

3. Life science field

3.1. Overview

(1) Current conditions in life science

A. Perspective as a science

As exemplified by the genome research of the 1990s, the life science field has displayed rapid development over the past 10 years. Reproductive science utilizing embryos, bioinstrumentation technology capable of imaging single molecules, bioinformatics such as systems biology, nanobiology, and other interdisciplinary areas previously unknown in life science have advanced particularly rapidly. This has dramatically deepened human understanding of life, but, as we will discuss below, society has its own demands, and research related to applications such as SNP analysis for lifestyle-related diseases has become notably active.

B. Perspective of society

The questionnaire results clearly show that as life science develops, expