetically levitated railways" (2011) and "08; Operation of Shinkansen bullet trains at a speed of 350 km/h while satisfying environmental quality standards" (2006) were rated high in terms of the degree of importance index. In air transportation, "55: Floating off-shore airports" (2009) were rated high, reflecting recent social trends. However, "47: A low noise vertical take-off and landing (VTOL) airplane" (2014) and "56: A low-noise helicopter" (2012), which relate to pure aircraft technologies, did not enjoy high importance ratings, while Japanese technology was rated low compared to that of the United States, with late realization times forecasted. In motor vehicle transportation, 28. Noise reduction for heavy-duty freight trucks (2010), was rated high, ranking among the 10 most important topics. Apart from this, "12: Noise reduction through improvements in road paving" (2009) and "29: Active noise control devices" (2014) were regarded as relatively important.

Regarding energy problems, "17: Motor vehicles 30% more fuel efficient than today's vehicles" (2007) was ranked No. 3 in the entire transportation field in terms of the degree of importance index, indicating strong interest, while, with "26: Electric vehicles" (2011) and "27: Electric vehicles based on fuel cells" (2014), which relate to oil-alternative energy sources, greater importance tended to be attached to the social environment and operational infrastructure than technological development. Although topics such as "09: Regenerative energy storage device" (2009), which relates to rail vehicles, attracted great technical interest, their feasibility was rate fairly low. There were quite a few voluntary opinions which pointed out, from outside the context of the questionnaire, that improvements in transportation systems and congestion alleviation measures would indirectly lead to energy savings.

Regarding recycling, "31: Recycling of motor vehicle parts and materials" (2009) were considered most important among all topics, indicating the existence of a high level of interest, along with "45: FRP vessel disposal technology" (2007), which relates to industrial waste disposal.

In the environment, energy and recycling area, a number of voluntary opinions were offered, expressing the need for an integrated approach encompassing issues such as the social environment (e.g. infrastructure and legal controls), costs and recycling, as well as the development of cutting-edge and innovative technologies. It was pointed out that this was a major reason why forecasted realization times were pushed back in most technological areas, along with the realization of the enormity of technological challenge, which became more apparent as R&D progressed.

(Shin Narasaka)

13.1.4. Safety and disaster prevention/preparedness

Safety is the most fundamental requirement for transportation, and its importance cannot be overstated. The share of topics relating to safety was 3 out of 9 in railway transportation, 6 out of 23 in road transportation, 3 out of 13 in water transportation, 2 out of 11 air transportation, and 1 out of 4 in other new types of transportation. As safety is the prerequisite for all new transportation technologies, all topics relating to transportation should, in a broad sense, be interpreted as including safety improvement technologies. In addition to technological development as a measure to reduce conventional types of accidents, safety improvement technologies developed in preparation for changes in social conditions in the future, such as labor shortages and the aging population, and safety technology as a prerequisite for the establishment of new transportation technologies, such as high speed transportation, were included as topics of direct relevance, with their importance rated high.

Remote sensing, GPS, laser, sensor technology, such as ultrasound, information technology/artificial intelligence form the basis of safety improvement technologies, and, building on technological innovation in these areas, the development of control and guidance systems that assist human decision-making and total systems that achieve automation are being pursued. As a result, individual topics overlap with those mentioned in 13.1.1.~3., and are therefore not discussed here. Other technologies include "13: Development of composite materials that adapt to external stimuli by changing characteristics for use in motor vehicle bodies to change their crash rigidity". (2014), "24: Monitoring of fatigue levels of bridges" (2009) and "22: Road surface snow-melting systems based on solar heat" (2010).

Just featuring earthquakes, there were only three topics that related to disaster prevention/preparedness as follows: "07: An automatic train stopping system based on the detection of the initial mild tremors of an earthquake" (2006), "23: Road structures with self-repairing functions to overcome damage sustained in major earthquakes" (2021) and "52: An observation and communication system deployed in midair for disaster prevention and other purposes" (2013). Due to restrictions on the number of topics and the need to avoid overlapping with other fields, there were not many topics relating to disaster prevention/preparedness in the transportation field. However, technological development geared toward disaster prevention/preparedness is extremely important in Japan as a disaster-prone country.

For accident prevention and disaster prevention/preparedness, a systems approach is particularly important, even more so than the development of individual technologies, giving rise to the need for system designs that regard the occurrence of accidents/disasters as a real possibility and improve overall safety encompassing transportation systems, transportation spaces, social and natural environments, and human beings. The Great Hanshin-Awaji Earthquake of 1996 reminded us anew of the importance of incorporating transportation safety into the social crisis management system, as well as the adoption of transportation system designs that take into account the desired functions of transportation systems in emergency situations. To this end, however, numerous problems must be overcome.

(Shigeru Morichi)

13.1.5. Transportation systems for affluent and fulfilling future society

Transportation systems in an affluent and fulfilling future society must be safe and environmentally-friendly, and capable of transporting passengers to their destinations with promptness, speed, comfort and low cost, with these individual requirements already discussed elsewhere in this report. To meet the needs such a future society, therefore, transportation systems must evolve to combine these elements in a comprehensive and balanced manner.

Major recent technological advances made in the field of transportation include i) greater reliability and speed and lower prices and size/weight in computer technology, as well as ii) greater reliability and lower prices in new materials centering on composite materials and new alloys. In the software area, there has been rapid progress in the iii) transportation system and transportation demand management techniques. Supported by progress in these areas, advances in transportation systems are expected to continue in the future, particularly in terms of labor saving, automation and effective management in areas of control/guidance, operation, maintenance and design though they are still at the conceptual stage, where there are plenty of ideas but few concrete achievements. Technologies expected to become important in the future include a design approach that takes recycling into consideration, a social penalty system that encourages consideration given to the environment, sacrificing performance and cost advantage, if necessary, and disaster prevention/preparedness design techniques that quantitatively incorporate estimated parameter values of disasters that are considered possible. With transportation systems that depend on internationally standardized hardware, such as vessels, aircraft and motor vehicles, new technologies must be implemented in accordance with international standards. While this would require a global-scale research cooperation structure, there is a high possibility that it will become a particularly disadvantageous area for Japan due to a language barrier and its unique social structure.

In the future, advances in the transportation field will be made within each of the railway, aircraft, motor vehicle, vessel, and other areas by incorporating new technologies, but the realization of large-scale new transportation systems do not seem likely. This is because conventional systems are capable of satisfying a large part of basic transportation needs, while the establishment of new systems would require enormous amounts of time and money. However, the realization of small-scale systems which cater for needs that cannot be covered by existing systems, such as the following, are forecasted: “57: Robots to guide blind people in particular districts such as stations and shopping centers” (2006) and “58: Intelligent wheel-chairs capable of coping with stairs, escalators, slopes, etc.” (2008) (systems designed for ease of use by the elderly and the disabled); and “60: Vertical transportation systems for super high-rise buildings” (2011) (a system designed for new architectural spaces), with fairly early realization expected, according to the survey results. Other future challenges include the following: “16: Shared connection-vehicle system used for transportation between specified areas or terminals” (2013) and “59: Cableways and other transportation systems that can be used for moving between a hilltop residential area and a railroad station below or between downtown building” (2009) (short-distance, diverse and convenient transportation systems for conveyance between the home and station); and “02: System that enables railway vehicles mounted on motorized-trucks to roll onto tracks of different rail gauges” (2007), “03: System in which road trucks become railway vehicle” (2009) and “15: Dual-mode motor vehicle transportation system” (2016) (mutual ride-in system between transportation systems of different modes).

In the transportation field, integration with the environment and city planning is an area which should be addressed in the future. While there are high expectations for transportation systems that give consideration to the environment, as discussed in detail under the environment in this report, this will be taken a step further, and transportation systems that are integrated with economic systems in terms of where to produce, consume and recycle or dispose of goods will be considered as part of city planning or regional development planning at the national level. In the near future, this will be accelerated by the fact that the supply of land, air and energy, which are resources until now considered unlimited, is in fact finite and places constraints on various human activities as industrial and economic activities intensify. As the availability of resources varies widely from one country to another, transportation systems will exhibit country-specific characteristics, resulting in the international coexistence of various transportation system models. In light of the fact that most developing countries are not resource-rich like the United States, Japan could play an important role, if it was able to propose and implement a transportation system model worth pursuing for developing countries, and this gives rise to an urgent need for the development of human resources and research environments suitable for proposing and establishing international standards leading to such a transportation system model under a global-scale research cooperation structure.

Recent history shows that, as receiving information from remote areas at fast speeds via written text, conversation and images stimulates becomes easier, people’s curiosity and sense of need is stimulated, and the demand for fast, comfortable and safe means of transportation increases. In view of the rapid increase in the number of people leaving for overseas destinations, which now far exceeds 10 million, and rapid progress in global computerized information handling, the growth in the demand for transportation services is expected to continue in the future.

(Keiji Kawachi)

13.2. Forecast topic framework

In the course of compiling forecast topics, a framework representing the organization of technologies in tabulated matrix form was drawn up for each field, with objectives and technological domains defining the rows and columns of the table, respectively. The framework is designed to present an overall picture of technological development in each field in terms of future prospects, importance, etc. as seen from the present perspective, and is also used as a working framework for future reviews of forecast topics.

Table 13.2-1 Forecast Topic Framework for Transportation Field

Objective \ Domain	Rail and track transportation systems	Road transportation systems	Water and underwater transportation systems	Air transportation systems	Other new transportation systems
Transportation services that are comfortable and convenient to use (comfort, human touch, culture, convenience, elements of play and response to aging population)	01	10 11 12 13 14	33	46 47	57 58 59
Provision of efficient transportation services (high speed, reliability, economy, and automation/labor saving)	02 03 04 05	15 16 17 18	34 35 36 37 38 39 40 41	48 49 50 51 52	60
Provision of safe transportation services (safety and reliability/maintainability)	06 07	19 20 21 22 23 24 25	42 43 44	53 54	
Provision of environmentally-friendly transportation services (environmental protection and resource/energy conservation)	08 09	26 27 28 29 30 31 32	45	55 56	

* Figures appearing in the table represent topic numbers.

13.3. Topics with high degree of importance

Degree of importance index scores (Note 1) averaged at 60.3 for topics in the transportation field as a whole. Topics considered of particular importance to Japan (top 20 topics in terms of degree of importance index score) are listed in the table below. As many as 10 topics that featured in the top 20 related to road transportation systems. Across the fields, 10 environment-related topics were included (8 from road transportation systems and 1 each from road transportation systems and Water and underwater transportation systems).

Table 13.3-1 Top 20 Topics in Terms of Degree of Importance Index

Topic	Degree of importance index	Forecasted realization time (year)
31 Achievement of a 90% recyclability for motor vehicle parts and material (scrapped vehicles).	88	2009
07 Development of a system that detects the initial mild tremors of an earthquake at appropriate locations, and safely stops trains as necessary to avoid places that have a high risk of collapse (because of the earthquake).	87	2006
17 Widespread use of motor vehicles with fuel efficiencies 30% greater than today's vehicles through the introduction of new materials that increase strength and reduce weight and development of element technologies such as one concerning engine thermal efficiency improvements.	86	2007
30 Practical use of heavy-duty freight truck exhaust clean-up technologies - such as diesel exhaust catalysts, particulate traps, lean-burn NO_x catalysts and high precision combustion technology - to reduce the harmful components of exhaust to 1/10 of present levels.	84	2010
14 Widespread use of traffic control systems on road, for optimal control of the	84	2007

Topic	Degree of importance index	Forecasted realization time (year)
flow of traffic in cities based on identification of vehicles on road, speed, and level of congestion.		
55 Practical use of floating off-shore airports.	78	2009
26 Widespread use of electric vehicles that carry a battery capable of powering a vehicle for 200 Km after about 15 minutes of rapid charging and are capable of driving patterns necessary to follow actual urban traffic flows.	77	2011
51 Reductions in direct operating cost per passenger per unit distance to about half present levels through more efficient aircraft production, and cuts in maintenance cost and crew numbers.	75	2013
28 Reduction of the noise generated by heavy-duty freight trucks to the passenger car levels through improvements in engines, transmissions, mufflers, tires, road surfaces, etc.	74	2010
38 Practical use of computer-integrated manufacturing systems (CIM) for shipbuilding, which incorporate design/production databases and intelligent CAD/CAM systems, leading to a reduction in shipbuilding labor costs to about half the present level.	74	2006
42 Completion of marine traffic control systems which enable safe and efficient movement of all ships in congested areas such as Tokyo Bay.	72	2011
27 Widespread use of electric vehicles carrying fuel cells which have high energy conversion efficiencies.	71	2014
29 Practical use of active noise control devices installed along roads to absorb traffic noise in the form of energy, and thereby reduce the noise level so that it conforms to environmental standards.	70	2014
08 Utilization of new materials in rails and wheels and improvements in the technology of vehicle structures, leading to the continuous operation of Shinkansen bullet trains at a speed of 350 Km/h while satisfying environmental quality standards.	69	2006
32 Widespread use of permeable road pavement, leading to improvements in the urban environment in ways such as the recharging of ground water and alleviation of the "heat island" phenomenon.	69	2008
45 Practical use of safe and simple FRP vessel disposal technology via pulverization, incineration, chemical treatment, etc.	69	2007
12 Widespread use of elastic body and other new materials in road paving, leading to a reduction in road traffic noise sufficient to satisfy government regulation.	69	2009
05 Spread of the automation and mechanization of the inspection/construction of railway vehicles, railroad tracks, etc. using robotics technology to cope with labor shortages and increase safety.	66	2008
54 Practical use of an all-weather category 3 (fully automatic) aircraft takeoff, landing and automatic taxiing system through advances in GPS, radar and other non-visual technologies.	65	2009
53 Achievement of radical automation of air traffic control through advances in computer technology, leading to a labor saving of about 50% compared to the present level.	65	2009

Note 1: Degree of importance index = (number of "high" responses × 100 + number of "medium" responses × 50 + number of "low" responses × 25 + number of "unnecessary" responses × 0) ÷ total number of degree of importance responses

13.4. Forecasted realization times

Forecasted realization times were distributed as shown in the diagram below.

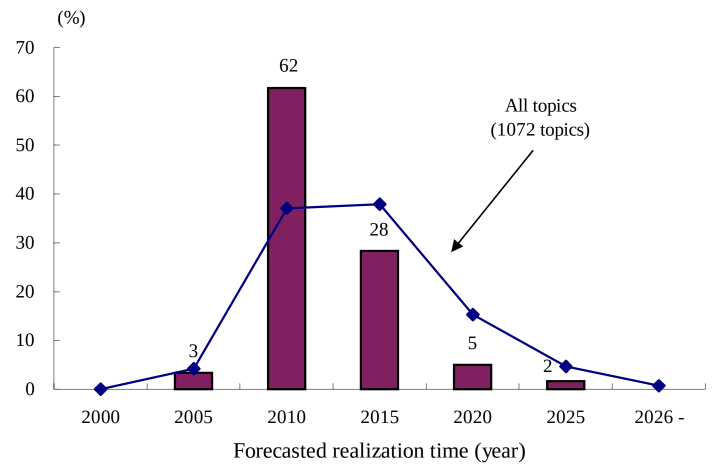

Fig. 13.4-1 Trends in Forecasted Realization Times

About 60% of the topics saw their forecasted realization times fall in the 2006-2010 range in the transportation field as a whole. Compared to the general trend covering all topics, many topics were forecasted to be realized relatively early.

13.5. Current leading countries etc.

Responses to the question concerning current leading countries etc. were as shown in the diagram below. Named by more than 50% of respondents, Japan ranked No. 1 overall in the transportation field, followed by the U.S. and the EU, both scoring more than 30%. Ratings of the former Soviet Union/Eastern Europe and other countries were extremely low.

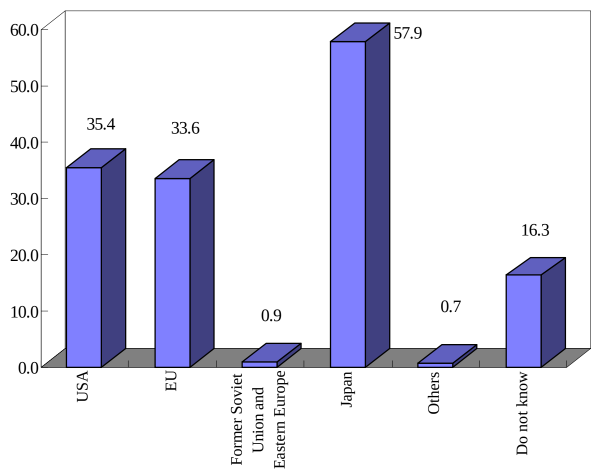

Fig. 13.5-1 Current Leading Countries etc. (%)

13.6. Comparison with the 5th Survey (previous survey)

Of the 60 topics included in the latest survey, 21 (35%) were identical to the previous survey, 15 (25%) were modified, and 24 (40%) were newly introduced. For identical topics, the results of the latest survey were compared with those of the previous survey in terms of degree of importance index scores and forecasted realization times, as shown in the table below.

Degree of importance index scores rose for 7 topics, fell for 11 topics and remained the same for 3 topics. "55: Practical use of floating off-shore airports" saw the greatest jump up 16 points, while "21: Widespread use of studless tires with road grips equal to or greater than those of studded tires" saw the greatest drop, down 18 points.

From the 4th to the 5th Survey, forecasted realization times were pushed back for all but one topic. Likewise, from the 5th to the 6th Survey, forecasted realization times were pushed back for all topics except for three, which saw their forecasted realization times remain the same. "46: Practical use of flying boats for regular transportation services between cities or between the mainland and an isolated island had its forecasted realization time pushed back most" (8 years).

Table 13.6-1 Comparison with 5th Survey for Identical Topics

Topic	Degree of importance index / forecasted realization time	
	6th survey	5th survey
01 <u>Development</u> of <u>intelligent railway vehicles</u> to be able to obtain improved riding comfort and reduce maintenance cost of ground facilities automatically controlling running speed and adjusting suitable parameters to control suspensions in response to track and catenary conditions.	54/2006	55/2000
04 <u>Practical use</u> of <u>superconducting magnetically levitated railways</u> with a maximum speed on <u>the order of</u> <u>500 Km per hour</u>.	64/2011	73/2007
06 <u>Practical use</u> of <u>systems</u> that use laser or ultrasonic technology to detect people, automobiles and other obstacles on railway tracks (including areas other than crossings), and <u>brake the train automatically.</u>	62/2005	69/1999
09 <u>Practical use</u> of <u>energy storage equipment on electrically powered trains</u> to accumulate regenerative energy and reduce the load on transformer substation at peak time.	56/2009	49/2004
14 <u>Widespread use</u> of traffic control systems on road, for <u>optimal control of the flow of traffic in cities</u> based on identification of vehicles on road, speed, and level of congestion.	84/2007	78/2003
17 <u>Widespread use</u> of motor vehicles with <u>fuel efficiencies 30%</u> greater than today's vehicles through the introduction of new materials that increase strength and reduce weight and development of element technologies such as one concerning engine thermal efficiency improvements.	86/2007	79/2003
18 <u>Development</u> of a construction method that can <u>halve the time required for</u> expressway pavement <u>repairs</u>.	61/2006	75/2001
21 <u>Widespread use</u> of studless tires with road grips equal to or greater than those of studded tires.	60/2006	78/1999
28 <u>Reduction</u> of the noise generated by heavy-duty freight trucks to the passenger car levels through improvements in engines, transmissions, mufflers, tires, road surfaces, etc.	74/2010	74/2005
29 <u>Practical use</u> of active noise control devices installed along roads to <u>absorb traffic noise in the form of energy</u>, and thereby reduce the noise level so that it conforms to environmental standards.	70/2014	65/2014
33 <u>Widespread use</u> of commuter and business sea traffic transportation network systems (including the traffic control systems) which use mass-transportation (300 passengers or more), high-speed (30 knots or faster) vessels in the areas around big cities.	40/2010	41/2005
34 <u>Development</u> of an ocean freight transportation facility based on technologies including superconductivity, capable of crossing the Pacific Ocean in two days (<u>100 knots or faster</u>).	47/2017	48/2017
35 <u>Development</u> of large high-speed boats about 500 tons in dead-weight, constructed entirely of <u>non-steel</u> new materials to reduce weight etc.	53/2008	48/2004

Topic	Degree of importance index / forecasted realization time	
	6th survey	5th survey
36 Development of fully automatic ships which are able to navigate and dock automatically.	45/2014	48/2007
37 Development of autonomous, unmanned, underwater investigation vessels employing artificial intelligence which are capable of investigating sea-bottom resources and undertaking other activities without receiving any energy supply or external communication.	51/2009	51/2006
42 Completion of marine traffic control systems which enable safe and efficient movement of all ships in congested areas such as Tokyo Bay.	72/2011	72/2004
46 Practical use of flying boats for regular transportation services between cities or between the main land and an isolated island, through the development of new materials with a high salt damage resistance and advances in engine design.	41/2014	36/2006
47 Practical use of quiet, energy-saving vertical take-off and landing (VTOL) airplane for intercity transportation.	48/2014	55/2008
55 Practical use of floating off-shore airports.	78/2009	62/2008
58 Practical use of intelligent wheel-chairs capable of coping with stairs, escalators, slopes, etc.	54/2008	58/2003
60 Practical use of vertical transportation systems for super high-rise buildings capable of providing a transporting capacity per occupant volume which is at least five times that of current elevators. (e.g., systems equipped multiple car-gondolas, turn-back function, and passing function)	43/2011	51/2008

Note: Up until the 5th Survey, realization meant realization in Japan unless otherwise specified. However, this was changed to mean realization somewhere in the world in the 6th Survey. Therefore, care should be taken when comparing forecasted realization times from the two surveys.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic development	Expected effect: Resolution of global problems	Expected effect: People's needs	Expected effect: Expansion of intellectual resources	Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Rail and track transportation systems	1	Development of intelligent railway vehicles to be able to obtain improved riding comfort and reduce maintenance cost of ground facilities automatically controlling running speed and adjusting suitable parameters to control suspensions in response to track and catenary conditions.	1	121	15	31	54	55	23	50	26	1	50	18	62	5		2	2	10	42	0	66	0	18	22	38	21	0	39	21	2	6	17	2	5
			2	118	14	29	58	54	20	56	23	1	53	11	70	2		2	2	8	42	1	72	0	13	19	51	21	0	44	19	2	4	31	1	3
			X	16	100	0	0	72	50	38	13	0	69	13	69	0		0	0	13	63	0	81	0	0	25	44	38	0	56	25	0	0	25	0	0
	2	Practical use of a system that enables railway vehicles mounted on motorized-trucks to roll onto tracks of different rail gauges.	1	118	13	29	58	50	19	45	35	1	73	15	36	1		7	10	3	51	2	44	2	18	14	29	15	0	38	30	3	4	18	4	10
			2	113	11	27	62	54	21	50	28	0	80	7	42	1		4	4	3	56	1	51	2	12	15	35	12	0	50	32	2	2	33	4	7
			X	12	100	0	0	79	67	17	17	0	92	8	50	0		8	0	0	67	0	67	8	0	33	33	25	0	42	17	0	0	33	0	0
	3	Practical use of a system in which road trucks become railway vehicle to make the transition between railway and road in freight transportation smooth.	1	142	11	22	68	49	21	41	31	7	65	48	18	1		17	11	20	31	1	26	3	35	11	40	12	0	37	44	1	7	19	2	8
			2	140	9	21	70	49	17	52	24	7	76	44	14	0		14	6	17	38	0	31	2	31	8	46	6	0	39	56	1	3	34	1	5
			X	13	100	0	0	69	54	15	31	0	92	85	8	0		15	0	31	54	0	62	8	8	15	46	0	0	46	46	0	0	38	0	0
	4	Practical use of superconducting magnetically levitated railways with a maximum speed on the order of 500 Km per hour.	1	150	12	28	60	64	37	46	16	1	91	19	26	17		8	4	6	45	0	91	1	1	25	31	23	0	67	18	3	51	35	4	11
			2	144	12	26	62	64	36	48	16	0	94	13	28	11		3	2	3	50	0	94	1	0	27	32	23	0	78	17	1	63	36	2	8
			X	17	100	0	0	88	76	24	0	0	100	29	29	18		0	0	0	41	0	100	0	0	24	29	24	0	82	29	0	47	29	0	12
	5	Spread of the automation and mechanization of the inspection/construction of railway vehicles, railroad tracks, etc. using robotics technology to cope with labor shortages and increase safety.	1	131	15	37	48	66	38	50	12	0	70	8	49	7		4	2	18	33	1	73	0	17	30	38	15	1	37	26	2	4	25	9	4
			2	130	12	34	55	66	37	53	9	0	78	3	43	3		2	1	12	32	0	78	0	13	26	47	11	1	42	30	1	4	39	5	2
			X	15	100	0	0	90	80	20	0	0	93	0	53	0		0	0	13	53	0	73	0	7	47	53	27	7	33	33	0	0	33	13	0
	6	Practical use of systems that use laser or ultrasonic technology to detect people, automobiles and other obstacles on railway tracks (including areas other than crossings), and brake the train automatically.	1	148	11	35	54	64	36	48	16	1	25	1	82	4		1	3	20	23	2	68	0	16	21	30	16	1	39	30	2	3	27	3	3
			2	144	10	30	60	62	30	58	11	1	19	1	92	3		1	0	19	25	0	82	0	10	17	38	9	0	53	34	1	3	36	2	2
			X	14	100	0	0	68	43	43	14	0	14	0	100	0		0	0	21	21	0	93	0	0	14	21	7	0	50	71	0	0	50	7	0
	7	Development of a system that detects the initial mild tremors of an earthquake at appropriate locations, and safely stops trains as necessary to avoid places that have a high risk of collapse (because of the earthquake).	1	123	12	28	60	80	63	29	8	0	29	4	81	8		3	5	11	6	0	78	0	16	32	36	17	5	54	6	6	2	24	1	6
			2	116	10	26	64	87	77	19	4	0	28	3	84	3		1	3	11	3	0	86	0	9	31	43	16	2	66	5	3	1	32	0	4
			X	12	100	0	0	85	75	17	8	0	33	0	92	0		0	0	25	8	0	92	0	0	33	42	25	17	42	0	0	0	17	0	0
	8	Utilization of new materials in rails and wheels and improvements in the technology of vehicle structures, leading to the continuous operation of Shinkansen bullet trains at a speed of 350 Km/h while satisfying environmental quality standards.	1	128	13	28	59	68	44	42	13	1	73	23	44	5		2	5	1	66	0	79	1	4	29	34	23	1	47	20	3	30	27	5	5
			2	127	13	28	59	69	45	43	11	1	75	14	54	5		2	3	0	75	0	85	0	1	25	42	20	1	61	17	1	46	32	1	4
			X	17	100	0	0	88	75	25	0	0	76	24	65	0		0	0	0	82	0	82	0	0	47	41	35	6	53	41	0	47	35	6	0
	9	Practical use of energy storage equipment on electrically powered trains to accumulate regenerative energy and reduce the load on transformer substation at peak time.	1	106	9	25	66	57	25	51	22	1	31	80	8	4		4	9	24	28	1	56	0	26	31	38	25	2	42	13	1	9	10	0	1
			2	105	7	17	76	56	20	63	17	0	23	88	5	4		1	3	20	31	0	75	0	13	30	50	23	0	60	10	0	10	16	0	0
			X	7	100	0	0	64	29	71	0	0	29	100	0	0		0	0	14	29	0	86	0	14	57	43	29	0	57	14	0	0	14	0	0
Road transportation systems	10	Practical use of driving simulators that enable a learner driver to have a realistic experience of driving under extreme conditions and being involved in a traffic accident (realistically simulates impact or inertia).	1	172	16	35	49	57	26	53	22	0	16	4	92	8		1	2	61	38	1	54	1	17	27	42	26	1	40	15	1	1	19	9	1
			2	167	13	36	51	55	21	56	23	0	13	1	92	3		1	1	69	35	1	61	0	11	22	56	23	0	50	11	1	1	30	5	1
			X	22	100	0	0	69	45	41	14	0	14	5	91	5		5	0	64	55	0	68	0	0	36	68	27	0	73	0	0	5	18	5	0

(Note) See page 7 for the interpretation of the graphs.

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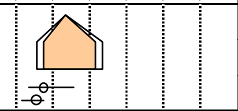
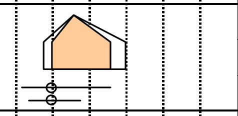
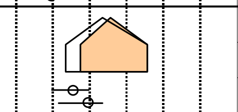
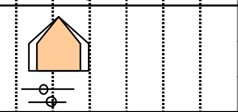
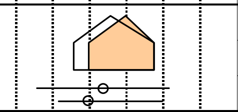
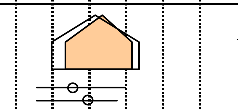
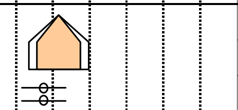
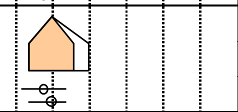
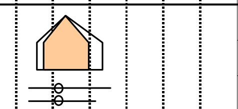
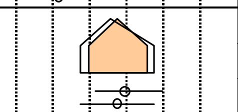
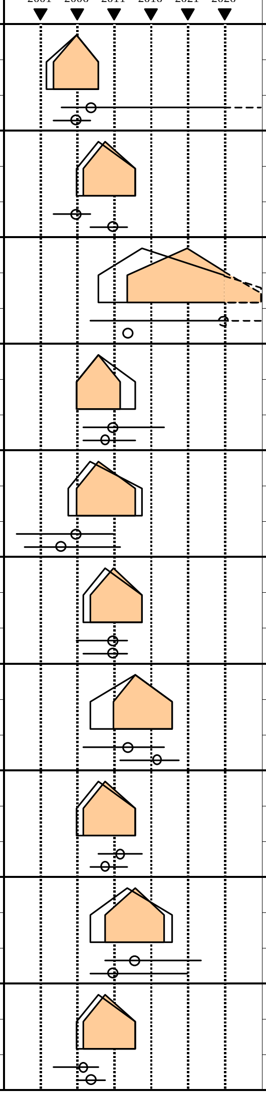
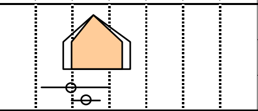
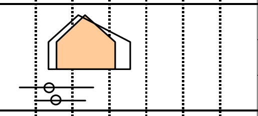
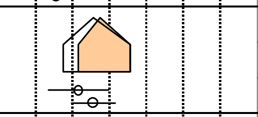
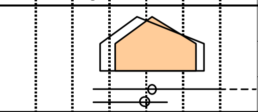
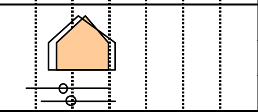
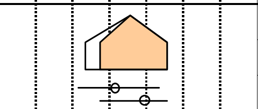
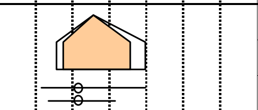
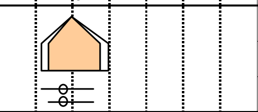
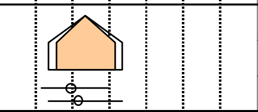
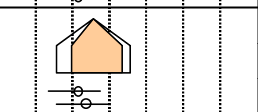
Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%) High	Medium	Low	Importance (index, %) Index	High	Medium	Low	Unnecessary	Expected effect (%) Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%) USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%) Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%) Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Road transportation systems	11	Practical use of construction technology for suspension bridges with a center span of 2,500 - 3,000 m designed for channel crossings.	1	98	13	20	66	52	21	45	33	1	88	6	23	16		2	5	30	21	0	83	0	9	38	37	23	0	51	4	3	39	36	2	2
			2	96	10	21	69	50	16	53	31	1	90	3	23	14		2	1	30	20	0	86	0	7	40	30	21	0	60	2	2	50	36	1	1
			X	10	100	0	0	73	50	40	10	0	100	10	30	30		0	0	40	40	0	80	0	10	50	40	30	0	70	20	0	50	30	10	10
	12	Widespread use of elastic body and other new materials in road paving, leading to a reduction in road traffic noise sufficient to satisfy government regulation.	1	104	18	25	57	66	41	43	14	2	27	37	76	2		6	8	13	27	1	40	1	40	33	54	22	2	51	19	2	22	12	4	5
			2	101	18	22	60	69	45	43	10	2	18	36	83	2		4	4	12	30	0	46	1	41	32	63	14	1	61	11	1	36	8	2	2
			X	18	100	0	0	81	61	39	0	0	11	33	89	0		0	0	6	61	0	72	6	17	50	67	6	0	61	6	0	44	11	6	0
	13	Development of composite materials that adapt to external stimuli by changing characteristics - e.g. change stiffness in response to a load - to improve motor vehicle road performance, vibration resistance, riding comfort, crashworthiness, etc.	1	75	12	20	68	51	14	64	21	1	44	8	71	19		12	8	43	17	0	31	3	39	43	57	29	7	36	7	0	15	21	4	3
			2	76	9	17	74	49	10	68	21	1	39	1	78	11		11	7	45	16	0	29	3	39	42	63	26	4	39	4	0	18	34	1	1
			X	7	100	0	0	50	17	50	33	0	57	0	100	14		14	0	57	43	0	43	29	14	57	43	14	0	57	0	0	43	14	0	0
	14	Widespread use of traffic control systems on road, for optimal control of the flow of traffic in cities based on identification of vehicles on road, speed, and level of congestion.	1	158	17	37	46	79	60	35	5	0	65	54	66	4		3	3	42	36	0	69	1	15	30	56	15	6	49	34	3	7	31	6	2
			2	155	15	33	52	84	70	28	2	0	65	47	79	3		1	0	48	34	0	79	1	11	28	59	8	4	61	33	3	6	43	5	1
			X	24	100	0	0	98	95	5	0	0	75	54	83	4		0	0	71	75	0	92	0	0	33	58	4	0	83	38	0	4	46	13	4
	15	Development of a dual-mode motor vehicle transportation system in which vehicles travel at high speeds without using wheels along specified sections (e.g. between major cities) as magnetically-levitated linear motor cars and travel on wheels along normal roads as convention vehicles.	1	136	13	26	61	43	11	43	42	4	67	34	48	6		17	11	15	24	1	40	1	36	25	44	18	1	48	21	4	15	28	1	4
			2	127	11	27	62	43	9	48	41	2	71	29	56	3		13	8	9	25	1	54	0	31	24	48	12	0	63	20	5	15	41	0	2
			X	14	100	0	0	66	36	57	7	0	79	57	86	7		14	7	21	50	0	79	0	21	36	43	14	0	79	43	7	36	36	0	0
	16	Practical use of a shared connection-vehicle system with a re-location function, based on the use of ultra-small cars in transportation between specified areas or terminals.	1	119	13	29	57	48	17	45	36	2	46	42	72	2		6	13	23	45	0	31	0	31	22	36	10	0	43	44	3	5	35	8	2
			2	115	13	24	63	46	11	54	35	1	44	42	79	1		4	12	19	54	0	35	0	26	17	37	4	0	61	50	2	6	53	4	0
			X	15	100	0	0	56	23	54	23	0	40	60	73	0		0	0	40	80	0	40	0	7	27	40	0	0	60	93	0	13	60	7	0
	17	Widespread use of motor vehicles with fuel efficiencies 30% greater than today's vehicles through the introduction of new materials that increase strength and reduce weight and development of element technologies such as one concerning engine thermal efficiency improvements.	1	123	12	22	66	80	61	37	2	0	41	91	25	4		2	3	37	37	1	76	0	15	33	41	20	2	44	21	3	23	9	2	2
			2	121	11	17	72	86	72	27	1	0	41	94	23	2		1	2	35	41	1	87	0	9	34	49	14	1	62	19	2	34	7	0	1
			X	13	100	0	0	100	100	0	0	0	38	100	31	0		0	0	31	62	0	92	0	8	38	38	15	0	62	31	15	38	15	0	0
	18	Development of a construction method that can halve the time required for expressway pavement repairs.	1	83	16	29	55	62	30	56	14	0	60	24	52	2		1	11	29	19	0	54	0	36	23	57	19	2	43	14	0	20	18	4	2
			2	79	14	27	59	61	28	61	12	0	75	18	63	0		1	9	25	16	0	59	0	28	19	68	10	1	48	10	0	27	19	1	1
			X	11	100	0	0	70	40	60	0	0	64	9	82	0		0	9	27	27	0	73	0	9	27	82	9	9	36	27	0	18	27	9	0
	19	Practical use of a driver support system that receives and recognizes information necessary for motor vehicle travel on normal roads and transmits danger avoidance signals to the on-board control systems of motor vehicles.	1	158	16	28	56	62	33	51	15	1	49	10	88	3		2	4	58	46	0	66	0	18	27	54	19	2	47	31	3	4	30	7	3
			2	154	15	27	58	61	29	58	12	1	42	6	92	1		1	3	68	45	0	78	0	10	20	64	15	1	56	34	1	3	44	5	1
			X	23	100	0	0	82	65	30	4	0	52	9	96	0		0	4	91	87	0	96	0	0	52	74	13	0	87	35	9	4	35	0	4
	20	Spread of the automatic operation of motor vehicles on expressways etc. via guidance and control to ensure safety, eliminate driver fatigue, increase traffic capacity, etc.	1	163	18	28	54	56	25	51	22	2	53	25	85	6		5	5	60	34	1	53	0	22	26	55	21	2	52	39	4	4	42	11	2
			2	156	15	31	53	55	21	58	18	2	51	16	88	4		3	2	69	31	1	62	0	16	19	66	15	0	63	37	1	3	53	8	1
			X	24	100	0	0	75	50	50	0	0	79	42	92	4		0	0	96	58	0	79	0	4	29	58	17	0	92	50	8	4	58	4	4

(Note) See page 7 for the interpretation of the graphs.

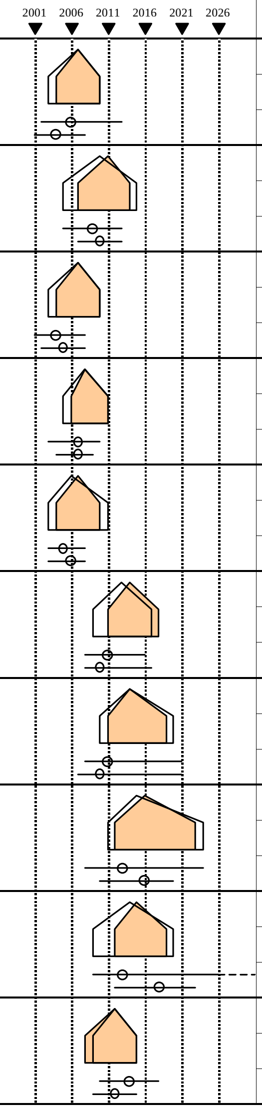
Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time			Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	 2001 2006 2011 2016 2021 2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Road transportation systems	21	Widespread use of studless tires with road grips equal to or greater than those of studded tires.	1	87	3	34	62	60	30	52	18	0	30	36	80	2		7	3	22	51	1	54	0	20	25	37	15	1	26	24	1	22	24	2	2
			2	85	2	33	65	60	27	60	13	0	22	32	87	4		5	1	20	52	0	67	0	14	21	48	8	1	29	27	0	26	36	1	0
			X	2	100	0	0	100	100	0	0	0	50	100	100	0		0	0	100	100	0	100	0	0	50	50	0	0	50	100	0	50	50	0	0
	22	Widespread use of snow-melting systems that store solar thermal energy and use it to melt snow and ice in the event of snow accumulation and road surface freezing on expressways and major national highways in snowy regions in Japan.	1	107	2	29	69	55	20	61	18	1	43	47	70	3		10	6	14	21	3	47	1	38	24	42	19	0	55	6	2	24	12	1	2
			2	109	2	23	75	54	13	77	9	1	33	36	82	2		8	1	11	23	2	61	0	29	20	48	11	1	76	4	1	46	11	1	0
			X	2	100	0	0	50	0	100	0	0	0	0	100	0		0	0	0	100	0	100	0	0	0	50	0	0	100	0	0	50	0	0	0
	23	Widespread use of road structures using smart materials with self-repairing functions to be able to overcome damage sustained in major earthquakes.	1	57	14	28	58	62	38	41	16	5	58	5	68	25		32	18	30	11	0	33	0	47	32	33	12	7	44	9	2	19	21	2	4
			2	58	7	21	72	59	31	47	19	3	60	3	67	16		31	16	31	5	0	36	0	45	40	33	14	0	53	7	0	16	29	2	0
			X	4	100	0	0	75	50	50	0	0	75	0	100	0		75	0	75	0	0	50	0	25	75	25	0	0	50	25	0	0	25	0	0
	24	Practical use of a technology to automatically monitor bridges for operational fatigue through strain-gauge measurement, ultrasonic testing, acoustic emission observation, etc.	1	98	12	32	56	62	34	48	16	2	50	9	62	10		3	7	37	26	3	58	0	33	45	40	20	2	46	7	1	6	29	1	3
			2	98	11	24	64	61	32	52	14	2	50	4	66	7		2	8	34	20	0	65	0	24	45	43	17	2	54	5	1	4	43	0	3
			X	11	100	0	0	73	64	9	18	9	82	0	55	9		0	9	36	0	0	55	0	27	55	18	27	9	45	0	0	0	45	0	9
	25	Practical use of a technique to improve the wind resistance of bridges via active control.	1	96	13	22	66	49	17	47	33	3	44	7	63	5		7	9	27	11	0	49	0	26	39	34	22	2	47	9	0	6	21	0	2
			2	97	10	20	70	49	13	57	29	1	48	2	72	4		5	6	27	8	0	67	0	19	44	35	15	0	59	7	0	1	40	0	2
			X	10	100	0	0	63	40	30	30	0	60	0	60	20		10	0	30	0	0	90	0	10	80	40	10	0	80	20	0	0	50	0	0
	26	Widespread use of electric vehicles that carry a battery capable of powering a vehicle for 200 Km after about 15 minutes of rapid charging and are capable of driving patterns necessary to follow actual urban traffic flows.	1	127	10	30	60	74	52	42	7	0	48	90	28	6		5	6	66	48	0	65	1	14	35	53	17	1	57	29	4	24	19	3	3
			2	132	10	23	67	77	54	44	2	0	40	96	17	3		3	5	78	48	0	70	1	6	33	62	13	0	73	24	1	35	17	2	2
			X	13	100	0	0	83	69	23	8	0	54	100	8	0		8	0	92	62	0	77	0	0	62	62	0	0	85	15	8	31	15	0	0
	27	Widespread use of electric vehicles carrying fuel cells which have high energy conversion efficiencies.	1	114	10	29	61	70	44	49	7	0	45	91	23	9		2	7	60	33	0	50	2	19	42	46	19	4	59	20	4	25	12	0	3
			2	114	8	25	67	71	42	58	0	0	32	93	16	3		0	4	76	33	0	58	1	11	40	55	13	2	76	16	2	38	14	1	1
			X	9	100	0	0	83	67	33	0	0	33	100	0	0		0	0	89	56	0	44	11	0	89	33	0	11	78	22	11	33	11	0	0
	28	Reduction of the noise generated by heavy-duty freight trucks to the passenger car levels through improvements in engines, transmissions, mufflers, tires, road surfaces, etc.	1	101	11	31	58	71	48	43	8	1	32	47	68	1		5	8	21	35	2	48	0	28	27	46	17	0	46	29	0	14	10	0	5
			2	101	9	28	63	74	51	44	5	0	23	42	80	2		3	7	12	37	1	61	0	21	21	55	8	0	58	26	0	22	9	0	4
			X	9	100	0	0	92	89	0	11	0	33	67	56	0		11	0	11	78	0	67	0	0	33	67	11	0	67	33	0	33	0	0	11
	29	Practical use of active noise control devices installed along roads to absorb traffic noise in the form of energy, and thereby reduce the noise level so that it conforms to environmental standards.	1	96	11	29	59	67	41	45	13	1	29	41	70	5		13	10	14	19	1	39	1	39	38	44	13	1	40	15	1	16	11	1	6
			2	98	7	28	65	70	44	48	7	0	20	33	76	5		11	6	12	19	0	48	1	34	36	50	8	0	55	9	2	26	12	1	6
			X	7	100	0	0	86	71	29	0	0	57	14	86	0		29	14	29	57	0	86	0	0	57	71	0	0	71	29	0	14	0	0	14
	30	Practical use of heavy-duty freight truck exhaust clean-up technologies - such as diesel exhaust catalysts, particulate traps, lean-burn NOx catalysts and high precision combustion technology - to reduce the harmful components of exhaust to 1/10 of present levels.	1	91	15	24	60	79	61	34	3	1	23	78	55	5		0	4	36	40	1	69	0	18	35	49	19	1	58	32	0	18	3	1	4
			2	95	15	20	65	84	69	30	1	0	14	86	53	6		0	7	33	47	0	80	0	13	32	56	13	0	72	26	0	24	2	0	3
			X	14	100	0	0	96	93	7	0	0	7	79	71	7		0	7	64	93	0	93	0	0	50	64	14	0	79	43	0	7	7	0	0

(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time			Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001 2006 2011 2016 2021 2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Road transportation systems	31	Achievement of a 90% recyclability for motor vehicle parts and material (scrapped vehicles).	1	104	8	20	72	80	63	34	2	1	46	96	17	9		3	4	21	67	0	41	1	15	34	48	16	1	50	40	2	25	9	4	5
			2	104	6	17	77	88	77	23	0	0	34	96	9	3		4	3	18	75	0	48	0	11	22	55	9	0	56	45	1	35	10	2	2
			X	6	100	0	0	100	100	0	0	0	50	100	0	0		0	0	17	100	0	67	0	0	17	67	50	0	67	33	0	0	0	0	0
	32	Widespread use of permeable road pavement, leading to improvements in the urban environment in ways such as the recharging of ground water and alleviation of the "heat island" phenomenon.	1	113	13	21	65	69	44	46	9	1	27	74	50	4		1	5	15	32	0	58	0	29	25	38	16	1	54	22	4	27	4	2	4
			2	106	11	20	69	69	42	51	7	0	13	84	46	3		1	6	11	32	0	67	0	24	25	42	10	1	65	19	1	42	1	1	3
			X	12	100	0	0	69	42	50	8	0	17	83	75	0		0	0	8	42	0	92	0	8	50	58	8	0	75	17	0	75	0	0	0
Water and underwater transportation systems	33	Widespread use of commuter and business sea traffic transportation network systems (including the traffic control systems) which use mass-transportation (300 passengers or more), high-speed (30 knots or faster) vessels in the areas around big cities.	1	124	26	31	44	42	13	37	43	8	55	34	56	2		17	15	13	39	2	42	4	21	17	31	9	0	32	44	5	16	24	6	4
			2	111	23	33	44	40	7	41	49	3	55	18	69	1		15	6	11	46	2	55	3	16	14	34	5	0	38	53	3	14	40	3	2
			X	25	100	0	0	49	12	60	28	0	76	28	76	0		8	4	4	52	4	76	4	4	16	28	8	0	32	76	4	20	36	0	0
	34	Development of an ocean freight transportation facility based on technologies including superconductivity, capable of crossing the Pacific Ocean in two days (100 knots or faster).	1	119	23	33	45	47	20	40	29	11	76	20	18	9		29	10	18	16	3	67	2	13	34	33	19	1	47	17	3	24	18	4	3
			2	109	19	33	48	47	15	49	30	6	83	15	15	5		32	6	18	15	3	80	1	9	40	34	13	1	63	15	1	39	25	3	2
			X	21	100	0	0	46	14	52	24	10	86	24	14	5		33	0	14	19	10	95	0	0	62	24	10	0	62	19	0	43	24	0	0
	35	Development of large high-speed boats about 500 tons in dead-weight, constructed entirely of non-steel new materials to reduce weight etc.	1	91	34	36	30	55	24	51	23	2	75	20	25	3		3	4	24	38	1	63	10	11	26	41	16	0	40	32	5	21	22	0	2
			2	87	26	38	36	53	15	67	17	0	89	8	18	2		7	1	22	43	1	71	9	13	21	51	8	0	53	32	2	20	31	0	1
			X	23	100	0	0	55	17	70	13	0	87	17	17	0		9	0	26	43	0	70	22	4	22	48	4	0	57	43	0	26	26	0	0
	36	Development of fully automatic ships which are able to navigate and dock automatically.	1	113	24	27	50	45	13	41	43	3	69	6	34	11		14	8	15	25	0	63	1	27	40	42	12	1	49	34	1	4	39	4	3
			2	103	20	25	54	45	15	40	42	4	79	4	30	7		14	4	17	24	0	75	0	17	37	48	4	0	58	36	1	5	54	2	0
			X	21	100	0	0	60	29	57	10	5	90	5	14	5		14	0	24	38	0	95	0	0	29	62	10	0	71	48	0	5	52	5	0
	37	Development of autonomous, unmanned, underwater investigation vessels employing artificial intelligence which are capable of investigating sea-bottom resources and undertaking other activities without receiving any energy supply or external communication.	1	103	22	29	49	50	19	49	29	3	42	56	10	29		3	7	51	33	2	61	0	12	50	43	19	0	66	4	1	17	6	1	1
			2	91	18	30	53	51	13	63	23	0	43	69	4	27		2	3	59	36	0	75	0	12	56	44	15	1	85	3	1	27	8	1	0
			X	16	100	0	0	47	6	69	25	0	38	75	0	38		6	0	75	50	0	75	0	0	69	50	13	0	81	0	0	19	6	0	0
	38	Practical use of computer-integrated manufacturing systems (CIM) for shipbuilding, which incorporate design/production databases and intelligent CAD/CAM systems, leading to a reduction in shipbuilding labor costs to about half the present level.	1	100	26	30	44	67	44	38	17	1	85	7	18	10		2	3	12	31	0	83	4	8	39	53	20	8	40	10	2	1	11	5	4
			2	95	22	29	48	74	52	40	9	0	94	1	17	8		2	0	7	31	0	86	3	7	40	76	11	7	46	3	0	0	16	5	2
			X	21	100	0	0	86	71	29	0	0	95	0	14	10		0	0	5	33	0	95	5	0	43	67	0	5	52	10	0	0	24	0	0
	39	Development of a vessel fluid dynamics simulation technique that eliminates the need for water tank tests in developing propulsion systems and designing hull shapes.	1	113	32	27	42	53	21	52	22	5	65	12	4	37		7	4	53	42	2	76	0	7	54	43	26	3	41	2	1	1	4	3	4
			2	100	31	26	43	53	16	65	18	1	79	5	2	36		6	3	59	42	2	82	0	8	65	49	22	3	50	1	0	1	7	3	3
			X	31	100	0	0	55	16	71	13	0	68	6	6	39		6	0	68	58	0	90	0	0	65	48	32	3	55	0	0	3	3	3	0
	40	Achievement of some 20% increase in propeller efficiency through technological advances in propeller development and hull shape/surface design.	1	92	30	29	40	60	30	51	18	1	72	50	5	16		8	7	34	35	2	85	1	5	54	48	24	0	47	2	2	8	9	3	2
			2	83	29	28	43	58	24	58	18	0	83	45	5	7		11	6	35	34	2	88	0	7	57	47	24	1	49	0	0	8	10	1	1
			X	24	100	0	0	59	25	63	13	0	79	63	8	4		13	8	50	46	0	88	0	4	63	50	25	0	50	0	0	21	4	0	0

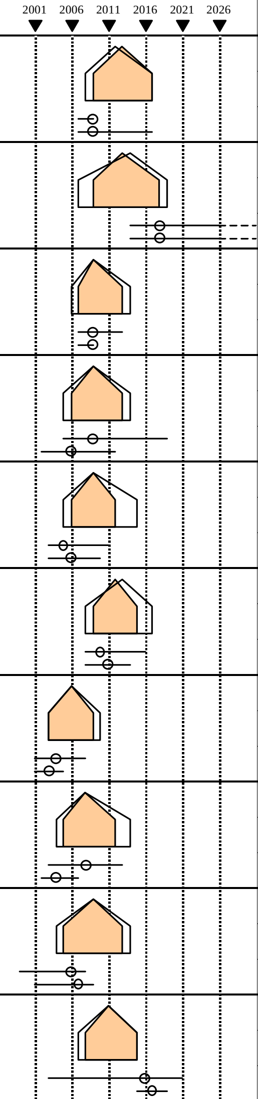
(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Medium	Low	Importance (index, %): Index	High	Medium	Low	Unnecessary	Expected effect (%): Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Forecasted realization time	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Water and underwater transportation systems	41	Practical use of fully automated container yards of the automatic warehouse type to deal with labor shortages and increase the cargo handling capacity.	1	120	13	30	57	59	25	61	14	0	85	10	29	3		2	2	38	38	1	59	3	19	19	47	8	2	42	33	3	3	18	6	3
			2	109	11	30	59	61	28	63	9	0	92	6	23	1		0	2	42	39	0	72	4	8	14	58	6	0	53	30	2	2	29	5	1
			X	12	100	0	0	75	50	50	0	0	100	8	33	8		0	0	50	50	0	83	8	0	33	67	8	0	58	42	0	0	42	8	0
	42	Completion of marine traffic control systems which enable safe and efficient movement of all ships in congested areas such as Tokyo Bay.	1	104	18	29	53	68	43	44	12	1	73	9	48	5		7	2	18	27	1	61	1	22	28	43	8	0	55	44	2	10	31	4	3
			2	89	15	30	55	72	47	46	7	0	84	7	47	4		3	1	20	29	0	81	1	10	19	54	3	0	67	48	1	6	42	1	2
			X	13	100	0	0	96	92	8	0	0	92	15	54	0		8	0	23	62	0	92	0	0	23	77	0	0	54	69	0	23	38	0	0
	43	Practical use of vessel collision avoidance systems through advances in detection technologies, e.g. radar, and artificial intelligence technology.	1	130	19	24	57	64	33	55	12	0	52	10	62	5		1	3	34	37	2	63	0	22	35	45	18	1	53	28	1	4	25	2	2
			2	120	16	27	58	63	30	63	7	0	56	7	70	1		2	2	33	34	0	77	0	13	27	57	8	1	59	27	0	3	41	0	1
			X	19	100	0	0	82	63	37	0	0	58	21	74	0		5	0	42	68	0	89	0	0	32	63	11	0	58	26	0	11	37	0	0
	44	Practical use of high-reliability vessels that can remain in service maintenance-free for about 2 years, through improvements in the reliability of hull materials, engines, etc. and the use of a real-time monitoring system.	1	84	23	30	48	59	27	55	18	0	76	19	31	2		7	0	15	36	0	79	1	11	29	50	17	4	50	30	0	4	21	5	2
			2	78	22	31	47	59	24	64	10	1	85	12	33	1		8	0	10	35	0	86	0	8	22	64	10	5	67	32	0	4	40	3	3
			X	17	100	0	0	69	41	53	6	0	88	6	47	0		18	0	18	53	0	88	0	0	35	59	6	12	71	47	0	0	18	0	0
	45	Practical use of safe and simple FRP vessel disposal technology via pulverization, incineration, chemical treatment, etc.	1	90	16	24	60	70	44	48	8	0	32	87	14	1		2	4	16	19	0	60	0	26	26	47	9	1	59	37	2	36	2	0	2
			2	81	10	26	64	69	40	58	2	0	28	89	6	0		1	1	15	21	0	77	0	11	16	62	5	0	69	31	0	52	4	0	1
			X	8	100	0	0	81	63	38	0	0	38	88	13	0		0	0	13	13	0	100	0	0	13	63	0	0	88	63	0	25	13	0	0
Air transportation systems	46	Practical use of flying boats for regular transportation services between cities or between the main land and an isolated island, through the development of new materials with a high salt damage resistance and advances in engine design.	1	86	10	23	66	42	12	36	48	5	45	9	72	1		14	16	44	15	9	29	8	20	29	34	13	0	42	27	2	19	19	3	3
			2	75	11	20	69	41	11	31	57	1	45	4	80	0		17	7	65	8	9	32	7	16	31	41	11	0	55	27	3	27	29	3	1
			X	8	100	0	0	53	25	38	38	0	63	13	88	0		13	0	75	0	0	88	25	0	50	38	0	0	63	38	0	50	38	0	0
	47	Practical use of quiet, energy-saving vertical take-off and landing (VTOL) airplane for intercity transportation.	1	89	15	24	62	49	21	42	30	7	62	19	52	2		9	8	73	43	3	20	0	18	39	29	19	0	54	25	2	29	28	2	3
			2	87	14	21	66	48	15	50	30	5	64	15	52	1		10	5	79	45	3	15	0	15	48	32	9	0	62	25	2	37	38	1	2
			X	12	100	0	0	69	42	50	8	0	58	25	58	8		8	0	92	58	8	8	0	0	75	17	17	0	67	42	0	42	42	0	0
	48	Development of a passenger transport that cruises at Mach 3 - 4 (1.5 - 2 times as fast as the Concorde) with a maximum of 300 passengers on board (3 times as many as the Concorde), and is capable of crossing the Pacific Ocean in 3 - 4 hours.	1	85	14	24	62	57	31	39	25	5	87	7	33	7		7	6	86	64	9	9	0	7	54	36	25	1	68	6	1	60	25	7	2
			2	81	14	21	65	57	28	46	25	1	90	4	38	10		2	5	90	62	9	6	0	5	63	36	20	0	72	5	0	69	28	2	1
			X	11	100	0	0	86	73	27	0	0	82	0	64	18		0	0	100	73	0	9	0	0	73	45	45	0	91	9	0	73	27	0	0
	49	Development of an ultra-large passenger transport with a gross weight of 1,000 tons (3 times as heavy as a jumbo jet) that cruises at a speed comparable to those of today's jet transport (around Mach 0.8).	1	83	16	22	63	51	25	38	30	8	81	22	33	4		12	14	88	42	6	2	0	7	48	36	17	0	59	7	2	39	34	6	4
			2	77	14	21	65	55	26	44	27	3	87	12	36	3		9	13	90	40	5	4	0	5	58	36	10	0	65	5	1	48	42	4	1
			X	11	100	0	0	75	55	36	9	0	91	9	45	0		18	18	91	64	0	9	0	0	82	45	18	0	73	9	0	36	45	0	0
	50	Development of an energy-efficient and extended-service-life large passenger transport using composite materials in main structural elements.	1	72	15	25	60	57	26	54	17	3	63	42	24	4		4	8	88	46	1	24	0	7	49	43	14	3	63	8	0	24	22	3	1
			2	67	13	24	63	57	18	73	9	0	79	40	19	3		3	3	94	51	0	21	0	3	51	45	12	1	76	7	0	36	28	1	1
			X	9	100	0	0	72	44	56	0	0	67	67	33	0		0	0	89	67	0	33	0	0	89	44	22	0	89	11	0	44	22	0	0



(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time			Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources		Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Air transportation systems	51	Reductions in direct operating cost per passenger per unit distance to about half present levels through more efficient aircraft production, and cuts in maintenance cost and crew numbers.	1	67	9	21	70	67	45	36	14	5	64	24	43	3		6	15	75	40	1	6	0	15	22	36	7	3	43	37	1	7	33	3	4
			2	62	10	19	71	75	56	31	13	0	84	11	50	2		3	11	85	45	0	5	0	10	21	45	8	3	53	34	0	5	40	2	3
			X	6	100	0	0	92	83	17	0	0	100	0	50	0		0	0	100	33	0	0	0	0	50	17	0	0	67	50	0	17	17	0	0
	52	Development of an observation and communication platform that is deployed in midair using helium gas for such purposes as environmental monitoring, disaster prevention and communication.	1	53	6	21	74	45	13	48	31	8	43	34	43	6		13	11	36	17	2	26	0	40	32	25	21	0	45	13	6	17	28	4	4
			2	50	6	14	80	48	8	66	26	0	52	32	50	2		12	10	42	12	0	34	0	40	40	30	14	0	54	12	2	16	30	2	2
			X	3	100	0	0	42	0	67	33	0	100	33	0	33		0	0	67	0	0	100	0	0	33	67	33	0	33	67	0	67	33	0	0
	53	Achievement of radical automation of air traffic control through advances in computer technology, leading to a labor saving of about 50% compared to the present level.	1	72	13	14	74	61	33	46	16	4	63	10	44	6		0	11	74	25	3	21	0	18	38	36	19	1	47	28	0	4	35	6	0
			2	65	9	17	74	65	35	53	11	0	72	9	49	3		0	8	80	20	2	22	0	9	38	48	14	0	58	23	0	2	58	3	0
			X	6	100	0	0	92	83	17	0	0	67	0	67	0		0	17	67	17	0	50	0	0	67	33	17	0	33	33	0	0	33	17	0
	54	Practical use of an all-weather category 3 (fully automatic) aircraft takeoff, landing and automatic taxiing system through advances in GPS, radar and other non-visual technologies.	1	75	11	27	63	61	33	51	12	4	57	4	60	4		0	8	77	33	1	28	0	11	37	36	19	0	49	24	1	3	39	3	3
			2	71	10	28	62	65	35	56	9	0	63	3	65	1		0	4	85	32	0	20	0	7	38	38	10	0	54	18	1	3	49	0	1
			X	7	100	0	0	79	57	43	0	0	86	0	71	0		0	14	86	29	0	14	0	0	57	43	0	0	43	0	0	0	29	0	0
	55	Practical use of floating off-shore airports.	1	143	16	33	51	70	47	39	11	3	87	38	32	3		2	5	12	6	0	72	1	20	23	47	13	0	64	39	3	46	24	3	2
			2	131	15	33	52	78	58	38	4	0	91	37	33	2		1	2	12	2	0	81	0	9	15	56	6	0	78	39	2	62	26	1	1
			X	20	100	0	0	93	85	15	0	0	90	50	55	5		0	0	15	0	0	95	0	0	20	70	5	0	80	65	0	55	40	5	0
	56	Development of an epoch-making low-noise helicopter which does not generate blade slap during takeoff or landing.	1	58	22	19	59	53	28	39	23	11	38	19	59	7		9	10	78	40	9	17	0	10	45	33	28	2	45	12	2	19	24	5	5
			2	51	24	20	57	55	27	45	22	6	43	10	82	4		6	8	84	41	6	20	0	6	59	39	25	0	55	6	0	16	31	2	6
			X	12	100	0	0	70	55	27	9	9	42	8	83	0		0	0	83	58	8	17	0	0	83	25	42	0	75	0	0	33	33	8	8
Other new transportation systems	57	Practical use of robots to guide blind people in particular districts such as stations and shopping centers.	1	125	9	24	67	59	28	52	18	2	7	0	98	2		0	6	29	38	0	33	0	34	22	43	11	2	65	26	1	0	26	14	2
			2	121	7	23	70	58	21	68	11	0	2	0	100	0		0	3	26	50	0	38	0	27	17	50	7	1	80	26	0	0	38	7	2
			X	8	100	0	0	81	63	38	0	0	13	0	100	0		0	0	50	75	0	38	0	0	25	75	25	0	75	50	0	0	25	0	0
	58	Practical use of intelligent wheel-chairs capable of coping with stairs, escalators, slopes, etc.	1	101	6	18	76	55	23	52	23	2	11	0	95	3		0	5	28	34	0	27	0	39	22	44	12	1	58	23	4	0	32	12	2
			2	99	3	16	81	54	16	66	18	0	5	0	99	1		0	2	28	44	0	26	0	34	14	45	7	0	77	23	0	0	47	6	1
			X	3	100	0	0	67	33	67	0	0	33	0	100	0		0	0	33	67	0	33	0	0	0	67	0	0	100	0	0	0	0	0	0
	59	Practical use of cableways and other transportation systems that can be used for moving between a hilltop residential area and a railroad station below, between downtown buildings, and between wharves in a port, through the bolstering of transportation capacities and anti-wind measures (operation can be carried out under the control standards same as railways).	1	98	14	27	59	39	9	41	38	12	46	11	73	2		13	9	9	21	1	31	1	39	14	36	13	0	42	42	5	13	32	3	3
			2	92	14	24	62	40	8	44	41	7	38	8	86	1		12	5	4	27	0	40	0	34	9	42	9	0	54	48	2	12	47	1	2
			X	13	100	0	0	65	31	69	0	0	54	31	85	0		0	0	15	38	0	69	0	0	15	54	8	0	69	77	8	15	46	0	8
	60	Practical use of vertical transportation systems for super high-rise buildings capable of providing a transporting capacity per occupant volume which is at least five times that of current elevators. (e.g., systems equipped multiple car-gondolas, turn-back function, and passing function)	1	74	5	26	69	44	11	46	39	4	46	5	68	7		4	11	30	22	0	38	0	43	22	45	18	0	35	41	4	4	47	5	1
			2	77	4	22	74	43	5	58	35	1	38	3	78	1		4	5	29	13	0	51	0	36	17	57	9	0	44	43	0	1	61	1	1
			X	3	100	0	0	58	33	33	33	0	67	0	33	0		0	0	33	33	0	67	0	0	0	100	0	0	67	67	0	0	67	0	0



(Note) See page 7 for the interpretation of the graphs.

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14. Survey Results in "Health, Medical Care and Welfare"

14.1. Trends in areas of attention

14.1.1. Malignant neoplasms

Topics relating to cancer ranked high in terms of the degree of importance, indicating a high level of interest. They scored an average 72.3 out of 100 in terms of the degree of importance index, which is extremely high compared to 63.2, the average score for all fields. Notably, 9 out of the 20 topics considered particularly important were cancer-related, including the top three, which were "05: Elucidation of carcinogenic mutation mechanisms", "44: Improvement in the average five-year survival rate for all types of cancer to more than 70% " and "06: Elucidation of cancer metastasis mechanisms". Their forecasted realization times were 2013, 2013 and 2012, respectively. Of these three, topics 05 and 44 were also included in the 5th Survey, which was held five years earlier in 1991. Their forecasted realization times then were 2010 for topic 05 and 2003 for topic 44, with topic 44 recording a 10 year difference between the two surveys. Incidentally, the forecasted realization time for topic 44 in the 4th Survey in 1986 was an even earlier 1999. These results show that, while many people feel that the pathology of cancer is gradually coming to light through research efforts centering on genes such as cancer-causing genes, cancer-suppressing genes and metastasis-related genes, they also feel that this has not been fully reflected in the treatment record.

No epoch-making progress has been made in the leading cancer treatment methods, which consist of chemotherapy, radiation therapy and surgical treatment. Related topics including "46: Widespread use of techniques to overcome the drug resistance of malignant tumors", "47: Development of radiosensitizers effective in cancer treatment" and "49: Widespread use of heavy particle against cancer" were added. New treatment methods include immunotherapy, biological therapy and gene therapy. The development of various cytokines based on genetic engineering, which began in the 1980s and came to full maturity in the 1990s, may have given rise to the impression that cancer treatment entered a new era and led to the optimistic result obtained in the 1991 survey. Since then, however, many cytokines have not produced the expected treatment effects. Interferon, once dubbed a dream anticancer drug, has turned out to be ineffective for many forms of cancer, and chronic myelocytic leukemia has been the only cancer which has shown a complete response to the drug. Progress in gene therapy is also slow. The only recent major achievements have been the development of the granulocyte colony stimulating factor, which alleviates the fall in the number of leukocytes due to anticancer drugs, and treatments which support radiation therapy and chemotherapy, such as bone marrow transplantation and peripheral blood stem cell transplantation, while the establishment of a bone marrow donor bank, which made bone marrow transplantation from persons outside blood relatives possible, is also noteworthy. However, these are only auxiliary treatment methods, which do not directly attack cancer. Stem cell plantation centering around bone marrow transplantation is used because chemotherapy and radiation therapy performed for hematologic malignancy turned out to be almost ineffective for many types of cancer despite increased dosages.

There is, however, a technology which holds great promise for future progress. It is differentiation therapy for acute leukemia. By just administering all-trans retinoic acid, a vitamin A derivative, orally, acute promyelocytic leukemia, which used to be considered most intractable among the various forms of acute leukemia, can be cured incredibly easily. Unlike conventional anticancer drugs, this drug shows a particularly high specificity for leukemic cells, and therefore accompanies few side effects. Namely, while conventional drugs are designed to kill leukemic cells, it induces leukemic cells to differentiate into normal leukocytes. The leukocytes resulting from differentiation have a finite life, so that they die out after a certain period. If these kinds of drugs can be discovered for other types of cancer, cancer treatment will make a giant leap forward.

It has been 15 years since cancer became the No. 1 cause of death for the first time in 1981. Over these years, the mortality rate of cancer has steadily increased, reaching 196 per 100,000 of population in 1994. Namely, cancer now accounts for 1 in every 3.5 deaths. Although the aging of the population is likely to have greatly contributed to this, there are other factors, as can be seen from the fact that the number of cerebrovascular disease cases, considered prevalent among the elderly, has fallen sharply. Indeed, this seems to give rise to the need for preventive measures, such as changing lifestyles and avoiding carcinogen intake.

“23: Widespread use of a cancer risk assessment technique based on genetic analysis” was a topic included in the latest survey by modifying a similar topic in the previous survey. Among the reasons why this topic was added is thought to have been the discovery of families with higher than usual cancer rates due to the mutation of cancer suppressing genes. Although this technique will lead to cancer prevention, it is necessary to ensure that it is never used as a means of controlling individuals.

Despite the fact that cancer deaths have been steadily increasing as discussed earlier, the number of deaths attributed to cancer does not appear to be so large according to newspaper obituaries etc. Recently, however, the instances of cancer given as the cause of death seem to have increased somewhat, following the issuance by the Ministry of Health and Welfare of guidance recommending the entry of the name of disease directly responsible for the death as the cause of death in death certificates, instead of a vague description of the condition, such as cardiac decompensation or respiratory failure. However, this has not gone far enough. If this is due to a sentiment of wanting to somehow avoid diagnosing cancer, it could quell the trend of squarely facing cancer. It is necessary to seek people’s understanding in this regard, as this will increase their awareness, and take us a step closer towards the eradication of cancer.

(Hideaki Mizoguchi)

14.1.2. Scientific lifestyle guidelines for adult disease (lifestyle disease) prevention

The survey was conducted by presenting the respondents with set technological topics and asking them to specify their forecasted realization times and degree of importance, instead of asking the respondents to come up with topics of their own which they considered would be important in the near future. As a result, topics relating to the development and application of cutting-edge technologies dominated the questionnaire, and there were only a few topics that related to health management. Against this background, it is noteworthy that “20: Widespread use of scientific guidelines for adult-disease-preventing life-styles (nutrition, rest and exercise)” was ranked No. 4 in terms of the degree of importance, despite the fact that survey subjects were researchers from the health, medical care and welfare field, including many who specialized in basic research, instead of lay people. This topic may therefore be taken as a nationwide demand which reflects the trend of the times.

The term adult disease used to evoke the image of a disease the onset of which came with advances in age and which can be delayed but not prevented. However, in recent years, many adult diseases began to be seen as diseases brought on by the effects of people’s daily habits accumulated over sustained periods, i.e. ones lifetime indulgence taking a toll on one’s body. For example, excessive nutritional intake and a dietary imbalance often cause diabetes, arteriosclerosis and cardiovascular diseases, as well as accelerating aging, while these seem to be preventable through moderate exercise and rest. Individuals adult disease risks specified according to their genetic heritage are considered to be reduced dramatically through improvements in everyday life habits. The Ministry of Health and Welfare is trying to promote the prevention of adult diseases by introducing the term lifestyle disease.

In the latest survey, many respondents specified 2006 as the forecasted realization time for “20: Widespread use of scientific guidelines for adult-disease-preventing life-styles (nutrition, rest and exercise)”, but this seems to be more an expression of hope, or perhaps many people thought that considerable scientific data had already been accumulated. While the compilation of guidelines by putting together all the information available at present and their widespread use are likely to be realized fairly soon, a problem remains as to whether this information is scientific enough. Namely, scientific information extracted from human populations (epidemiological study data) does not seem abundant, and, in many cases, basic or animal experiment data is relied on for a scientific basis.

The preparation of scientific lifestyle guidelines aimed at adult disease prevention is an urgent task. However, as it takes a long time to plan and conduct epidemiological studies, obtain results and verify them, the widespread use of scientific guidelines that many researchers would agree to will be pushed back, although some kind of data such as that on smoking habits has already been extensively accumulated, with the only remaining problem being the technicalities of how to spread it.

(Hiroyuki Shimizu and Toshikazu Yoshikawa)

14.1.3. Advances in science and technology, changes in lifestyles and emerging infections

Half a century ago, infectious diseases were the most feared diseases, which posed serious threats to Japanese people's lives and health, and subsequent advances in science and technology played a key role in their control. Municipal water supply, sewage service, food hygiene control (freezers and refrigerators), progress in antibacterial chemotherapy, etc. made a great contribution to this, and many people thought that infectious diseases had ceased to be a medical problem. However, it is becoming apparent that this was an illusion, as changes in lifestyles and living environments provide breeding grounds for new types of infectious diseases. WHOs proposal drawing attention to the importance of emerging infections (new/revival) is based on this point of view. Using actual examples, emerging infections, as a product of advances in science and technology and changes in lifestyles, are discussed in outline below, along with the tasks required to control them in the future.

(1) Opportunistic infections

Advanced medical treatments such as surgical procedures, antineoplastic therapy and organ transplantation have been developed by overcoming various technological challenges including infectious disease control. As a result, people can now survive with extremely low resistance to infection, but this has led to a concentration of low infection-resistant persons, centering around hospitals. For such low infection-resistant persons, microbes whose pathogenicity in the past was rarely a problem can now cause fatal infections. Examples include various drug-resistant bacteria, fungi, cytomegalovirus, Pneumocystis carinii and Cryptosporidium, for which satisfactory treatment methods have not been developed. Moreover, once they are overcome, their carriers are allowed to live under an even more serious state of infection, giving rise to infectious diseases caused by even weaker pathogens. With infectious diseases of this category, the most important task is to identify pathogens which could cause problems in the future and develop control measures. The development of antitumor agents and immunosuppressant agents which do not reduce infection resistance, and artificial organs and medical supplies (e.g. catheters) which do not easily cause infection are needed.

(2) Multiple-drug-resistant microbe infections

People and microbes both constantly evolve in an ever changing environment. The speed of evolution is linked to the time taken for a generational change, and there is an approximate 25,000-fold difference between humans and staphylococci in this regard. Microbes, therefore, undergo rapid evolution to survive in environments where antibacterial drugs are present. This evolution involves genetic mutations, genetic variations via transposons, plasmid integration, etc. Amid selection pressures applied by antibacterial drugs, drug-resistant microbes selectively propagate. Infestation by drug-resistant microbes is more likely to occur in a hospital environment, where a strong selection pressure applied by antibacterial drugs exists, or a livestock or fish farming industry environment, where antibacterial drugs are added to feed, and the importance of drug-resistant microbe control measures will increase in the future. Technological tasks include i) elucidation of resistance acquisition mechanisms and development of control methods, ii) development of antibacterial drugs for drug-resistant microbes, iii) development of medical facilities and equipment aimed at preventing hospital infections, and iv) measures targeting livestock and fish farming industries.

(3) Changes in lifestyles and emerging infections

Legionella pneumophila, which is a bacillus normally present in natural soil or water environments, has invaded modern buildings featuring characteristic piping or air conditioning systems, and is causing new problems. For example, the bacillus spreads throughout a building by entering the cooling tower as part of the air conditioning system or the water supply system that feeds the hot water supply system. The Legionella contamination of 24-hour bath houses and hot springs has also become a problem. While the widespread use of refrigerators made food management easier, Listeria monocytogenes favors a refrigerated environment. Once an influenza virus enters a closed space such as an aircraft cabin or building, many people are simultaneously exposed to the virus in high concentrations. If a pathogen enters a large-scale food manufacturing and distribution mechanism, the risk of the simultaneous outbreak of a large number of infectious cases arises. Mass food poisoning by enteropathogenic Escherichia coli O157 via school lunches was a typical example. New diverse artificial spaces always harbor such problems, and infection control involving such spaces will continue to be an important task in the future.

(4) Cross-border infections/tourist-borne infections

People who grow up in a hygienic environment do so without gaining immunity to many microbes as they have limited exposure to pathogens during their growth periods. Today, people can travel anywhere in the world easily by airplane, but this means that they enter foreign environments without developing immunity to pathogens that are native to these environments. A foreign pathogen brought onto virgin soil gives rise to the danger of mounting casualties. The importance of cross-border infection control measures will further increase in the future.

(5) Restoration of nature and new/revival infectious diseases

The spread of Lyme disease in North America and an increase in hydatid disease cases are considered to be linked to the restoration of a local forest environment/wildlife located close to an urban environment. There are concerns over increases in cases of schistosomiasis, malaria, filariasis, etc., which are attributable to the irrigation of desert areas, as well as concerns over an expansion of tropical and semi-tropical regions (areas where tropical diseases such as malaria originate) due to global warming. The implementation of tropical disease control measures in developing countries will be an important task.

(6) Summary

As discussed above, environmental changes brought about by advances in science and technology, in turn, facilitate the outbreak of new infectious diseases. Efforts to develop a monitoring system and control measures for such new infectious diseases will continue to be necessary.

(Takashi Inamatsu)

14.1.4. Gene diagnosis and therapy

Apart from application to cancer, AIDS and various hereditary diseases, attempts are being made to develop gene therapy techniques for acquired diseases such as rheumatism and atopy. Although various techniques have been developed for the introduction of genes into animal cells and promotion of gene expression, including physical, chemical and biochemical methods, none has proven to be infallible, so that they need to be used on a case by case basis, depending on the cell into which a gene is being introduced and the gene which is being introduced or promoted to manifest. The current problem concerns how to efficiently introduce genes and safely control their expression. For this purpose, it is necessary to elucidate expression mechanisms of disease-causing genes, identify the DNA sequences (control regions) necessary for their control, and prepare the most suitable vectors to activate their control regions. Namely, producing proteins needed by a living organism in large quantities is not enough to maintain its homeostasis, and such proteins need to be adequately controlled. The control of the expression of a gene involves more than one transcriptional control gene, and an ideal vector is one which has a fine gene expression control mechanism. From the viewpoint of both introduction efficiency and safety, the early development of a technique to introduce genes into specific tissues and promote their expression is desired. To do this, several methods are being studied including one aimed at incorporating expression control mechanisms based on tissue-specific promoters/enhancers, one taking advantage of tissue specificity that viruses naturally have, and one trying to introduce a gene through a specific combination of the membrane protein of the target tissue and the vector. The problem is that all methods are still low in introduction efficiency.

The ultimate gene therapy technique is the repairing of gene abnormalities without affecting normal genes, which would make gene therapy targeting reproductive cells possible. Although a technique aimed at replacing a DNA containing abnormal sequences with a healthy one based on homologous recombination is being studied, its recombination frequency is still too low for practical application. Vectors capable of introducing genes at specific locations of chromosomes (i.e. locations with no effects on the cells) rather than random locations have been discovered, and the introduction of a gene at a desired gene locus is becoming a reality. Vectors used for gene introduction are not yet perfectly safe. The development of hybrid vectors that eliminate viral side-effects as much as possible and combine a viral component necessary for gene introduction and a non-viral chemical compound is under way. At present, the development of a gene introduction system centering on large quantities of purified harmless gene-introducing vectors is the most important task in facilitating practical application of gene therapy.

Notably, the top 20 topics in terms of the degree of importance index contained those relating to adult diseases, such as "20: Widespread use of scientific guidelines for adult-disease-preventing life-styles (nutrition, rest and exercise)" or "09: Elucidation of the arteriosclerosis contraction mechanisms". In the future, preventive medicine for adult diseases will further make progress, with gene therapy based on an accurate gene diagnosis incorporated into adult disease prevention as a treatment option.

In this regard, guidelines to deal with ethical, legal and social issues (ELSI) associated with the application of genetics in medicine (e.g. gene diagnosis and gene therapy) must be urgently developed.

Advantages of gene diagnosis include clear-cut diagnostic results compared to enzyme-based diagnosis, histological diagnosis and tolerance tests, no need to collect a tissue sample from the gene expression site in some cases and the possibility of pre-implantation diagnosis. Gene diagnosis do, however, have limitations such as a very small number of diseases to which it can be applied due to the involvement of a wide range of disease-causing gene abnormalities in many genetic disorders. There are many issues that must be sorted out, such as the objectives of gene diagnosis and the level of understanding a doctor performing gene diagnosis must have about diseases. It is necessary to prevent gene diagnosis from becoming a threat to the protection of privacy.

(Akihiro Morikawa)

14.1.5. Advances in artificial organs

When an important organ of a living organism ceases to function properly, treatment aimed at replacing the organ or providing a functional support becomes necessary. For organ replacement or support treatment, artificial organs are available and used in clinical applications, although they are still short of being perfected medical devices. At present, the artificial kidney is the artificial organ most widely used in clinical applications. Artificial kidneys provide renal failure patients with a total loss of kidney functions with artificial kidney function support consisting of the removal of extra moisture and uremic toxins from their blood and correction of electrolyte imbalances. Under current practices, hemodialysis and continuous ambulatory peritoneal dialysis (CAPD), which do not replace the multiple functions of the kidney, are used.

At present, 154,413 patients (end of December 1995) receive this treatment in Japan. Of them, 30,000 have survived more than 10 years, with the longest survival record standing at 29 years. The good survival rate, despite a recent increase in the number of dialysis patients developing systemic complications, such as diabetes, due to advances in their age, seems to be attributable to progress in dialysis machine technology and medicine. However, new complications (bone and joint disorders and amyloid accumulation) are emerging in long-term dialysis patients.

The need for a true artificial kidney which would eliminate all those complications is increasing, and it is necessary to step up efforts to develop a next-generation artificial kidney in the future, instead of being complacent about the current machines. The ultimate form of an artificial kidney is a wearable-type (portable) or implantation, but, to attain that goal, several technical hurdles must be cleared. The results of the 6th technology forecast survey confirmed that the practical use of fully implanted artificial kidneys has a high degree of importance to Japan. To develop such artificial organs and put them into clinical application, technological innovation is necessary to improve their performance and safety in terms of materials, modules, overall system and so on to satisfactory levels.

On the other hand, pump-oxygenators and artificial hearts are already in use for temporary functional substitution during open-heart surgery etc. Although hopes are high for the development of fully implanted artificial hearts, technical hurdles currently exist in terms of the antithrombotic property and durability of materials and energy supply systems. Artificial valves, pacemakers, large-size artificial blood vessels, artificial sense organs, artificial skin, etc. have already been successfully implanted in patients, making a semi-perfect substitution of functions of the living human body possible, though on a limited scale.

Artificial lungs do not pose major clinical problems for use in open-heart surgery lasting several hours as a result of the development of membrane lungs using hollow fibers. However, the practical use of fully implanted artificial lungs will not be realized, unless performance enhancement and down sizing take place, along with the development of membrane materials, which are biological-membrane-like, and circuit materials. Aiming to develop a hybrid (bio) artificial liver, the species of the liver cells, culture medium and modules are being studied in pursuit of a synthetic metabolic function and a detoxication function, but ultimately the developmental goal will be a hybrid artificial liver based on human liver cells.

The pancreas regulates insulin secretion in response to fluctuations in blood sugar levels. The focus of current research is the development of a device that detects blood sugar levels accurately and swiftly. There are expectations for the development of a hybrid artificial pancreas and attempted implementation of human islets of langerhans in the human body after implementation as a microcapsule.

A technology that is common for all the above artificial organs is to improve the biological compatibility of materials, in terms of both blood and tissue affinity. The former includes antithrombotic properties, and points to a study of biomaterials in a broad sense of the term. Expectations for the development and practical use of fully-implanted organs in the near future are high, as has been strongly confirmed by the latest survey.

(Fumitake Gejyo)

14.1.6. Direction of welfare and nursing care

Welfare in Japan has undergone a fundamental conceptual and institutional change, following amendments to its welfare laws in 1990.

As a result, welfare is now considered part of essential social services, instead of government relief for the poor, the old notion of welfare.

It encompasses diverse areas, such as old age, children, and physical and intellectual disability, centering on old age.

Until 1990 old-age welfare revolved around facilities, but this has now shifted to services centering on home visits to support the elderly to enable them to remain independent in their own homes. This is thought to be based on the 10-Year Strategy for Old-age Health and Welfare Promotion (Gold Plan), established in 1989. Its home-based welfare concept consists of three policy pillars, home helpers, short stay and day care, and this was followed up by the New Gold Plan, established in 1994, which proposes an increase in the number of home helpers, day-care centers, visiting nurse stations, home helper stations, etc. Indeed, nursing care is becoming a social agenda, and a systematic approach based on public nursing care security is being called for.

Home-based welfare and nursing care services, which are provided mainly by municipal governments, reflect an increase in the number of households consisting of elderly couples or single elderly persons living alone, as well as the declining family nursing care capabilities as a result of the greater social activity involvement of women.

To enable the elderly and the disabled to live independently in the community, informal support, the development of medical-care and nursing-care technologies, and the like are necessary, and the development of injury/disease prevention and self management techniques is important.

It is also necessary to establish a welfare infrastructure consisting of welfare service providing agencies, economic assistance, man power, etc. and develop programs setting out service methods and content.

To improve welfare and nursing care programs, technological topics should be geared towards making it possible to have health checks and treatment advice in one's everyday life environment, "with 88. Practical use of systems by which an appropriate diagnosis can be given at home in the event of an accident or illness" forecasted to be realized by 2009. It is also necessary to identify the physical and psychological needs of the disabled as quickly as possible, with "83: Development of a device to sense the needs of demented aged people" and "89. Widespread use of portable conversational speech interpretation systems" forecasted to be realized by 2019 and 2010, respectively.

On the other hand, while improvement and innovation in old-age and disability care technology is important, a reduction in the burden placed on carers is also necessary in terms of bathing, moving around and improvement of the living environment, in view of the possibility that care will be required over longer periods of time in the future. The development of care technology aimed at improving the efficiency of nursing care and reducing the burden on carers is necessary, with “90: Widespread use of robots that care for people with severe physical and mental disabilities” forecasted to be realized by 2012.

In Japan, nursing care is considered to be a family matter, and therefore has not been discussed in terms of its social aspect. In fact, a discussion on its institutional framework, system, etc. has only recently begun, with the care and welfare system involving professional carers established in 1987.

The development of advanced care techniques is largely left for the future. At present, there is a need to recruit professional carers and deploy them appropriately, and the development of effective educational techniques for them is an important issue.

(Katsuko Kanagawa)

14.1.7. Conclusions

In the health, medical care and welfare field in the latest technology forecast survey, the five areas of malignant neoplasms, adult diseases (lifestyle diseases) and lifestyles, emerging infections, gene diagnosis/treatment, artificial organs, welfare and nursing care were chosen as areas of attention. A comparison between the top 10 topics in the last two surveys in terms of the degree of importance index shows that Alzheimer's disease scored highest in the previous survey, with arteriosclerosis, cancer and AIDS also included. In the latest survey, on the other hand, cancer (malignant neoplasms) was top, with arteriosclerosis and Alzheimer's disease included as before, but AIDS was replaced by viral hepatitis, with scientific guidelines for adult-disease-preventing life-styles newly included.

In the latest survey, the inclusion of malignant neoplasms as an area of attention was meant to focus on the most common type of diseases, while the other areas of attention represented issues that applied more or less across the board. The inclusion of guidelines on adult disease prevention, which newly appeared in the top 10, was partly because of a perceptional change that is occurring with regard to the term. Namely, hypertension, diabetes, etc., traditionally referred to as adult diseases have recently begun to be called lifestyle diseases, as lifestyles and habits from a younger age play an important role in their prevention. Not limited to AIDS and viral hepatitis, infectious diseases as a whole have begun to attract attention from a new perspective, and were included as an area of attention under emerging infections. Gene diagnosis and artificial organs have been a focus of attention as cutting-age areas of medicine. The trends in the welfare and nursing care area were summarized as an area of attention, as the area was newly included in the health, medical care and welfare field.

Collectively, malignant neoplasms are the No. 1 cause of death in Japan. Although prevention efforts such as changing lifestyles and habits and stepped-up screening for early detection ó and attempts at new treatment methods, the progress so far has been far short of dramatically reducing the mortality rate, with the realization of the average five-year survival rate exceeding 70% forecasted to be more than 15 years away. The second and third cause of death are cerebrovascular diseases and heart diseases (e.g. myocardial infarction), respectively, and these closely linked to arteriosclerosis, which was discussed under adult diseases (lifestyle diseases). While the greatest factor for arteriosclerosis is age, lifestyle also plays an important role as a modifying factor. The effectiveness of the use of the term lifestyle diseases in prevention should be fully monitored in the future. This would necessitate the drawing up of clear scientific guidelines on lifestyles for adult disease prevention. Although it was not discussed as an individual topic this time, an increase in the number of old-age dementia cases has become a major social issue, with Alzheimer's disease requiring particularly urgent attention. As no effective prevention or treatment methods are available at present, it was only mentioned in relation to the issue of care under welfare and nursing care. However, basic research is making fairly rapid progress, and there are vigorous treatment drug development efforts. With viral hepatitis, progress was more pronounced in prevention than treatment, and the situation was the same with AIDS. Over time, however, there has also been considerable progress with regard to AIDS treatment drugs.

With the rapid progress in molecular genetics, gene diagnosis has been advancing at a breathtaking pace, although gene treat has only just begun. This area also faces considerable ethical problems. Although artificial organs that are operated outside the human body or are of a temporary nature have been fairly extensively used for some organs, artificial organs, in the true sense of the word, are largely still to be developed. There are also ethical problems associated with their use.

In the area of welfare and nursing care, while technological issues exist, institutional issues weigh heavily, and the attitudes of administrative authorities can have a great influence over its future course.

(Syunsaku Hirai)

14.2. Forecast topic framework

In the course of compiling forecast topics, a framework representing the organization of technologies in tabulated matrix form was drawn up for each field, with objectives and technological domains defining the rows and columns of the table, respectively. The framework is designed to present an overall picture of technological development in each field in terms of future prospects, importance, etc. as seen from the present perspective, and is also used as a working framework for future reviews of forecast topics.

Table 14.2-1 Forecast Topic Framework for Health, Medical Care and Welfare Field

Domain / Objective	Infectious diseases, immune disorders, and metabolic/endocrine diseases	Neoplasms	Neurological, mental and muscular diseases	Circulatory, renal and respiratory diseases	Digestive system diseases	Birth trauma and newborn disorders	Injuries (including accidents)	Hereditary diseases	General/ common
Health promotion			01						02
Elucidation of disease development mechanisms	03 04	05 06	07	08 09 10					
Improved standard of prevention methods	11 12 13		14 15		16	17 18 19			20
Improved standard of testing and diagnostic methods	21	22 23 24 25 26	27	28 29	30				31 32 33 34
Improved standard of treatment methods	35 36 37 38 39 40 41 42 43	44 45 46 47 48 49 50 51	52 53 54 55 56 57 58	59 60 61 62 63 64 65	66 67 68 69		70 71 72	73 74	75 76 77 78 79
Improved standard of rehabilitation/assistance			80 81 82 83 84				85 86		
Integration (systems approach)				87					88 89 90 91 92
Basic (elucidation of functions and nature of living bodies, etc.)			93 94 95						96 97 98

* Figures appearing in the table represent topic numbers.

14.3. Topics with high degree of importance

Degree of importance index scores (Note 1) averaged at 61.5 for topics in the health, medical care and welfare field as a whole. Topics considered of particular importance to Japan (top 20 topics in terms of degree of importance index score) are listed in the table below. Nine of the top 20 topics, including the top three, were related to cancer, highlighting the high level of importance attached to it. Although disease-related topics dominated the top 20, “20: Widespread use of scientific guidelines for adult-disease-preventing life-styles” (nutrition, rest and exercise), a topic relating to health management, squeezed in 4th place.

Table 14.3-1 Top 20 Topics in Terms of Degree of Importance Index

Topic	Degree of importance index	Forecasted realization time (year)
05 Elucidation of carcinogenic mutation mechanisms.	88	2013
44 Improvement in the average five-year survival rate for all types of cancer to more than 70% (currently about 40% for stomach cancer).	87	2013
06 Elucidation of cancer metastasis mechanisms.	86	2012
20 Widespread use of scientific guidelines for adult-disease-preventing life-styles (nutrition, rest and exercise).	81	2006
45 Practical use of chemotherapy that brings complete remission to digestive organ cancer with low drug-responsiveness.	78	2015
09 Elucidation of the arteriosclerosis contraction mechanisms.	78	2011
46 Widespread use of techniques to overcome the drug resistance of malignant tumors.	77	2013
48 Practical use of effective methods against cancer metastasis.	76	2013
35 Widespread use of drugs that cure viral liver disease.	75	2010
07 Elucidation of the origins of Alzheimer-type senile dementia.	73	2012
50 Widespread use of biological and immunological therapy effective for cancer.	73	2011
53 Development of effective methods of preventing Alzheimer's disease.	73	2013
39 Possible to cure allergic diseases.	72	2018
13 Development of an HIV vaccine.	72	2007
51 Widespread use of gene therapy against malignant tumors.	72	2014
11 Widespread use of prevention methods for the contraction of diabetic complications.	71	2008
95 Elucidation of individual aging mechanisms.	71	2018
36 Practical use of anti-AIDS therapy.	70	2009
24 Widespread use of an early cancer diagnosis technique based on biochemical examination.	69	2007
37 Widespread use of a technique to eliminate viruses from blood.	69	2010

Note 1: Degree of importance index = (number of “high” responses × 100 + number of “medium” responses × 50 + number of “low” responses × 25 + number of “unnecessary” responses × 0) ÷ total number of degree of importance responses

14.4. Forecasted realization times

Forecasted realization times were distributed as shown in the diagram below. The distribution peaked between 2011 and 2015, with many forecasted realization times also falling in the 2006~2010 period. Overall, the distribution was in line with the general trend covering all topics.

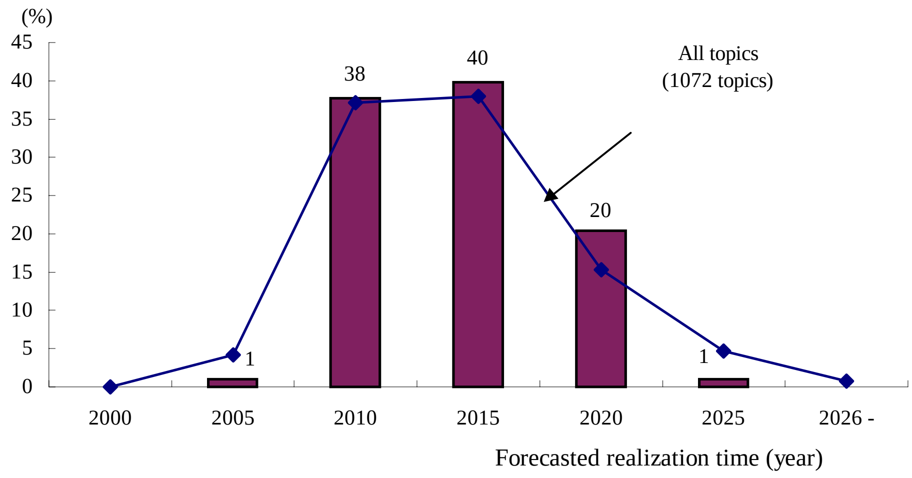

Fig. 14.4-1 Trends in Forecasted Realization Times

14.5. Current leading countries etc.

Responses to the question concerning current leading countries etc. were as shown in the diagram below. The U.S. was named by an overwhelming number of respondents, with its score almost twice that of second-ranking Japan.

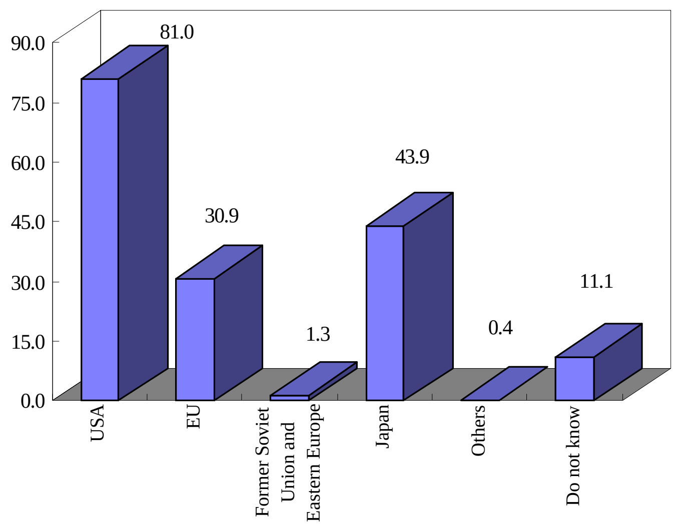

Fig. 14.5-1 Current Leading Countries etc. (%)

14.6. Comparison with the 5th Survey (previous survey)

Of the 98 topics included in the latest survey, 34 (35%) were identical to the previous survey, 34 (35%) were modified, and 30 (31%) were newly introduced. For identical topics, the results of the latest survey were compared with those of the previous survey in terms of degree of importance index scores and forecasted realization times, as shown in the table below.

Degree of importance index scores rose for 2 topics, remained the same for 1 topic and fell for 31 topics. Fourteen topics saw their importance index scores plummet by 15 or more points, including 34. Practical use of a rapid diagnostic method for rejection in organ and tissue transplantation, down 20 points.

From the 4th to the 5th Survey, forecasted realization times were pushed back for all topics. From the 5th to the 6th Survey, on the other hand, forecasted realization times were brought forward for 2 topics (73. Practical use of gene therapy for genetic disorders and 75. Practical use of heterogeneous organ transplantation as means of treatment), remained the same for 1 topic, and were pushed back for 32 topics. 44. Improvement in the average five-year survival rate for all types of cancer to more than 70% saw its forecasted realization time pushed back most (10 years).

Table 14.6-1 Comparison with 5th Survey for Identical Topics

Topic	Degree of importance index / forecasted realization time	
	6th survey	5th survey
02 Practical use of a method to quantitatively assess the level of aging (biological age) in relation to chronological age.	63/2008	63/1999
04 Elucidation of the cause and contracting mechanisms in rheumatoid arthritis.	61/2012	74/2004
07 Elucidation of the origins of Alzheimer-type senile dementia.	73/2012	89/2007
08 Elucidation of contributing factors to bronchial asthma.	64/2010	58/2004
09 Elucidation of the arteriosclerosis contraction mechanisms.	78/2011	93/2004
12 Practical use of a preventive measure against diabetic complications.	56/2009	62/2004
13 Development of an HIV vaccine.	72/2007	88/2003
14 Practical use of prevention methods for stress-induced mental disorders.	60/2011	71/2009
20 Widespread use of scientific guidelines for adult-disease-preventing life-styles (nutrition, rest and exercise).	81/2006	79/2002
21 Elucidation of gout-causing genes.	46/2008	54/2003
26 Widespread use of automatic testing equipment for cancer cytodiagnosis.	63/2006	68/2003
27 Practical use of classification and stage determination of schizophrenia based on diagnostic imaging.	50/2013	61/2012
28 Practical use of diagnosing methods for determining the level and spread of arteriosclerosis focused by a non-invasive process.	62/2008	75/2003
31 Practical use of specialist-level medical diagnosis assistance systems.	53/2008	60/2005
34 Practical use of a rapid diagnostic method for rejection in organ and tissue transplantation.	56/2007	76/2002
36 Practical use of anti-AIDS therapy.	70/2009	88/2006
41 Development of an effective insulin that can be administered orally.	63/2008	65/2004
44 Improvement in the average five-year survival rate for all types of cancer to more than 70% (currently about 40% for stomach cancer).	87/2013	88/2003
48 Practical use of effective methods against cancer metastasis.	76/2013	97/2007* 86/2011
52 Development of a technique to cause drug delivery to targeted sites in the brain.	59/2015	70/2009
53 Development of effective methods of preventing Alzheimer's disease.	73/2013	89/2011
55 Practical use of a safe pain control method without side effects.	63/2009	78/2004

Topic	Degree of importance index / forecasted realization time	
	6th survey	5th survey
57 Development of effective treatment for amyotrophic lateral sclerosis.	49/2018	68/2011
60 Practical use of batteries of artificial organs implanted in the living body.	54/2014	71/2006
67 Development of artificial liver (external devices supporting liver functions) usable on a long-term, continuous basis.	61/2016	78/2011
73 Practical use of gene therapy for genetic disorders.	58/2012	74/2016
75 Practical use of heterogeneous organ transplantation as means of treatment.	58/2016	63/2017
81 Development of artificial eyes featuring electronic circuitry that can be connected to nerve and brain cells.	49/2019	68/2019
82 Development of methods for recombining disconnected central nerves.	65/2018	80/2015
85 Development of controlling devices which help the cooperative muscular actions enabling object-oriented movement.	55/2014	67/2007
86 Widespread use of artificial legs featuring a small power source and computer control.	51/2010	66/2004
88 Practical use of systems for monitoring health condition and providing information for an appropriate diagnosis at home in event of accident or diseases.	63/2009	70/2005
93 Elucidation of molecular mechanism of memory.	65/2018	68/2014
94 Development of hybrid-type artificial intelligence that combines ICs and living cells.	55/2019	57/2018

* Identical topic from life science field

Note: Up until the 5th Survey, realization meant realization in Japan unless otherwise specified. However, this was changed to mean realization somewhere in the world in the 6th Survey. Therefore, care should be taken when comparing forecasted realization times from the two surveys.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time			Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001 2006 2011 2016 2021 2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Health promotion	1	Realization of the quantification of stress levels.	1	119	9	35	55	59	30	49	19	2	20	1	92	18		6	16	74	26	6	18	1	22	61	48	15	8	54	2	2	3	30	52	1
			2	91	9	31	60	60	31	49	19	1	19	2	92	18		3	8	81	27	5	19	1	11	71	49	12	5	56	0	0	1	30	63	0
			X	8	100	0	0	88	75	25	0	0	0	0	88	38		0	0	88	63	13	25	13	0	75	50	13	13	75	0	0	0	25	88	0
	2	Practical use of a method to quantitatively assess the level of aging (biological age) in relation to chronological age.	1	132	15	36	49	62	35	45	18	2	23	6	94	27		2	5	68	33	4	30	1	20	62	38	21	31	53	2	2	5	33	61	2
			2	104	14	33	53	63	36	47	14	3	17	4	94	17		1	2	71	28	3	34	0	17	70	42	11	30	55	1	1	5	28	68	1
			X	15	100	0	0	90	80	20	0	0	20	0	100	13		0	0	100	40	0	47	0	0	67	53	13	20	73	0	0	7	33	60	0
Elucidation of disease development mechanisms	3	Elucidation of the contracting mechanisms in autoimmune diseases.	1	130	12	35	53	68	40	52	7	1	15	2	92	37		0	8	88	44	2	50	1	8	68	29	27	39	54	0	2	9	18	28	3
			2	100	10	35	55	66	36	57	6	1	15	2	96	28		0	5	91	39	0	48	0	5	72	27	20	37	58	0	0	4	17	33	2
			X	10	100	0	0	90	80	20	0	0	20	0	100	40		0	0	100	20	0	70	0	0	90	30	20	30	60	0	0	0	30	40	0
	4	Elucidation of the cause and contracting mechanisms in rheumatoid arthritis.	1	115	13	33	54	61	28	59	12	1	13	3	96	26		0	5	83	40	2	49	1	9	67	29	24	37	56	0	2	5	17	27	3
			2	87	9	39	52	61	28	63	8	1	16	3	98	21		0	3	90	36	0	49	1	6	74	22	18	37	59	0	0	3	9	33	1
			X	8	100	0	0	88	75	25	0	0	25	0	100	25		0	0	100	25	0	75	0	0	63	38	0	38	50	0	0	0	13	50	0
	5	Elucidation of carcinogenic mutation mechanisms.	1	147	19	31	50	87	76	21	2	1	21	6	95	50		3	9	95	55	3	61	1	3	65	31	30	47	65	0	2	7	15	40	3
			2	113	17	32	51	88	78	20	2	1	22	4	94	42		2	6	96	46	1	59	1	3	76	23	25	42	69	0	1	1	11	45	2
			X	19	100	0	0	100	100	0	0	0	32	11	89	37		0	5	100	42	0	68	0	0	74	11	16	47	68	0	0	0	16	37	5
	6	Elucidation of cancer metastasis mechanisms.	1	147	18	31	51	83	69	26	4	1	19	4	95	39		2	7	89	44	3	51	1	8	68	35	27	39	67	1	1	5	9	40	3
			2	113	16	32	52	86	75	21	3	1	20	4	94	29		2	4	94	38	1	53	1	5	75	32	25	34	67	0	1	2	11	43	1
			X	18	100	0	0	96	94	0	6	0	39	11	89	39		6	6	94	39	0	61	6	6	78	22	28	44	61	0	0	0	17	50	0
	7	Elucidation of the origins of Alzheimer-type senile dementia.	1	106	11	24	65	72	49	40	11	0	27	0	96	33		4	5	92	38	1	41	0	8	69	29	31	33	59	1	1	5	22	45	2
			2	87	10	25	64	73	48	47	5	0	31	1	95	23		2	3	92	33	1	40	0	6	77	26	26	26	63	0	0	0	18	53	1
			X	9	100	0	0	100	100	0	0	0	11	0	100	33		0	0	89	22	11	56	0	0	89	11	22	33	44	0	0	0	44	56	0
	8	Elucidation of contributing factors to bronchial asthma.	1	108	13	30	57	62	31	57	11	1	16	4	98	22		0	5	80	44	2	49	0	13	66	37	26	31	57	0	2	17	9	25	3
			2	85	12	31	58	64	30	64	6	0	16	1	99	19		0	2	87	39	0	52	0	8	72	34	21	20	64	0	0	11	8	36	1
			X	10	100	0	0	80	60	40	0	0	20	0	100	30		0	0	90	60	0	50	0	0	70	40	20	30	60	0	0	20	0	40	0
	9	Elucidation of the arteriosclerosis contraction mechanisms.	1	120	13	34	53	73	50	44	6	0	28	8	97	29		2	4	89	46	3	47	1	7	65	35	31	30	61	0	1	7	13	32	3
			2	91	10	34	56	78	59	36	6	0	26	1	97	26		1	3	96	43	0	49	1	2	73	34	20	20	67	0	0	2	9	41	1
			X	9	100	0	0	94	89	11	0	0	11	11	100	44		11	0	100	44	0	44	0	0	67	22	22	11	67	0	0	0	0	44	0
	10	Elucidation of factors contributing to chronic nephritis (primary) contraction.	1	88	10	22	68	56	23	53	23	0	23	2	99	22		1	7	78	42	2	47	0	16	65	34	26	25	63	0	1	6	9	28	5
			2	71	7	18	75	58	21	67	11	0	23	1	97	17		1	6	86	37	0	45	0	11	76	28	15	20	65	1	0	1	7	34	4
			X	5	100	0	0	80	60	40	0	0	0	20	100	60		20	20	100	40	0	60	0	0	60	60	20	20	40	0	0	0	20	20	20

(Note) See page 7 for the interpretation of the graphs.

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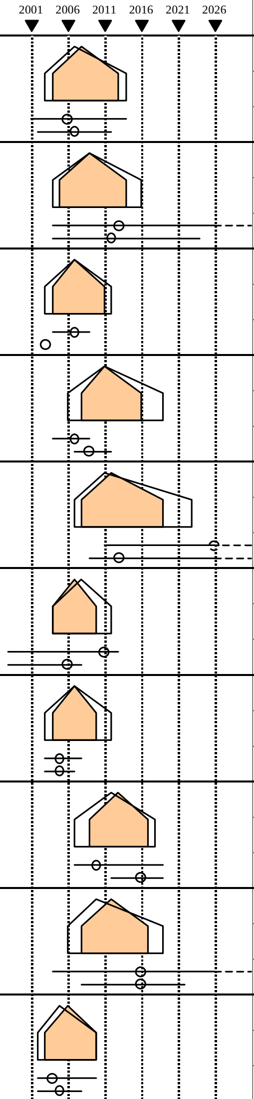
Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time		Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Improved standard of prevention methods	11	<u>Widespread use</u> of prevention methods for the contraction of diabetic complications.	1	112	9	38	54	70	43	51	6	0	21	2	96	16	3	3	83	46	1	51	0	12	65	33	26	25	54	4	1	4	15	37	4
			2	88	9	33	58	71	45	48	7	0	23	0	95	13	1	1	89	43	0	49	0	7	78	28	22	19	60	1	1	0	11	40	2
			X	8	100	0	0	81	63	38	0	0	38	0	100	25	0	13	100	38	0	38	0	0	75	50	25	25	63	0	0	0	25	38	0
	12	<u>Practical use</u> of a preventive measure against diabetic complications.	1	95	11	31	59	57	23	59	18	0	23	1	91	16	5	9	74	42	2	40	0	19	63	39	22	32	49	0	1	2	11	37	1
			2	77	10	25	65	56	18	70	12	0	23	0	92	14	8	6	82	42	0	43	0	14	74	34	18	23	60	0	1	0	8	36	1
			X	8	100	0	0	66	38	50	13	0	13	0	63	38	38	0	88	50	0	50	0	0	88	38	25	50	38	0	0	0	13	38	0
	13	<u>Development</u> of an HIV vaccine.	1	113	6	26	68	69	45	42	12	1	24	6	91	25	4	5	94	36	1	23	0	5	65	35	22	31	61	4	3	5	30	43	0
			2	87	1	29	70	72	48	44	8	0	23	6	94	20	1	2	94	41	0	24	1	3	67	38	24	25	66	1	3	0	26	51	0
			X	1	100	0	0	100	100	0	0	0	100	0	100	0	0	0	100	100	0	100	0	0	100	100	0	100	0	0	0	0	0	100	0
	14	<u>Practical use</u> of prevention methods for stress-induced mental disorders.	1	83	7	33	60	62	32	50	18	0	27	2	94	17	7	10	78	37	2	27	1	17	71	37	25	11	42	2	2	2	31	53	1
			2	65	6	35	58	60	27	61	13	0	26	2	94	14	9	5	83	40	5	18	2	9	80	35	23	5	51	2	3	0	25	60	0
			X	4	100	0	0	81	75	0	25	0	0	0	100	0	0	25	100	50	0	0	25	0	75	50	50	0	50	0	0	0	25	75	0
	15	<u>Widespread use</u> of presbyopia prevention methods.	1	59	7	24	69	51	22	38	38	2	24	0	92	14	17	10	49	24	7	32	0	31	49	25	20	8	39	0	3	3	15	32	2
			2	47	6	15	79	46	15	38	47	0	26	0	87	6	19	4	60	28	2	38	0	28	68	17	19	4	49	0	2	0	6	34	2
			X	3	100	0	0	67	33	67	0	0	0	0	67	0	0	0	67	33	0	67	0	33	100	0	0	0	67	0	0	0	33	0	0
	16	<u>Widespread use</u> of a laser-applied tooth decay treatment method.	1	35	6	17	77	50	18	48	30	3	31	3	86	14	0	9	66	34	0	51	0	20	49	57	11	3	40	9	0	9	20	23	9
			2	33	6	12	82	55	22	53	25	0	33	0	88	9	3	6	70	45	0	64	0	12	61	55	15	0	48	0	3	3	15	27	3
			X	2	100	0	0	75	50	50	0	0	50	0	100	0	0	0	100	50	0	100	0	0	100	0	50	0	100	0	0	0	0	0	0
	17	<u>Widespread</u> method of prevention against a premature delivery through the progression of management system of fetal information.	1	52	17	29	54	54	26	40	32	2	21	4	94	13	2	4	75	42	2	54	0	13	50	27	25	19	48	2	4	4	21	50	4
			2	46	13	28	59	54	22	50	28	0	28	0	96	11	2	4	76	43	2	59	0	11	67	22	20	11	61	0	0	0	24	54	2
			X	6	100	0	0	83	67	33	0	0	33	0	100	0	0	17	67	67	17	83	0	17	67	33	50	0	67	0	0	0	17	17	0
	18	<u>Practical use</u> of the prevention against congenital anomaly originating in the embryonic or fetal period.	1	70	16	21	63	54	25	44	29	1	17	9	91	19	10	7	74	39	3	39	1	19	57	19	14	49	50	9	3	4	34	67	1
			2	58	14	19	67	53	19	57	24	0	22	0	91	17	7	3	84	43	0	33	2	7	66	12	3	50	55	9	0	0	29	66	0
			X	8	100	0	0	69	38	63	0	0	25	0	100	25	13	0	75	25	0	50	13	13	63	13	13	50	63	13	0	0	38	63	0
	19	<u>Widespread use</u> of preventive measure for cerebral palsy.	1	61	16	23	61	60	32	42	25	0	15	8	95	10	2	10	67	34	3	38	0	26	79	23	23	23	48	5	3	5	21	48	2
			2	49	14	22	63	56	24	49	27	0	20	2	96	6	0	8	80	39	2	39	0	16	86	14	14	18	57	2	2	2	18	59	0
			X	7	100	0	0	71	43	57	0	0	29	0	100	0	0	14	86	71	0	57	0	14	100	14	14	14	57	0	0	0	43	71	0
	20	<u>Widespread use</u> of scientific guidelines for adult-disease-preventing life-styles (nutrition, rest and exercise).	1	131	22	29	49	76	56	37	7	0	35	9	94	14	1	3	75	46	2	47	0	8	50	53	25	20	46	5	2	5	11	47	2
			2	101	26	30	45	81	65	31	4	0	40	5	95	10	1	1	80	45	1	56	0	5	63	48	21	17	56	4	1	3	10	54	1
			X	26	100	0	0	92	85	15	0	0	35	4	96	19	0	0	88	35	4	54	0	8	69	46	27	8	81	4	4	4	4	58	4

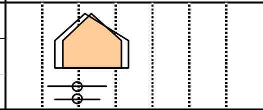
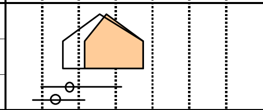
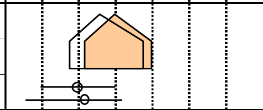
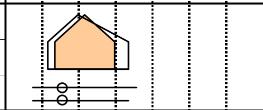
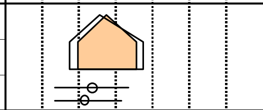
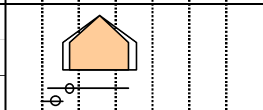
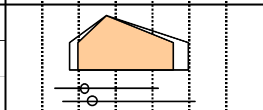
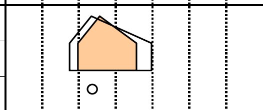
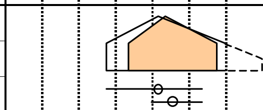
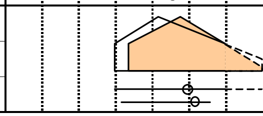
Forecasted realization time



(Note) See page 7 for the interpretation of the graphs.

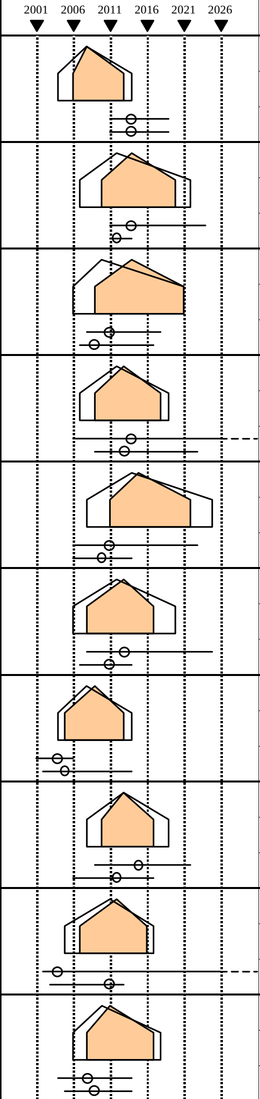
Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time	Will not be realized (%)	Do not know (%)	Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001 2006 2011 2016 2021 2026			USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Improved standard of testing and diagnostic methods	21	Elucidation of gout-causing genes.	1	78	3	23	74	45	8	58	32	3	10	5	92	23		0	5	82	37	3	28	0	13	63	24	17	44	45	0	0	4	18	28	1
			2	65	2	26	72	46	6	64	30	0	15	3	94	20		0	2	85	38	2	37	0	9	80	23	12	45	49	0	0	0	17	32	2
			X	1	100	0	0	100	100	0	0	0	100	0	100	0		0	0	100	100	0	0	0	0	100	0	0	100	100	0	0	0	0	100	0
	22	Widespread use of a cancer spread diagnosis technique based on 3-D imaging.	1	114	15	32	54	66	37	51	12	0	30	1	91	17		0	4	82	37	1	68	0	11	54	54	35	8	55	2	1	1	19	21	2
			2	89	10	38	52	63	30	62	8	0	33	0	94	15		0	1	84	35	2	75	0	3	56	54	29	10	58	1	0	1	19	27	2
			X	9	100	0	0	67	33	67	0	0	56	0	100	11		0	0	78	33	0	89	0	0	67	67	22	0	78	0	0	0	22	44	0
	23	Widespread use of a cancer risk assessment technique based on genetic analysis.	1	124	13	26	61	66	38	51	10	1	21	4	90	23		3	6	92	48	2	52	1	6	54	33	19	57	52	5	1	2	38	52	2
			2	95	9	24	66	66	36	56	7	0	26	2	94	25		2	0	94	47	2	56	1	2	67	25	15	56	55	4	0	1	21	57	1
			X	9	100	0	0	94	89	11	0	0	56	11	78	44		0	0	89	56	0	56	11	0	78	33	11	67	56	0	0	0	33	56	0
	24	Widespread use of an early cancer diagnosis technique based on biochemical examination.	1	134	18	28	54	69	44	47	7	2	26	1	93	18		9	5	81	37	3	64	1	11	55	41	19	29	57	2	1	1	25	31	1
			2	104	14	24	62	69	43	50	7	1	31	1	93	12		9	1	79	36	1	65	1	12	60	38	16	23	63	2	0	0	17	35	1
			X	15	100	0	0	83	67	33	0	0	33	0	100	20		13	7	80	40	7	73	7	7	87	27	7	20	73	0	0	0	27	33	0
	25	Widespread use of against of cancer cells drug sensitivity measurement method.	1	118	19	25	55	66	42	40	16	2	34	3	87	17		2	6	78	39	2	60	1	11	58	41	24	25	54	2	1	3	15	23	2
			2	93	17	29	54	65	37	50	12	1	32	0	87	12		1	3	84	33	0	62	1	6	63	40	20	23	53	0	0	0	14	26	1
			X	16	100	0	0	80	63	31	6	0	44	0	75	0		0	6	88	44	0	75	6	0	81	44	31	19	63	0	0	0	38	19	0
	26	Widespread use of automatic testing equipment for cancer cytodiagnosis.	1	106	16	29	55	63	38	40	22	1	32	2	91	13		3	7	75	28	2	61	0	12	57	53	25	18	48	1	1	1	20	24	5
			2	81	17	28	54	63	36	46	17	1	33	0	93	9		4	2	77	28	1	65	0	9	62	53	22	17	44	0	0	0	17	28	1
			X	14	100	0	0	75	57	29	14	0	50	0	86	0		7	0	86	43	0	64	0	0	64	50	21	21	57	0	0	0	29	21	0
	27	Practical use of classification and stage determination of schizophrenia based on diagnostic imaging.	1	53	9	23	68	51	15	60	23	2	13	2	87	30		8	6	77	38	6	34	0	17	70	42	25	11	53	6	0	0	34	53	2
			2	48	10	19	71	50	10	69	21	0	15	0	92	27		6	6	79	38	2	35	2	17	71	35	25	8	54	4	0	0	33	58	2
			X	5	100	0	0	80	60	40	0	0	20	0	100	40		0	20	100	80	0	20	20	0	100	20	40	20	80	0	0	0	60	40	0
	28	Practical use of diagnosing methods for determining the level and spread of arteriosclerosis focused by a non-invasive process.	1	81	15	37	48	64	36	47	16	1	22	1	90	19		0	1	80	40	1	53	0	9	56	53	37	10	49	1	0	1	16	25	4
			2	66	11	38	52	62	28	63	9	0	27	2	92	17		0	2	80	44	0	55	0	9	73	48	38	9	50	2	0	0	17	32	3
			X	7	100	0	0	79	57	43	0	0	14	0	86	43		0	0	86	57	0	71	0	0	86	57	43	0	57	0	0	0	57	29	0
	29	Establishment of a correct diagnostic measure for kidney diseases without renal biopsy.	1	70	9	30	61	53	19	56	24	1	19	0	90	17		6	13	63	30	0	46	0	27	63	34	21	14	54	0	0	1	17	20	3
			2	57	7	25	68	54	16	67	18	0	19	0	95	12		4	4	77	30	0	61	0	16	74	33	18	11	56	0	0	0	14	28	2
			X	4	100	0	0	75	50	50	0	0	0	0	75	50		0	25	100	75	0	100	0	0	100	50	25	25	75	0	0	0	50	50	0
	30	Development of a capsule-type total gastro intestinal tract monitoring system.	1	70	11	26	63	57	26	52	17	4	39	1	89	19		7	7	60	14	0	56	1	16	53	56	24	10	51	4	3	3	10	27	3
			2	53	8	28	64	59	25	62	13	0	40	0	91	15		8	2	62	13	0	68	0	15	60	57	21	4	47	4	0	0	11	28	2
			X	4	100	0	0	63	50	0	50	0	25	0	100	0		0	0	25	25	0	75	0	0	50	50	25	0	50	0	0	0	0	25	0

(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic development	Expected effect: Resolution of global problems	Expected effect: People's needs	Expected effect: Expansion of intellectual resources	Forecasted realization time (2001 2006 2011 2016 2021 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Improved standard of testing and diagnostic methods	31	Practical use of specialist-level medical diagnosis assistance systems.	1	114	12	31	57	55	24	47	29	0	45	2	89	18		3	5	81	27	3	46	0	10	46	61	20	14	46	4	1	3	25	27	4
			2	90	10	34	56	53	17	62	21	0	44	2	91	12		2	0	90	18	3	51	0	6	51	60	24	14	52	2	0	0	24	31	1
			X	9	100	0	0	72	44	56	0	0	56	22	89	11		0	0	100	22	0	78	0	0	67	56	33	11	56	0	0	0	44	22	0
	32	Development of non-invasive cell-level diagnostic imaging.	1	94	12	29	60	59	30	48	22	0	41	0	90	26		6	9	73	28	1	51	0	15	48	60	26	13	49	0	1	3	14	23	2
			2	83	8	25	66	59	26	57	17	0	43	0	90	20		4	5	81	22	1	58	1	12	49	60	27	6	57	0	1	0	13	29	1
			X	7	100	0	0	71	57	14	29	0	71	0	100	14		0	0	100	29	0	71	0	0	57	43	14	0	71	0	14	0	14	14	0
	33	Practical use of a non-invasive technique to obtain blood biochemical examination data using body surface sensors.	1	84	11	31	58	63	33	51	16	0	49	2	86	23		5	10	68	25	2	49	0	23	54	64	24	11	52	0	2	4	18	24	4
			2	71	10	24	66	57	24	59	15	1	46	1	86	15		6	6	77	20	0	63	0	15	59	62	25	1	59	0	4	1	17	27	1
			X	7	100	0	0	75	57	29	14	0	71	14	57	29		0	0	86	29	0	100	0	0	57	43	29	0	57	0	29	0	14	29	0
	34	Practical use of a rapid diagnostic method for rejection in organ and tissue transplantation.	1	90	17	26	58	59	28	52	19	0	19	0	93	22		0	4	91	44	1	43	0	6	61	47	22	24	54	3	0	4	16	31	2
			2	70	21	14	64	56	20	64	16	0	23	0	87	19		0	1	94	41	1	47	0	3	73	44	17	17	64	3	0	1	13	33	1
			X	15	100	0	0	68	40	53	7	0	20	0	93	20		0	0	100	67	0	60	0	0	73	67	20	20	73	0	0	0	13	27	0
Improved standard of treatment methods	35	Widespread use of drugs that cure viral liver disease.	1	97	13	26	61	76	53	44	3	0	36	3	94	21		5	4	76	40	3	64	0	8	62	47	22	23	59	3	1	2	15	28	5
			2	74	9	24	66	75	51	46	3	0	38	1	97	15		4	1	80	35	1	72	0	5	69	42	18	16	69	1	0	1	14	28	1
			X	7	100	0	0	93	86	14	0	0	29	14	100	29		0	0	71	14	0	86	0	0	71	57	0	14	100	0	0	0	14	43	0
	36	Practical use of anti-AIDS therapy.	1	111	10	22	68	74	51	40	9	0	36	5	93	24		1	5	96	40	2	25	2	1	69	37	28	18	59	1	2	3	28	41	1
			2	85	6	21	73	70	45	45	10	0	28	7	92	18		1	1	95	44	1	27	0	1	75	38	25	14	65	1	1	0	24	45	0
			X	5	100	0	0	90	80	20	0	0	20	0	100	20		0	0	100	80	20	40	0	0	60	60	40	20	80	0	0	0	40	40	0
	37	Widespread use of a technique to eliminate viruses from blood.	1	81	10	17	73	69	45	41	13	1	38	6	86	31		10	10	74	28	0	37	0	20	67	49	21	12	53	1	0	5	14	31	5
			2	63	5	24	71	69	43	46	11	0	38	2	90	22		8	3	84	30	0	48	0	11	79	51	19	8	59	2	0	2	22	32	2
			X	3	100	0	0	100	100	0	0	0	0	0	100	33		0	0	100	33	0	100	0	0	100	100	0	33	67	0	0	33	33	33	0
	38	Widespread use of malaria vaccines.	1	54	4	15	81	33	8	26	51	15	24	19	76	20		4	7	52	30	7	28	6	22	70	17	9	13	56	0	4	15	9	28	4
			2	43	2	14	84	34	7	23	63	7	35	9	84	14		5	5	63	33	2	30	2	26	74	14	12	16	63	2	0	16	7	26	2
			X	1	100	0	0	0	0	0	0	100	0	0	100	0		100	0	0	0	0	0	0	100	100	0	0	0	0	0	0	0	0	0	0
	39	Possible to cure allergic diseases.	1	110	12	27	61	70	46	43	11	0	34	6	97	24		13	11	78	45	2	50	2	14	64	36	21	32	55	2	1	6	10	22	2
			2	85	11	28	61	72	48	43	8	0	33	5	91	20		18	8	80	40	0	53	1	11	71	34	20	22	61	0	0	1	11	24	1
			X	9	100	0	0	83	67	33	0	0	56	22	89	11		11	0	67	44	0	78	11	0	89	44	11	44	78	0	0	11	11	33	0
	40	Possible to cure autoimmune diseases.	1	110	8	26	65	65	36	51	12	0	28	1	95	24		14	15	81	42	3	45	1	15	68	35	23	32	60	1	1	3	9	28	1
			2	82	6	32	62	67	37	56	7	0	28	0	95	20		16	13	85	37	0	52	0	11	80	34	22	22	68	0	0	0	12	26	1
			X	5	100	0	0	100	100	0	0	0	20	0	100	20		0	0	100	20	0	100	0	0	80	60	0	20	100	0	0	0	20	20	0

(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic development	Expected effect: Resolution of global problems	Expected effect: People's needs	Expected effect: Expansion of intellectual resources	Forecasted realization time: Will not be realized (%)	Forecasted realization time: Do not know (%)	Leading countries (%): USA	Leading countries: EU	Leading countries: Former Soviet Union and Eastern Europe	Leading countries: Japan	Leading countries: Other countries	Leading countries: Do not know	Measures the government should adopt (%): Foster human resources	Measures: Promote exchanges among industrial, academic and government sectors and different fields	Measures: Upgrade advanced facilities and equipment	Measures: Develop a research base	Measures: Increase government research funding	Measures: Adjust regulations (relax/toughen)	Measures: Others	Potential problems (%): Adverse effect on the natural environment	Potential problems: Adverse effect on safety	Potential problems: Adverse effect on morals, culture or society	Potential problems: Other adverse effects
Improved standard of treatment methods	41	Development of an effective insulin that can be administered orally.	1	85	7	31	62	66	39	52	7	2	38	4	95	18	9	8	71	38	1	38	0	20	56	52	21	16	49	1	0	1	12	24	6
			2	72	8	25	67	63	31	63	6	1	44	1	97	13	4	6	83	40	0	42	0	10	67	64	19	11	56	1	0	0	10	32	1
			X	6	100	0	0	79	67	17	17	0	50	0	100	17	17	0	83	17	0	33	0	0	67	83	17	0	50	0	0	0	17	17	0
	42	Practical use of gene therapy for diabetes.	1	93	9	25	67	66	39	47	13	1	27	2	95	22	11	11	88	39	1	33	0	10	59	34	22	45	53	5	0	2	19	39	2
			2	74	11	19	70	62	30	58	12	0	32	1	96	16	9	7	92	43	0	32	0	4	66	32	20	46	57	7	0	0	22	50	3
			X	8	100	0	0	72	50	38	13	0	38	0	100	13	25	13	88	13	0	38	0	0	50	38	25	38	38	0	0	0	25	50	0
	43	Widespread use of gene therapy for familial hypercholesterolemia.	1	90	8	27	66	52	21	48	30	1	21	2	94	17	9	12	86	32	2	30	0	10	59	34	17	42	54	4	0	2	19	38	1
			2	69	6	20	74	54	22	52	26	0	26	0	97	14	6	9	93	38	0	29	1	4	71	33	16	39	58	6	0	0	20	48	1
			X	4	100	0	0	88	75	25	0	0	25	0	100	25	25	0	100	0	0	50	0	0	75	75	25	25	50	0	0	0	25	25	0
	44	Improvement in the average five-year survival rate for all types of cancer to more than 70% (currently about 40% for stomach cancer).	1	124	22	33	45	82	66	28	6	0	31	2	96	15	3	6	82	41	4	69	0	9	64	47	31	27	57	2	0	3	13	31	4
			2	97	20	30	51	87	75	22	3	0	32	0	98	11	4	4	86	39	2	76	0	6	69	43	27	18	69	1	0	0	12	29	1
			X	19	100	0	0	92	84	16	0	0	32	0	100	16	5	11	89	58	11	79	0	5	79	47	16	32	74	0	0	0	21	32	0
	45	Practical use of chemotherapy that brings complete remission to digestive organ cancer with low drug-responsiveness.	1	93	23	25	53	74	52	40	8	0	33	1	94	18	22	14	75	33	1	56	0	12	61	51	26	17	57	2	0	2	12	27	4
			2	74	23	26	51	78	58	39	3	0	39	0	95	11	23	5	85	34	1	62	0	7	70	49	24	14	65	0	0	1	12	27	1
			X	17	100	0	0	81	65	29	6	0	35	0	88	6	29	6	88	47	0	82	0	0	76	53	12	6	88	0	0	0	12	24	0
	46	Widespread use of techniques to overcome the drug resistance of malignant tumors.	1	103	21	23	55	71	49	38	13	0	26	3	90	22	10	15	75	34	1	50	0	16	62	50	20	26	54	0	0	3	11	26	3
			2	78	21	23	56	77	56	37	6	0	33	0	95	15	14	8	81	33	0	56	0	10	68	51	18	17	60	0	0	1	12	24	1
			X	16	100	0	0	86	75	19	6	0	31	0	100	13	13	6	100	44	0	81	0	0	75	50	19	31	88	0	0	6	6	19	0
	47	Development of radiosensitizers effective in cancer treatment.	1	91	12	27	60	64	35	51	14	0	32	2	96	16	2	14	76	34	2	44	0	16	64	53	30	18	56	3	0	5	12	21	5
			2	68	10	25	65	65	34	57	9	0	41	1	94	15	0	12	84	35	0	51	0	10	68	56	22	12	59	3	0	4	12	26	1
			X	7	100	0	0	61	29	57	14	0	57	0	100	29	0	0	100	57	0	57	0	0	86	57	14	0	57	14	0	0	29	14	0
	48	Practical use of effective methods against cancer metastasis.	1	115	17	30	53	73	50	42	9	0	24	2	94	25	7	13	80	36	2	50	0	16	70	43	26	27	57	0	0	4	12	22	4
			2	85	13	32	55	76	56	36	7	0	32	1	93	18	7	9	84	34	0	54	0	14	76	46	24	19	59	0	0	1	13	26	1
			X	11	100	0	0	89	82	9	9	0	55	0	91	36	9	9	100	45	0	82	0	0	91	55	0	45	73	0	0	0	27	27	0
	49	Widespread use of heavy particle against cancer.	1	69	10	25	65	53	22	50	24	4	25	1	90	19	10	17	72	28	9	54	0	14	46	52	33	6	55	0	1	6	19	26	4
			2	52	6	25	69	56	23	54	23	0	33	0	92	15	8	10	69	31	2	56	0	13	54	54	31	2	67	2	0	4	17	37	2
			X	3	100	0	0	42	0	67	33	0	33	0	100	33	33	0	67	0	0	100	0	0	100	33	67	0	100	0	0	0	33	33	0
	50	Widespread use of biological and immunological therapy effective for cancer.	1	118	15	32	53	70	47	41	12	0	29	2	93	20	8	9	77	35	5	57	1	13	62	50	21	27	59	1	0	3	11	20	3
			2	85	13	31	56	73	50	42	8	0	34	0	94	12	8	5	80	35	1	62	0	9	73	52	18	21	68	2	0	0	13	25	1
			X	11	100	0	0	86	73	27	0	0	45	0	91	18	0	9	100	45	0	91	0	0	100	91	9	18	82	0	0	0	27	18	0



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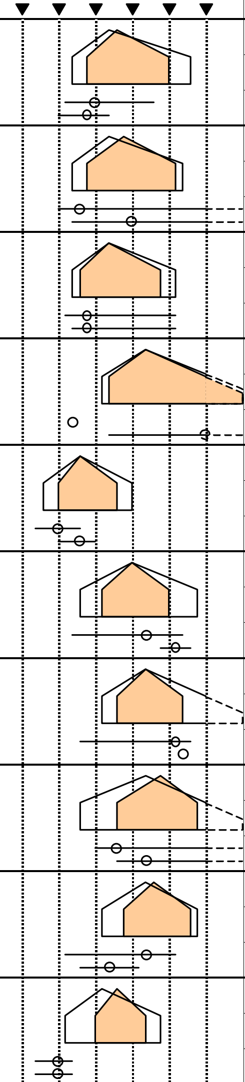
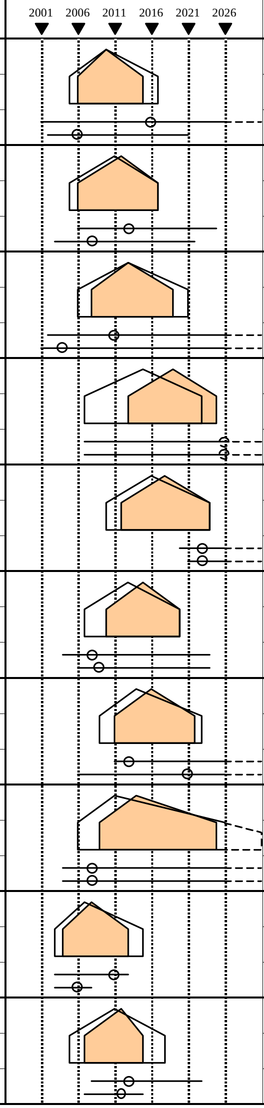
Improved standard of treatment methods	51	Widespread use of gene therapy against malignant tumors.	1	119	16	24	61	70	47	39	12	1	26	3	92	24		8	14	89	33	3	35	0	6	69	38	20	44	54	3	0	3	18	36	3
			2	88	14	25	61	72	48	43	9	0	27	2	92	24		8	6	94	33	0	38	0	3	81	34	18	43	59	3	0	2	16	44	1
			X	12	100	0	0	100	100	0	0	0	42	0	83	25		17	8	100	50	0	58	0	0	92	50	0	75	83	0	0	0	50	50	0
	52	Development of a technique to cause drug delivery to targeted sites in the brain.	1	77	8	36	56	56	23	57	19	1	30	0	91	26		4	12	75	23	1	35	0	14	68	42	34	8	51	1	0	1	16	31	5
			2	65	6	35	58	59	25	59	16	0	29	2	95	26		2	8	85	17	0	40	0	11	74	45	34	5	49	2	0	0	18	37	2
			X	4	100	0	0	75	50	50	0	0	25	0	100	25		0	0	100	25	0	25	0	0	75	25	0	25	25	0	0	0	50	25	0
	53	Development of effective methods of preventing Alzheimer's disease.	1	87	10	22	68	68	43	48	7	2	25	1	92	28		3	18	87	40	0	39	0	7	68	41	24	24	62	0	0	0	14	37	3
			2	72	11	21	68	73	49	46	6	0	33	0	99	24		1	13	92	38	0	42	0	4	72	33	33	22	64	0	0	0	14	33	1
			X	8	100	0	0	100	100	0	0	0	25	0	100	25		0	13	100	50	0	63	0	0	75	38	25	38	63	0	0	0	0	13	0
	54	Development of a cure method for schizophrenia.	1	61	5	21	74	63	34	52	12	2	21	2	89	36		20	20	67	34	3	21	0	23	59	38	28	21	51	5	0	2	11	43	2
			2	54	7	20	72	64	31	61	7	0	30	2	96	30		30	17	70	35	2	22	4	22	65	26	35	17	50	4	0	0	13	39	2
			X	4	100	0	0	100	100	0	0	0	25	25	100	75		25	25	100	50	0	50	25	0	75	0	50	25	75	25	0	0	0	50	0
	55	Practical use of a safe pain control method without side effects.	1	100	12	36	52	65	37	50	13	0	22	1	97	19		4	11	77	44	6	38	1	16	66	45	17	9	53	3	0	3	7	29	3
			2	84	10	26	64	63	31	59	10	0	25	0	99	15		4	7	81	46	2	31	0	15	73	52	15	5	61	5	0	0	11	32	1
			X	8	100	0	0	81	63	38	0	0	50	0	100	25		0	13	100	63	13	63	0	0	75	50	0	0	63	13	0	0	13	50	13
	56	Widespread use of gene therapy for muscular dystrophy.	1	66	9	30	61	47	16	42	39	3	18	2	89	18		5	9	83	33	2	35	0	11	71	33	15	50	42	2	2	3	18	32	3
			2	49	6	29	65	48	17	44	38	2	27	0	94	16		2	4	86	31	0	39	0	6	73	24	18	45	43	6	2	0	22	41	2
			X	3	100	0	0	42	0	67	33	0	33	0	100	33		0	0	100	67	0	100	0	0	67	67	33	100	33	0	0	0	33	33	0
	57	Development of effective treatment for amyotrophic lateral sclerosis.	1	55	9	29	62	48	19	41	37	4	20	0	89	24		5	11	75	27	2	31	0	15	71	40	18	18	47	2	0	2	15	29	4
			2	45	2	27	71	49	18	43	36	2	24	0	93	18		2	11	87	27	0	33	0	7	76	29	24	11	51	2	0	0	13	31	2
			X	1	100	0	0	50	0	100	0	0	0	0	100	0		0	0	100	100	0	100	0	0	100	100	0	0	100	0	0	0	0	0	0
	58	Practical use of artificial muscles for limbs.	1	46	13	30	57	51	20	49	24	7	43	0	87	26		11	15	61	24	2	26	0	22	57	54	24	11	59	0	0	2	13	28	4
			2	40	8	25	68	47	13	54	28	5	50	0	90	13		10	13	78	23	3	33	0	13	73	48	30	5	55	0	0	0	10	30	5
			X	3	100	0	0	75	50	50	0	0	67	0	100	33		0	0	100	33	0	33	0	0	67	100	33	0	100	0	0	0	33	33	0
	59	Practical use of a technique to induce the differentiation of fibroblasts into cardiac muscle and its application to the treatment of myocardial infarction.	1	65	9	29	62	59	32	45	16	6	26	0	88	35		15	23	68	14	0	18	0	20	65	51	29	15	52	0	0	3	11	26	5
			2	50	6	26	68	56	20	67	8	4	28	0	90	24		14	14	82	18	0	26	0	14	78	40	24	6	54	0	0	0	10	30	4
			X	3	100	0	0	67	33	67	0	0	33	0	67	0		0	0	100	0	0	0	0	0	100	0	0	0	33	0	0	0	0	67	0
	60	Practical use of batteries of artificial organs implanted in the living body.	1	55	5	35	60	55	24	51	22	4	44	13	87	22		5	13	69	18	0	44	0	20	62	62	25	7	49	4	2	5	18	24	5
			2	41	7	27	66	54	20	60	18	3	44	5	88	12		7	5	85	15	0	51	0	10	80	56	24	2	46	2	0	2	17	32	2
			X	3	100	0	0	75	50	50	0	0	67	0	100	0		33	0	100	0	0	67	0	0	33	33	33	0	0	0	0	0	0	0	0



(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%) High	Medium	Low	Importance (index, %) Index	High	Medium	Low	Unnecessary	Expected effect (%) Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%) USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%) Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%) Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Improved standard of treatment methods	61	Widespread use of functional blood purifiers that selectively remove specified components from blood.	1	79	10	28	62	56	22	62	14	3	41	1	91	20		0	9	70	28	3	52	0	20	59	62	30	10	54	6	0	4	11	23	5
			2	61	13	23	64	57	21	66	13	0	39	2	97	16		0	7	80	26	3	57	0	11	56	64	26	5	56	5	0	3	16	33	2
			X	8	100	0	0	75	50	50	0	0	50	13	100	13		0	0	88	25	0	100	0	0	88	88	13	0	50	0	0	25	13	25	0
	62	Widespread use of artificial hemoglobin as a red blood cell substitute.	1	77	13	30	57	61	31	53	13	3	45	1	91	19		5	8	75	26	4	49	1	16	58	55	29	10	52	5	0	4	12	29	3
			2	63	13	24	63	61	27	62	11	0	49	3	92	16		5	6	83	21	0	56	0	13	68	60	22	5	54	5	0	0	13	38	2
			X	8	100	0	0	72	50	38	13	0	63	0	88	13		0	13	88	50	0	88	0	13	75	50	13	25	50	0	0	0	0	38	0
	63	Development of fully implanted artificial hearts.	1	73	11	22	67	63	34	49	15	1	45	0	97	22		5	4	82	25	1	55	0	11	58	63	36	5	49	3	0	1	19	38	1
			2	56	9	20	71	65	34	57	9	0	48	2	95	13		2	4	91	20	0	61	0	4	57	59	32	0	52	2	0	0	14	45	2
			X	5	100	0	0	80	60	40	0	0	80	0	100	20		0	0	100	0	0	100	0	0	60	80	40	0	60	20	0	0	40	40	0
	64	Practical use of fully implanted artificial lungs.	1	63	11	27	62	56	24	53	19	3	38	2	97	19		11	10	71	24	5	25	0	21	56	65	29	6	52	3	0	3	17	29	2
			2	51	10	20	71	61	26	64	10	0	37	2	96	14		12	10	80	12	0	25	0	14	61	65	22	2	55	2	0	2	18	33	2
			X	5	100	0	0	60	20	80	0	0	60	0	80	20		0	0	80	40	0	0	0	20	80	60	40	0	40	0	0	0	0	20	0
	65	Practical use of fully implanted artificial kidneys.	1	59	15	14	71	63	34	52	12	2	44	3	93	22		12	7	73	25	0	34	0	24	59	61	32	3	49	3	0	3	15	29	3
			2	47	17	11	72	63	30	62	9	0	45	2	98	15		13	4	81	17	0	36	0	13	68	64	21	0	53	4	0	2	17	36	2
			X	8	100	0	0	78	63	25	13	0	63	13	88	25		0	0	88	25	0	75	0	0	100	75	25	0	38	0	0	13	50	50	0
	66	Practical use of fully implanted artificial pancreas.	1	60	10	13	77	60	31	49	19	2	40	2	90	22		13	13	65	20	0	33	0	25	60	58	27	10	50	0	0	3	15	27	5
			2	46	15	17	67	66	37	52	11	0	43	2	93	13		11	15	78	15	0	37	0	15	67	57	22	2	52	2	0	2	15	35	2
			X	7	100	0	0	71	57	14	29	0	57	14	86	14		14	14	86	29	0	57	0	14	71	57	29	0	43	0	0	14	29	43	0
	67	Development of artificial liver (external devices supporting liver functions) usable on a long-term, continuous basis.	1	59	7	17	76	62	32	54	13	2	42	2	92	24		5	12	66	24	0	36	0	22	64	66	24	10	56	3	0	2	15	24	5
			2	44	9	23	68	61	26	67	7	0	48	0	93	18		2	9	77	20	0	41	0	16	61	64	16	7	55	2	0	0	14	39	2
			X	4	100	0	0	75	50	50	0	0	75	0	100	0		0	0	100	0	0	100	0	0	100	75	25	0	75	0	0	0	25	50	0
	68	Development of hybrid-type artificial endocrine organs in which living cells and artificial objects coexist.	1	52	8	29	63	53	21	52	23	4	40	0	90	25		4	27	56	17	0	33	0	33	62	67	25	6	52	0	0	2	17	29	4
			2	45	9	27	64	57	22	60	18	0	49	0	93	18		7	11	71	9	0	36	0	20	64	64	22	2	58	0	0	0	16	40	2
			X	4	100	0	0	56	25	50	25	0	75	0	100	25		0	25	75	25	0	75	0	0	75	100	0	0	75	0	0	0	50	50	0
	69	Widespread use of prevention and treatment methods for tooth decay and periodontitis to ensure the retention of 20 or more teeth at 80 years of age.	1	59	3	14	83	61	33	47	14	5	32	2	97	15		8	3	39	24	0	31	2	41	58	41	20	7	41	7	2	2	12	29	8
			2	49	4	12	84	66	38	50	13	0	33	0	96	10		8	0	47	16	2	41	2	37	69	29	14	6	53	4	4	0	10	35	2
			X	2	100	0	0	100	100	0	0	0	100	0	100	0		0	0	50	0	0	0	0	50	50	50	50	50	100	0	0	0	50	50	0
	70	Widespread use of a technique to store, cultivate and transplant one's own tissues.	1	87	8	28	64	63	37	46	15	2	28	6	95	20		2	11	80	28	6	38	0	14	72	45	28	16	62	6	0	2	11	34	3
			2	66	15	20	65	62	31	57	12	0	32	3	95	15		2	6	88	24	6	38	0	9	79	45	18	9	70	6	0	0	12	38	2
			X	10	100	0	0	85	70	30	0	0	60	10	100	30		0	0	100	40	20	80	0	0	90	80	0	30	90	0	0	0	10	30	0

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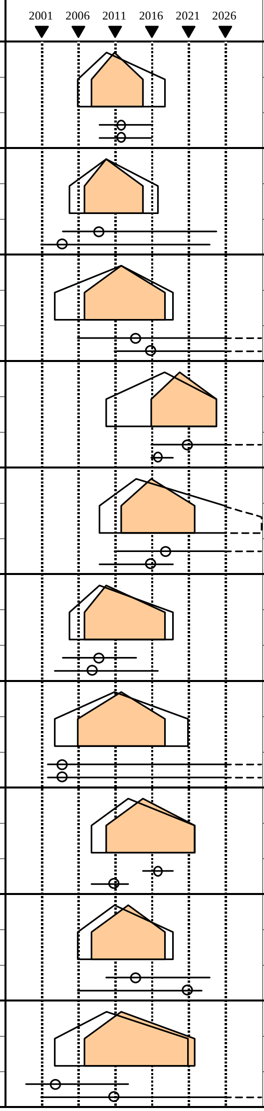
Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%) High	Degree of expertise (%) Medium	Degree of expertise (%) Low	Importance (index, %) Index	Importance High	Importance Medium	Importance Low	Importance Unnecessary	Expected effect (%) Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Forecasted realization time	Will not be realized (%)	Do not know (%)	Leading countries (%) USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%) Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%) Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Improved standard of treatment methods	71	Widespread use of a wound healing acceleration technique as a general treatment method through the elucidation of anagenetic mechanisms.	1	87	16	25	59	55	22	57	20	1	34	1	91	20		2	11	69	25	2	31	0	22	68	46	23	16	59	1	0	2	14	26	6
			2	65	14	25	62	55	22	57	20	2	29	2	95	14		3	6	78	25	2	38	2	15	72	46	20	15	60	2	0	0	15	28	3
			X	9	100	0	0	69	44	44	11	0	22	0	100	33		0	11	78	44	0	44	0	22	89	44	22	22	100	0	0	0	22	11	11
	72	Practical use of implanted bladder control devices.	1	47	19	28	53	53	20	54	26	0	32	0	96	9		2	9	57	17	0	26	0	34	66	57	30	9	60	0	2	2	19	26	9
			2	43	12	23	65	54	21	53	26	0	37	0	95	9		0	5	72	21	0	37	0	19	74	58	19	2	49	5	2	0	26	33	5
			X	5	100	0	0	65	40	40	20	0	40	0	100	0		0	0	60	20	0	20	0	20	60	100	40	0	40	0	0	0	0	20	20
	73	Practical use of gene therapy for genetic disorders.	1	96	14	21	66	58	28	48	24	0	20	1	97	22		3	7	91	33	2	27	1	7	66	31	24	51	45	7	0	3	21	50	1
			2	73	11	19	70	58	22	64	14	0	21	0	96	16		1	4	96	37	0	32	0	0	70	25	16	48	51	8	0	0	18	53	0
			X	8	100	0	0	63	25	75	0	0	50	0	100	25		0	0	100	38	0	75	0	0	88	38	13	75	63	0	0	0	0	50	0
	74	Availability of genetherapy based on oral deliverly.	1	78	15	19	65	54	26	45	24	5	32	1	90	23		31	24	63	17	3	19	0	24	56	40	23	38	42	3	1	4	18	42	0
			2	62	11	18	71	54	21	56	20	3	26	0	89	13		27	15	73	16	0	15	0	19	61	35	21	26	45	5	0	3	18	47	0
			X	7	100	0	0	64	29	71	0	0	43	0	100	29		14	14	100	14	0	57	0	0	86	43	14	57	71	0	0	0	43	57	0
	75	Practical use of heterogeneous organ transplantation as means of treatment.	1	85	14	15	71	53	23	46	27	4	27	7	91	22		15	11	88	24	2	19	0	6	65	39	21	20	41	9	0	4	16	61	2
			2	59	14	14	73	58	27	49	24	0	37	2	92	12		12	8	97	20	0	19	0	2	69	42	20	14	47	8	0	0	20	61	2
			X	8	100	0	0	72	50	38	13	0	38	0	75	38		25	0	100	25	0	38	0	0	88	63	25	25	63	0	0	0	38	63	0
	76	Widespread use of a worldwide organ supply system.	1	92	14	17	68	60	32	44	23	0	28	14	89	18		8	10	87	45	7	17	2	10	42	27	20	30	43	30	0	0	25	64	1
			2	65	12	11	77	61	33	44	23	0	28	8	91	11		8	5	94	42	0	9	2	2	54	28	15	25	48	29	0	0	22	68	2
			X	8	100	0	0	84	75	13	13	0	38	0	88	13		13	0	100	88	0	25	13	0	50	25	38	25	63	50	0	0	38	75	0
	77	Development of a partial tissue destruction method non-invasive to the living body.	1	62	8	24	68	53	20	52	28	0	27	6	92	18		0	18	63	27	0	31	0	26	68	48	21	11	52	2	0	2	19	29	5
			2	52	8	19	73	53	18	58	24	0	25	0	88	12		2	10	81	27	0	29	0	15	71	42	25	6	62	6	0	0	21	33	2
			X	4	100	0	0	88	75	25	0	0	50	0	100	25		0	25	100	50	0	75	0	0	75	50	25	0	75	0	0	0	50	25	0
	78	Widespread use of a complete cure method for myopia.	1	45	9	20	71	59	32	41	27	0	38	0	91	20		18	13	51	27	18	31	2	29	60	44	18	9	40	2	2	2	18	33	4
			2	39	8	13	79	59	31	44	26	0	33	0	90	13		15	15	72	33	10	36	0	18	77	46	13	3	46	3	0	3	21	36	5
			X	3	100	0	0	83	67	33	0	0	0	0	100	0		0	33	100	67	0	100	0	0	100	33	0	0	100	0	0	0	33	67	0
	79	Practical use of a drug safety verification method (mutagenicity, teratogenicity and toxicity) without relying on animal tests.	1	83	13	33	54	68	43	46	10	1	52	16	63	28		17	13	70	41	2	30	0	19	60	47	19	20	42	12	0	8	11	41	4
			2	63	10	33	57	65	35	56	8	2	59	14	62	19		11	6	86	44	0	30	0	8	63	57	17	13	41	5	0	2	13	41	2
			X	6	100	0	0	75	67	17	0	17	67	50	33	33		17	17	100	67	0	17	0	0	67	67	33	0	50	17	0	0	17	50	0
Improved standard of rehabilitation/assistance	80	Practical use of implanted artificial cochleas effective for both conductive hearing loss and perceptive hearing loss.	1	40	15	18	68	61	28	59	13	0	53	0	95	25		13	10	63	38	0	35	3	23	65	55	20	10	55	3	0	3	18	33	5
			2	37	11	14	76	60	27	59	14	0	49	0	89	16		3	8	78	38	0	35	3	16	68	59	16	3	51	3	0	0	16	38	5
			X	4	100	0	0	75	50	50	0	0	75	0	100	25		0	0	100	75	0	50	0	0	75	75	25	0	50	0	0	0	0	0	25



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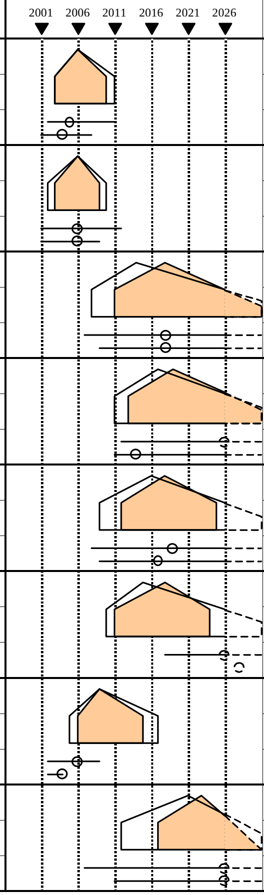
Improved standard of rehabilitation/assistance	81	Development of artificial eyes featuring electronic circuitry that can be connected to nerve and brain cells.	1	46	15	28	57	50	18	49	31	2	33	2	96	33		22	22	59	17	9	20	0	24	63	52	24	13	59	2	2	4	22	20	4
			2	44	11	23	66	49	14	58	26	2	36	0	93	32		18	16	80	16	5	25	0	14	73	41	23	5	55	0	0	0	25	30	5
			X	5	100	0	0	38	0	50	50	0	40	0	100	60		20	0	80	20	20	40	0	20	80	40	80	0	60	0	0	0	40	20	20
	82	Development of methods for recombining disconnected central nerves.	1	63	13	33	54	65	38	48	14	0	24	0	89	38		13	24	63	29	3	30	0	21	68	40	30	8	48	0	2	2	16	29	5
			2	55	13	29	58	65	33	59	7	0	27	0	95	33		15	13	78	27	0	27	0	16	82	33	33	2	53	0	0	0	18	33	4
			X	7	100	0	0	50	0	100	0	0	43	0	86	43		0	0	100	14	0	29	0	0	86	14	57	0	86	0	0	0	29	29	14
	83	Development of a device to sense the needs of demented aged people.	1	61	15	23	62	64	41	37	20	2	36	2	92	28		16	15	46	31	0	25	0	34	64	48	33	10	54	3	3	0	16	36	8
			2	56	13	20	68	67	44	35	19	2	34	0	89	18		14	9	54	25	0	27	0	30	68	45	23	2	52	4	4	0	14	38	4
			X	7	100	0	0	54	33	33	17	17	29	0	86	29		14	0	71	57	0	29	0	0	71	43	43	0	14	0	0	0	14	14	14
	84	Elucidation of the pathogenesis of autism.	1	50	10	12	78	43	10	43	45	2	14	0	82	34		6	16	48	30	4	22	0	32	52	34	22	22	42	0	0	2	24	30	4
			2	49	10	12	78	43	8	50	38	4	16	0	88	29		10	12	63	35	0	24	0	22	63	27	18	6	45	0	0	0	20	31	2
			X	5	100	0	0	50	0	100	0	0	0	0	100	80		0	0	80	40	0	40	0	0	80	20	40	0	60	0	0	0	20	40	0
	85	Development of controlling devices which help the cooperative muscular actions enabling object-oriented movement.	1	55	13	22	65	56	24	54	20	2	40	0	96	24		5	9	58	33	0	36	2	27	64	51	24	7	58	2	2	2	24	16	4
			2	45	9	20	71	55	23	53	21	2	42	0	93	18		4	9	73	29	0	47	0	13	69	47	22	0	64	0	0	0	27	20	4
			X	4	100	0	0	50	0	100	0	0	75	0	100	0		0	0	50	75	0	75	0	0	75	50	50	0	50	0	0	0	0	0	25
	86	Widespread use of artificial legs featuring a small power source and computer control.	1	54	17	24	59	53	17	62	19	2	41	0	98	7		0	6	61	35	2	57	0	20	61	67	22	6	56	6	2	2	24	20	6
			2	48	10	19	71	51	15	62	21	2	35	0	96	8		2	4	79	33	0	67	0	6	71	60	17	2	44	2	0	0	23	19	4
			X	5	100	0	0	88	75	25	0	0	40	0	100	0		0	0	80	60	0	80	0	0	80	100	40	0	40	0	0	0	0	0	20
Integration (systems approach)	87	Practical use of a blood cell production and supply technique based on industrial-scale cultivation.	1	58	21	28	52	61	34	43	21	2	40	9	84	24		9	9	76	22	0	40	0	19	62	52	26	24	48	12	0	5	12	41	3
			2	49	18	22	59	63	35	46	17	2	39	6	88	20		8	4	82	18	0	49	0	10	61	57	16	8	51	8	0	0	18	37	0
			X	9	100	0	0	83	67	33	0	0	67	22	100	33		0	0	100	44	0	89	0	0	67	78	22	11	44	11	0	0	11	33	0
	88	Practical use of systems for monitoring health condition and providing information for an appropriate diagnosis at home in event of accident or diseases.	1	110	12	31	57	63	36	46	18	0	50	2	95	12		4	7	62	27	1	45	0	19	47	58	19	12	47	15	3	2	33	32	2
			2	86	14	24	62	63	34	48	18	0	51	1	94	6		5	3	77	26	0	59	0	9	51	66	14	7	53	12	1	1	37	36	1
			X	12	100	0	0	65	40	40	20	0	58	8	100	17		0	8	58	17	0	75	0	8	42	58	8	8	33	17	8	0	33	17	0
	89	Widespread use of portable conversational speech interpretation systems.	1	66	6	20	74	62	37	40	22	2	67	3	70	29		0	6	52	21	0	59	2	15	48	68	30	3	41	5	0	0	11	35	3
			2	58	5	17	78	58	26	56	16	2	66	2	78	17		2	2	64	14	0	72	0	7	50	67	24	0	43	2	0	0	14	36	2
			X	3	100	0	0	100	100	0	0	0	100	0	33	33		0	0	100	67	0	67	0	0	67	100	67	0	0	0	0	0	0	33	0
	90	Widespread use of robots that care for people with severe physical and mental disabilities.	1	71	14	15	70	62	33	49	18	0	49	3	97	13		6	7	58	31	1	55	0	18	51	77	27	4	49	8	1	0	25	38	4
			2	57	14	11	75	60	30	50	20	0	47	0	96	12		2	4	68	25	2	68	0	9	61	68	23	0	46	9	0	0	21	39	2
			X	8	100	0	0	86	71	29	0	0	75	0	100	25		0	0	50	38	0	75	0	13	63	75	38	0	25	13	0	0	13	38	0

(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Medium	Low	Importance (index, %): Index	High	Medium	Low	Unnecessary	Expected effect (%): Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Forecasted realization time: Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Integration (systems approach)	91	Advancements in patient and hospital information management, leading to a reduction in waiting time at Japanese hospitals to 15 minutes or less.	1	129	21	29	50	66	40	45	16	0	38	3	96	6	9	4	56	29	2	36	0	23	26	50	11	11	31	30	5	0	21	29	5
			2	98	19	29	52	68	42	46	11	1	35	1	94	3	7	3	58	27	1	35	0	21	23	53	9	11	35	38	3	0	16	26	3
			X	19	100	0	0	82	63	37	0	0	42	0	100	5	5	11	79	42	5	42	0	5	26	37	21	0	32	47	5	0	5	26	5
	92	Practical use in Japan of an ID card system that thoroughly covers an individual's health conditions and medical data.	1	125	11	30	59	62	32	52	16	0	50	3	90	11	1	5	56	24	2	47	0	19	27	56	13	18	34	29	2	0	46	34	2
			2	97	13	28	59	63	32	56	10	1	46	3	90	7	0	2	62	16	0	58	0	18	24	59	12	16	36	32	1	0	40	32	1
			X	13	100	0	0	75	54	38	8	0	69	0	92	8	0	8	92	38	0	62	0	0	38	46	23	0	38	38	8	0	38	31	0
Basic (elucidation of functions and nature of living bodies, etc.)	93	Elucidation of molecular mechanism of memory.	1	68	15	25	60	66	39	47	13	2	32	4	71	74	9	15	78	47	3	43	0	13	69	40	32	15	60	0	1	1	13	41	1
			2	58	14	21	66	65	36	52	10	2	33	2	72	67	7	16	86	40	0	41	0	9	74	34	29	7	64	0	0	0	17	48	2
			X	8	100	0	0	81	63	38	0	0	38	0	88	63	13	0	100	63	0	50	0	0	100	38	38	0	50	0	0	0	25	25	0
	94	Development of hybrid-type artificial intelligence that combines ICs and living cells.	1	46	15	15	70	57	24	56	20	0	52	4	65	50	20	20	72	17	4	30	0	22	57	54	24	11	48	0	0	2	22	52	0
			2	42	14	17	69	55	21	55	24	0	55	2	74	43	14	19	83	19	2	36	0	12	69	62	24	0	52	0	0	0	24	57	0
			X	6	100	0	0	54	17	67	17	0	50	0	83	17	17	0	100	33	0	33	0	0	83	33	50	0	33	0	0	0	33	33	0
	95	Elucidation of individual aging mechanisms.	1	112	13	26	62	67	45	32	21	2	32	12	81	46	5	16	79	42	3	44	0	15	70	37	26	35	62	1	0	8	13	42	3
			2	84	15	15	69	71	52	26	20	1	33	5	88	36	8	14	92	43	1	48	0	5	77	40	21	20	63	0	0	1	17	43	1
			X	13	100	0	0	96	92	8	0	0	38	8	92	54	8	8	100	46	8	62	0	0	85	15	8	8	77	0	0	8	15	38	0
	96	Elucidation of the mechanism whereby living organisms undergo changes in the space environment.	1	40	10	25	65	42	10	38	49	3	38	30	63	63	5	15	83	10	28	8	0	15	68	43	28	10	63	0	3	15	15	25	3
			2	36	3	25	72	41	12	29	59	0	31	25	67	53	3	22	86	14	39	8	0	11	78	39	19	6	58	0	3	11	11	31	3
			X	1	100	0	0	100	100	0	0	0	100	100	100	100	0	0	100	100	0	100	0	0	100	100	100	0	0	0	0	100	0	0	0
	97	Elucidation of the biological clock, leading to drug administration that takes it into consideration.	1	87	8	31	61	53	21	49	27	2	20	2	90	18	3	13	76	33	1	32	1	21	69	44	20	16	47	3	1	2	13	25	3
			2	73	8	25	67	53	18	60	21	1	23	1	96	10	1	7	78	41	0	42	0	18	75	52	14	7	59	1	0	0	12	30	3
			X	6	100	0	0	71	50	33	17	0	17	17	100	17	0	17	100	67	0	50	0	0	83	67	17	0	67	0	0	0	0	33	17
	98	Practical application of the production of artificial cells with organ characteristics.	1	53	13	21	66	58	28	47	23	2	40	0	79	34	11	13	68	17	0	23	2	26	62	49	19	19	55	2	0	4	15	42	0
			2	48	13	23	65	58	25	58	17	0	40	0	88	23	8	6	81	17	0	35	2	15	75	46	17	15	60	0	0	0	21	50	0
			X	6	100	0	0	58	33	33	33	0	50	0	67	33	17	17	67	50	0	50	0	33	100	67	17	33	50	0	0	0	67	83	0



(Note) See page 7 for the interpretation of the graphs.

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Members of Technology Forecast Committee and Subcommittees

1. Technology Forecast Committee (in charge of the subject in parentheses)

Chairman	Noboru Makino	Senior Adviser, Mitsubishi Research Institute, Inc.
Member	Masaaki Hirooka	Professor, Faculty of Information Science, Ryutsu Kagaku University (Materials and processing)
Member	Kenichi Iga	Director, Professor, Precision & Intelligence Laboratory, Tokyo Institute of Technology (Electronics)
Member	Hideo Aiso	Chairperson, Graduate School of Media and Governance, Keio University (Information)
Member	Isao Karube	Professor, Research Center for Advanced Science and Technology (RCAST), The University of Tokyo (Life science)
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Vice-chief	Azusa Tomiura	Executive Advisor, Nippon Steel Corporation
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<Communication>

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<Transportation>

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Member	Keiji Kawachi	Professor, Research Center for Advanced Science and Technology, The University of Tokyo
Member	Tomonobu Nakaoka	Managing Director, Institute for Traffic Accident Research and Data Analysis
Member	Shin Narasaka	Manager, Research Div, Kokusai Koutsu Anzen Gakkai (IATSS)

<Health, medical care and welfare>

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Member	Hideaki Mizoguchi	Professor and Chairman, Department of Hematology, Tokyo Women's Medical College
Member	Akihiro Morikawa	Professor & Chairman, Department of Pediatrics, Gunma University School of Medicine
Member	Toshikazu Yoshikawa	Associate Professor, Internal Medicine, Kyoto Prefectural University of Medicine

(Name without title)

Two Members, Prof. Yoichi Ishida (Materials and processing field) and Mr. Yoichi Nojiri (Urbanization and construction field), passed away half way through their tenure. Taking this opportunity, we would like to express our sincere condolences to their families.

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Reference 2

Authoring task allocation

In preparing the report, the National Institute of Science and Technology Policy took responsibility for Capture 1 and 2, while the Institute for Future Technology worked on Capture 3. However “Trends in areas of attention” sections in Capture 3, were written by subcommittee members. The following researchers from the National Institute of Science and Technology Policy and the Institute for Future Technology were involved in this project.

• National Institute of Science and Technology Policy

Fourth Policy-Oriented Research Group

Terutaka Kuwahara	Director
Koji Suzuki	Senior Researcher
Masamichi Taguchi	Senior Researcher
Akio Nishimoto	Former Senior Researcher
Tomoaki Koga	Researcher
Toshimori Sato	Former Researcher
Ayako Kusunose	Assistant Researcher
Rie Naruke	Assistant Researcher
Akiko Tsuji	Former Assistant Researcher

• The Institute for Future Technology

First Research Division

Tetsuo Naito	Senior Manager, Research Division
Kiichiro Takagi	Former Senior Manager, Research Division
Takashi Kikuta	Senior Researcher
Masataka Sawaki	Senior Researcher
Shinji Yokota	Senior Researcher
Yusaku Otani	Senior Researcher
Hideto Yasuda	Researcher
Yasushi Kasai	Researcher
Chihiro Sato	Researcher
Yoshiko Wada	Researcher

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Reference 3

Top 100 topics in the fifth survey

Ranking	Field	Topic	Degree of importance index	Forecasted realization time	Notes; Classification of topic	
1	Life science	42. Practical use of effective means to prevent metastasis of cancer.	97	2007	Life	Cancer
2	Lifestyles and culture	10. Practical use of technologies that will eliminate the Nox, and other pollutants that cause today's air pollution.	97	2002	Environment	
3	Particles	26.Practical use of computers with a throughput exceeding 10 TFlops.	96	2004	Information	
4	Health and medical care	04. Elucidation of mechanism of canceration for virtually all types of malignant neoplasms.	96	2009	Life	Cancer
5	Production	30. Progress in the development of technologies including those for absorbing carbon dioxide, artificial photosynthesis, turning wastes into harmless substances and preventing desertification, leading to world-wide implementation of global environmental preservation measures.	96	2011	Environment	Global environment
6	Information and electronics	03. Practical use of VLSI with memory capacities on the order of 1 Gb/chip.	95	2001	Information	Semiconductors etc.
7	Information and electronics	02. Practical use of technology easily enabling processing of patterns with line-spacing down to 10 nm.	95	2002	Information	Semiconductors etc.
8	Life science	12. Identification of all genes inhibiting cancer and elucidation of the relationships between those genes and carcinogenesis.	94	2009	Life	Cancer
9	Outer space	11. Practical use of worldwide air traffic control systems using artificial satellites.	94	2001		
10	Particles	27. Practical use of large-capacity recording equipment with a writing speed of 1 GB or more per second.	94	2003	Information	Semiconductors etc.
11	Marine science and earth science	73. Development of technology capable of forecasting the occurrence of major earthquakes (magnitude 7 or above) a few days in advance.	94	2010	Disasters	Earthquakes
12	Life science	41. Development of highly sensitive techniques for simple and early diagnoses of cancers, using blood serums or others.	94	2001	Life	Cancer
13	Mineral and water resources	19. Practical use of economical methods of segregating valuable substances in city garbage for their retrieval.	93	2001	Environment	Recycling
14	Life science	74. Possibility of prevention of Alzheimer's disease.	93	2010	Life	Brain
15	Life science	75. Possibility of healing of senile dementias such as Alzheimer's disease.	93	2015	Life	Brain
16	Life science	40. Development of medicines preventing the development of cancers.	93	2012	Life	Cancer

Ranking	Field	Topic	Degree of importance index	Forecasted realization time	Notes; Classification of topic	
17	Life science	11. Elucidation of the mechanisms of the immune response at the level of molecular biology.	93	2008	Life	
18	Health and medical care	07. Elucidation of the mechanism of atherosclerosis.	93	2003	Life	
19	Agriculture, forestry, and fisheries	02. Practical use of improved crop varieties (higher yield and more disease-and cold-resistant) created by plant gene manipulation.	93	2002	Life	
20	Materials and processing	38. Development of superconductive materials with a transition temperature around room temperature.	92	2017		
21	Life science	29. Practical use of technologies enabling solar energy to be converted into, or stored as biochemical energy.	92	2009	New energy	
22	Energy	28. Practical use of technology for the safe disposal of highly radioactives solid waste.	92	2009	New energy	Nuclear energy
23	Life science	94. Practical use of (breeding methods to produce) plants with drought and salt tolerance at a high degree to stop the spread of desert environments.	92	2008	Environment	Global environment
24	Production	28. Widespread use of designing, producing, collecting and recycling systems which make it possible to recycle most used materials through legally establishing manufacturers' responsibilities for collection and disposal of disused products.	92	2004	Environment	Recycling
25	Production	72. Diffusion of systems to prevent damage at such facilities as oil complexes or nuclear power generation plants due to earthquakes or other disasters, e.g., incorporating safety equipment triggered by first slight tremors.	92	2006	Disasters	Earthquakes
26	Urbanization and construction	51. Development of waste recycling technology, enabling the amount of city waste (i.e., that must be disposed of) to be reduced to half its current level.	91	2004	Environment	Recycling
27	Environment	11. Determination of impacts of global warming on the whole world's agricultural production.	91	2004	Environment	Global environment
28	Life science	22. Elucidation of the whole aspect of the signal transduction in the carcinogenesis of cells.	91	2006	Life	Cancer
29	Urbanization and construction	65. Establishment of safe and efficient demolition technologies for decommissioned commercial nuclear power plants.	91	2003	New energy	Nuclear energy
30	Environment	12. Reduction of global carbon dioxide emissions to 20% below the current level.	91	2014	Environment	Global environment
31	Environment	04. Practical use of materials that replace91 fluorocarbon and halon, that do not damage the ozone layer and cause no global warming problem.	91	1998	Environment	Global environment

Ranking	Field	Topic	Degree of importance index	Forecasted realization time	Notes; Classification of topic	
32	Health and medical care	16. Development of effective methods of preventing Alzheimer's disease.	91	2010	Life	Brain
33	Materials and processing	22. Practical use of multi layer solar cells with a conversion efficiency of more than 50%.	91	2009	New energy	Solar cells
34	Marine science and earth science	40. Elucidation of the mechanisms of the formation, change and extinction of the ozone layer surrounding the earth.	91	2001	Environment	Global environment
35	Life science	23. Common use of medical treatments for dysdifferentiating carcinogenic cells.	91	2015	Life	Cancer
36	Environment	32. Widespread use of fuel control technologies in virtually all types of automobiles, capable of meeting the emission control standard for nitric oxide on the order of 0.1 to 0.2 g/km. (The current level for heavy diesel motorcars is on the order of 4 to 5 g/km, and the standard control value for gasoline passenger cars in 1978 is 0.25 g/km.)	90	2002	Environment	
37	Production	02. Prevailing use of cold superconductive materials for industrial products.	90	2008		
38	Life science	63. Elucidation of the mechanisms of aging.	90	2012	Life	
39	Transportation	05. Practical use of railcars capable of continuous operation at a speed of 300 km/h while still meeting environmental standards, using today's Shinkansen facilities and equipment.	90	1997	Environment	
40	Agriculture, forestry, and fisheries	69. Widespread and general use of biodegradable packing materials that can be decomposed naturally to harmless substances by microorganisms, enzymes or the like.	90	2003	Environment	
41	Life science	04. Elucidation of molecular mechanisms of particular interactions between proteins or between proteins and nucleic acids.	90	2002	Life	
42	Marine science and earth science	76. Realization of forecasting volcanic eruptions with certainly 2 to 3 days in advance.	90	2006	Disasters	Natural disasters
43	Marine science and earth science	77. Realization of forecasting outbreak and scale of pyroclastic fows (nuee ardente, etc.) accompanying volcanic eruption.	90	2005	Disasters	Natural disasters
44	Health and medical care	05. Elucidation of the onsetting mechanism of Alzheimer's disease.	89	2007	Life	Brain
45	Life science	10. Elucidation of the morphogenic and developmental processes of the brain at the molecular level.	89	2014	Life	Brain
46	Marine science and earth science	80. Development of technologies for maintaining good balance between the use of fossil fuels and the conservation of the global environment, based on elucidation of the whole aspect of the movement and storage of carbon dioxide	89	2010	Environment	Global environment

Ranking	Field	Topic	Degree of importance index	Forecasted realization time	Notes; Classification of topic	
		extending over the air oceans and sea bottoms.				
47	Outer space	41. Development of technologies for full recycling of water and oxygen at space stations.	89	2006		
48	Communications	03. Practical use of large-capacity optical fiber communications based on optical heterodyne modes and other types of coherent optical transmission technology.	89	1999	Information	Networks
49	Life science	03. Establishment of technologies enabling prediction of the functions of proteins from their higher order structures.	89	2006	Life	
50	Environment	06.Elucidation of precise mechanisms of the emission and extinction of carbon dioxide in the atmosphere.	89	2003	Environment	Global environment
51	Urbanization and construction	45. Improvement of water quality by building various water treatment facilities, seawater exchanging facilities, etc. in estuaries and bays near metropolitan areas suffering severe pollution and contamination.	89	2005	Environment	
52	Energy	23. Development of fusion reactors.	89	2021	New energy	
53	Health and medical care	62. Development of effective treatment for Alzheimer’s disease.	89	2011	Life	Brain
54	Life science	90. Establishment of technologies enabling prediction of the effects of human activities on natural ecosystems.	89	2008	Environment	
55	Information and electronics	09. Development of large scale integrated memory silicon devices with an access time of 1 ns.	89	2000	Information	Semiconductors etc.
56	Lifestyles and culture	79. Widespread use of local disaster prediction and prevention systems against earthquakes, landslides, etc.	89	2007	Disasters	Earthquakes
57	Life science	59. Clinical application of organ implants by multiplication and regeneration of their own cells.	89	2008	Life	
58	Health and medical care	45. Establishment of cure for AIDS.	88	2006	Life	
59	Outer space	17. Practical use of technology for measuring in real time the distribution and movement of atmospheric pollutants, based on observation from space.	88	2002	Environment	Global environment
60	Outer space	44. Possibility of observing minute space debris (space dust, broken pieces of satellites and rockets, and space refuse such as coating chips, etc.) that are harmful to space stations, etc., and development of technologies for avoiding such dangers.	88	2008		
61	Life science	93. Possibility of increased food production by dramatical improvement of photosynthetic ability in plants	88	2011	Life	

Ranking	Field	Topic	Degree of importance index	Forecasted realization time	Notes; Classification of topic	
62	Particles	11.Practical use of technologies for creating any desired patterns of 10 nanometers or less by lithography, using synchrotron orbital radiation (SOR) as a light source.	88	2004	Information	Semiconductors etc.
63	Communications	38. Completion of international integrated services digital networks (ISDN) covering virtually all countries, with automatic access from domestic ISDN.	88	2004	Information	Networks
64	Life science	02. Establishment of technologies enabling prediction of the three dimensional structures of proteins from their amino acid sequences.	88	2002	Life	
65	Transportation	52. Development of four-dimensional control systems based on aircraft location and time, including on-board collision prevention systems, to address increased flight service frequency and safety.	88	2002		
66	Marine science and earth science	66. Control of artificial heat generation and accumulation of heat in the air through improved technologies for utulizing natural energy, leading to successful heat balancing of the earth.	88	2015	Environment	Global environment
67	Marine science and earth science	46. Widespread use of accurate, short-time forecasting of very intense rainfall, snowfall, and other sharply localized phenomena based on improvement of the radar observation network and the development of data processing technology.	88	1998	Disasters	
68	Health and medical care	12. Development of an HIV vaccine.	88	2002	Life	
69	Agriculture, forestry, and fisheries	70. Realization of systems capable of monitoring around-the-clock changes in global agricultural and forestry resources and agricultural and forestry environments through advancement of next-generation remote sensing technology with high resolutions.	88	2004	Environment	Global environment
70	Marine science and earth science	71. Practical use of technology for predicting and forecasting landslides or rockslides due to intense rainfall.	88	2001	Disasters	Natural disasters
71	Life science	61. Elucidation of the outlines of the molecular mechanisms of development and differentiation.	88	2009	Life	
72	Health and medical care	14. Enhancement of secondary cancer prevention (early detection) system and social awareness of importance of same, resulting in an average survival rate exceeding 70% five years after outbreak for all types of cancer (current rate: 50%)	88	2003	Life	Cancer
73	Outer space	38. Reduction of the space transportation cost of 1/10 or less of the current cost by using heavier booster rockets.	88	2010		

Ranking	Field	Topic	Degree of importance index	Forecasted realization time	Notes; Classification of topic	
74	Production	71. Practical use of a technology to assess potential risk and estim00ate extent of hypothetical disasters, resulting in spread of safety measures for industrial complexes, aircraft, takers, and large-scale storage tank facilities, based on techniques to determine the proper balance of scale performance and safety.	88	2007	Disasters	
75	Marine science and earth science	81. Inauguration of global science and technology education organizations in the broad sense for fostering international scientists and technologists contributing to conservation of global environment, development and maintenance of global resource, etc.	88	2000	Environment	Global environment
76	Environment	38. Widespread use of product design techniques easy to recover and separate materials of disposed durable consumer goods for recycling purposes.	88	2001	Environment	Recycling
77	Materials and processing	97. Practical use of carbon dioxide fixation technology necessary for protecting global environments.	87	2007	Environment	Global environment
78	Health and medical care	68. Practical use of extremely effective treatment for atherosclerosis.	87	2007	Life	
79	Materials and processing	20. Practical use of beam processing technology which achieves a memory capacity of 1 Gb per chip.	87	2001	Information	Semiconductors etc.
80	Life science	44. Elucidation of the encoding and retrieval mechanisms of memories in the brain.	87	2017	Life	Brain
81	Environment	44. Determination of presence or absence of trans-generation effects of environmental contamination on human beings.	87	2015		
82	Mineral and water resources	21. Establishment of technologies for forecasting rainfall with good accuracy, and the effective use for precipitation.	87	2004		
83	Materials and processing	57. Practical use of signal responsive missile drugs capable of efficiently reaching affected parts such as tumor cells.	87	2006	Life	Cancer
84	Environment	40. Development of technologies for turning harmful wastes into harmless without causing any secondary pollutions.	87	2006	Environment	
85	Agriculture, forestry, and fisheries	58. Possibility of prevention of eutrophication and other types of environmental control in lakes and marshes, inner bays, shallow seas, and other major water regions through the development of technologies for the concentration or absorption and removal of nitrogen, phosphorus, potassium and other substances by biological or biochemical methods.	87	2008	Environment	

Ranking	Field	Topic	Degree of importance index	Forecasted realization time	Notes; Classification of topic	
86	Particles	30.Pracical use of analysing equipment with a precision ceiling on the order of parts per trillion.	87	2004		
87	Urbanization and construction	58. Establishment of nationwide networks for detecting earthquakes, enabling dissemination of disaster preventing systems which transmit information on earthquakes at distances of about 50 km or more in advance.	87	2006	Disasters	Earthquakes
88	Agriculture, forestry, and fisheries	62. Elucidation of the mechanisms of totipotency of plant cells.	87	2013	Life	
89	Energy	51. Domination of non Freon type air conditioning systems.	87	2001	Environment	
90	Mineral and water resources	31. Practical use of water purification technology for rivers, lakes, and marshes, spurring environmental improvement and more effective water use.	86	2004	Environment	
91	Health and medical care	24. Predominance of preventive medicine in medical science.	86	2010	Life	
92	Agriculture, forestry, and fisheries	63. Widespread use of technologies enabling the storage and use at the DNA and cellular level of the genetic resources.	86	2005	Life	
93	Life science	46. Elucidation of basic molecules concerning with higher order functions in the brain.	86	2014	Life	Brain
94	Information and electronics	102. Advances in software inspection and verification technology, enabling short-term development of error-free, large-scale software.	86	2009	Information	
95	Health and medical care	91. Development of rapid and sure methods of determining the efficacy and safety (i.e., mutagenicity, teratogenicity, and toxicity) of pharmaceuticals.	86	2003	Life	
96	Health and medical care	57. Practical use of effective means of preventing cancer metastasis.	86	2011	Life	Cancer
97	Life science	09. Thorough elucidation of the structures and functions of signal transducing molecules.	86	2006	Life	
98	Life science	21. Elucidation of the functions of immunocytes responsible for the distinguishment between self and not self.	86	2004	Life	
99	Materials and processing	23. Practical use of large area amorphous silicon solar cells with a conversion efficiency of more than 20%.	86	2004	New energy	Solar cells
100	Urbanization and construction	44. Development of compact waste water treatment systems applying biotechnology, enabling highly efficient processing of substances not readily decomposed and harmful substances.	86	2001	Environment	

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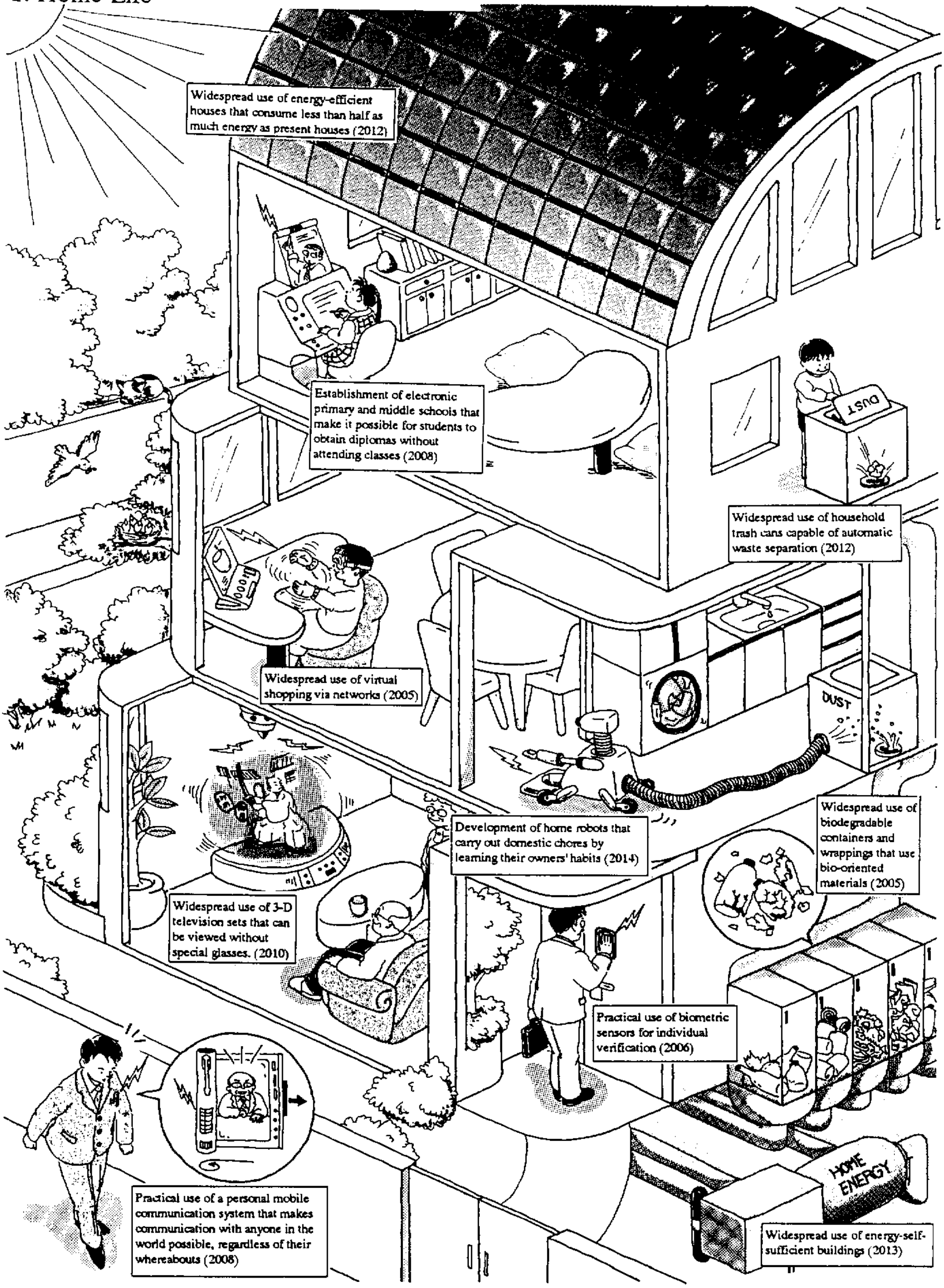
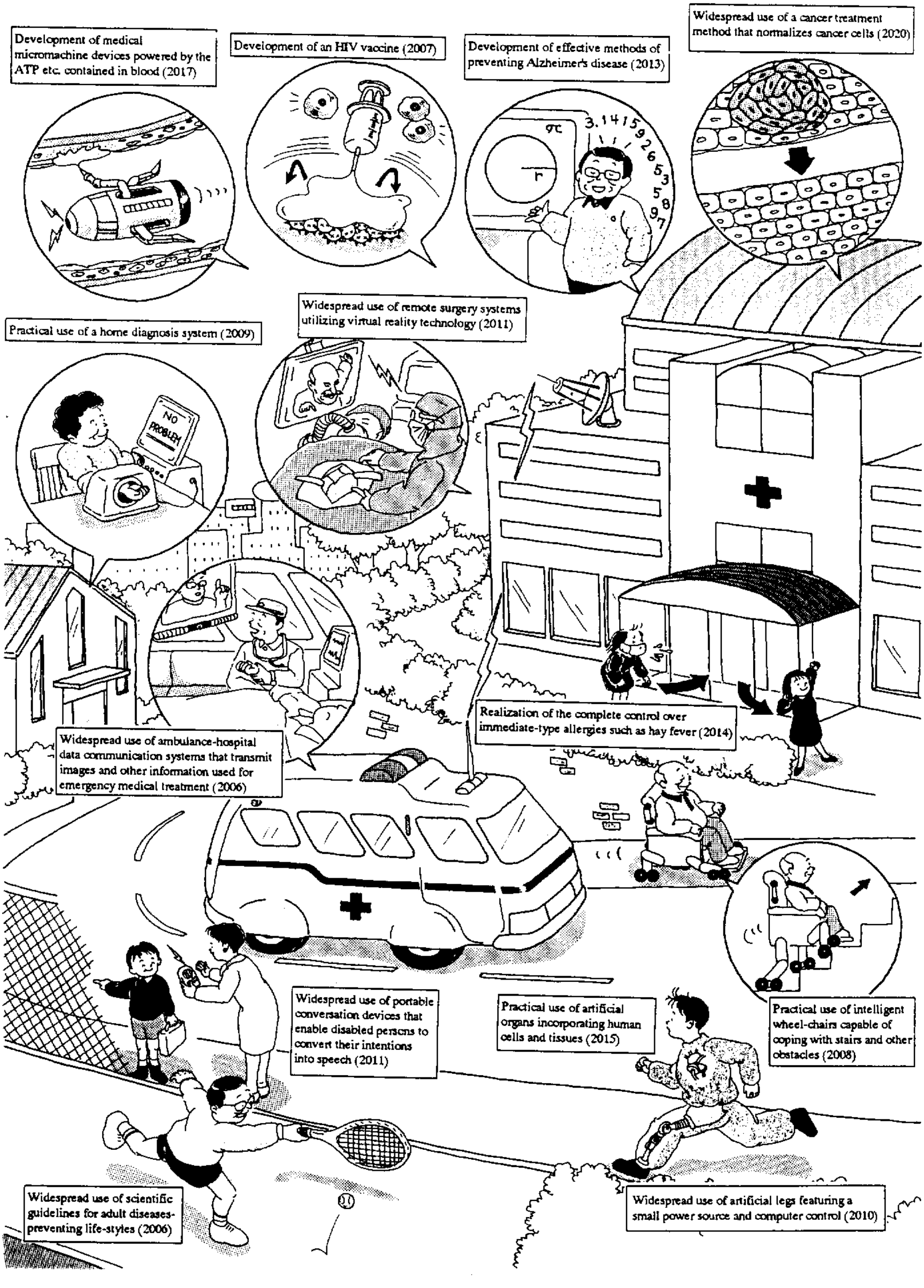
Technology Forecasts Illustrated

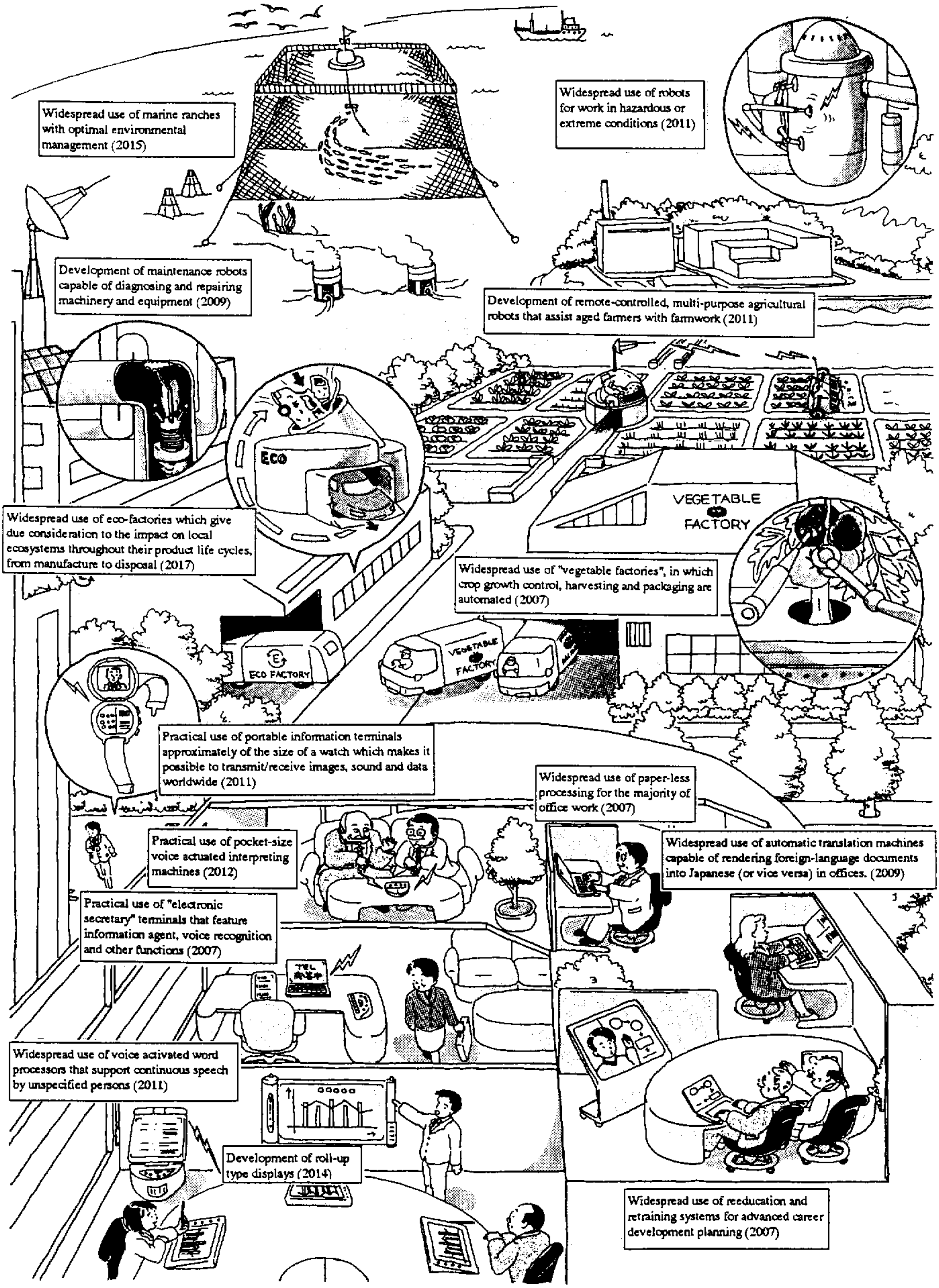
1. Home Life



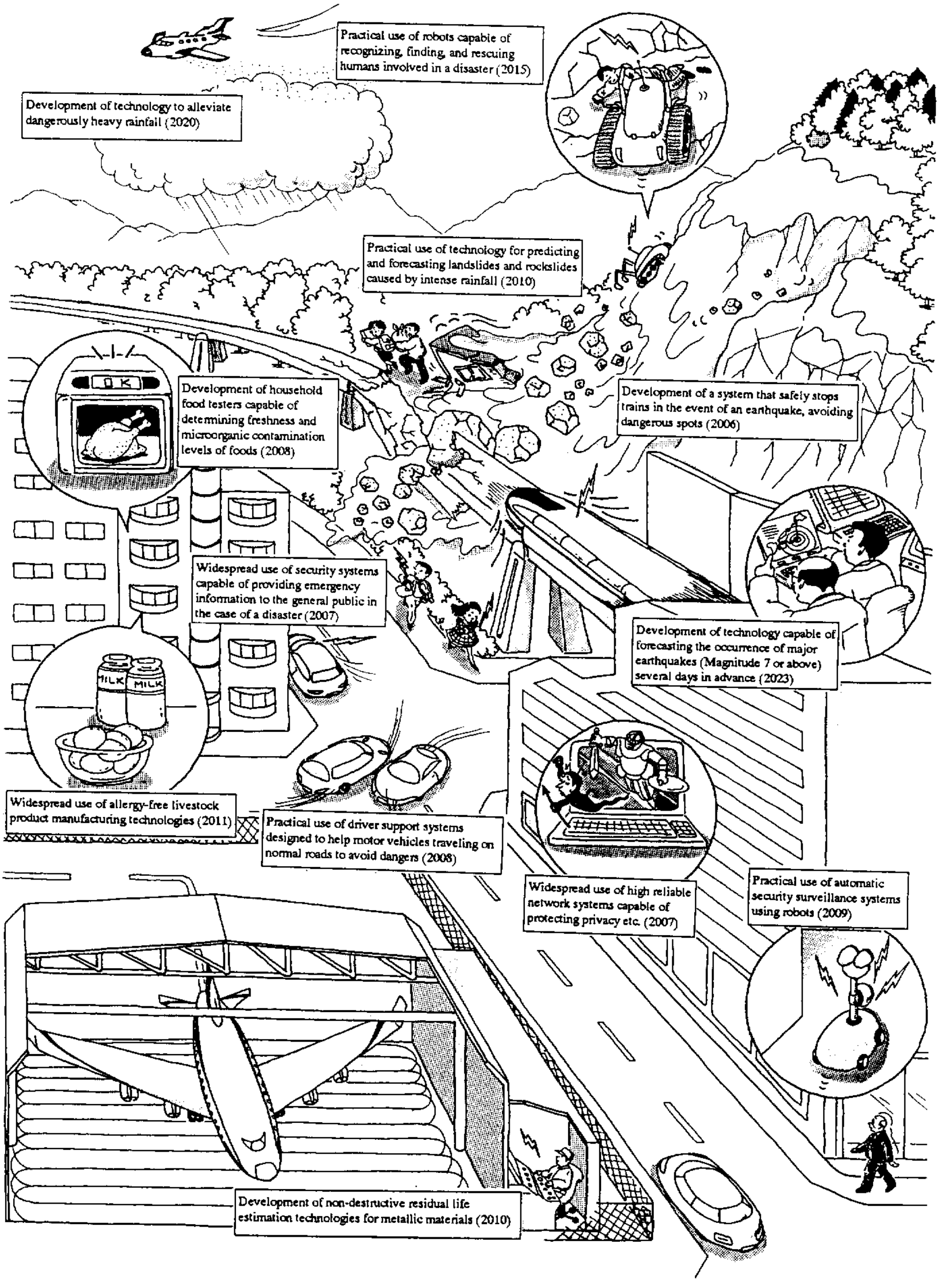
2. Medical Care and Welfare



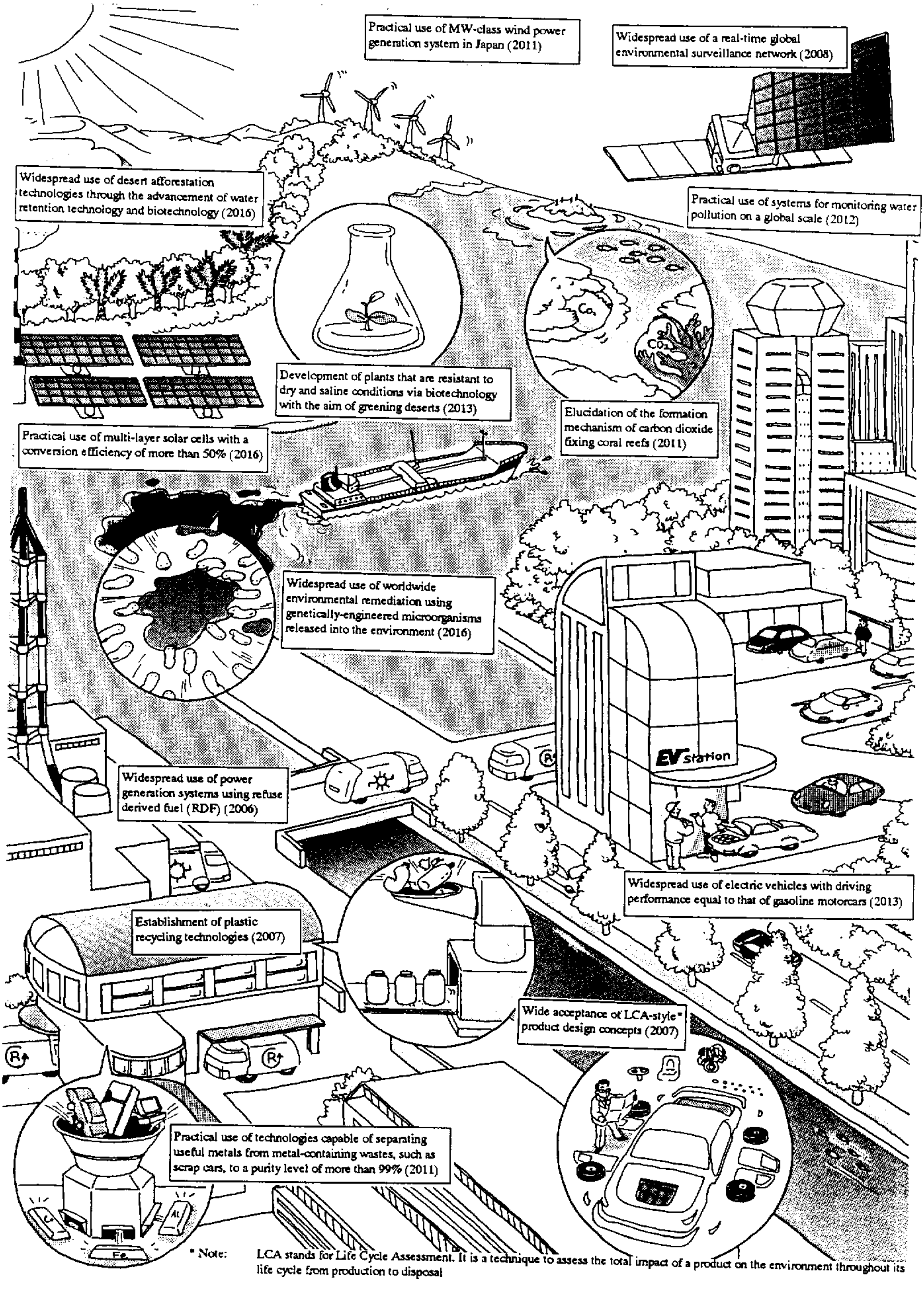
3. Workplace and Production Sites



4. Disaster Prevention and Safety

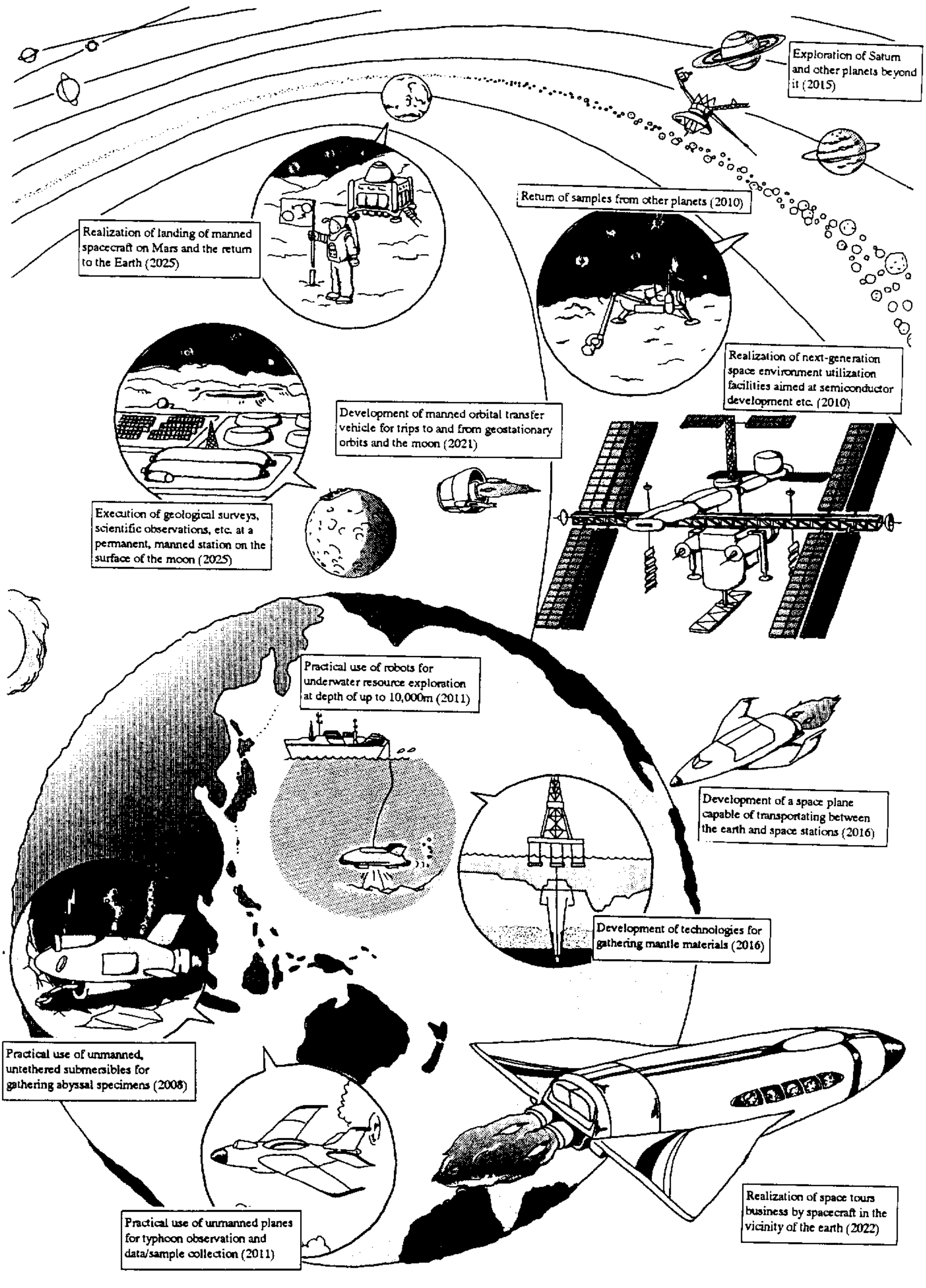


5. Global Environment and Energy



* Note: LCA stands for Life Cycle Assessment. It is a technique to assess the total impact of a product on the environment throughout its life cycle from production to disposal

6. From Earth to Space



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7. Frontiers of Microscopic World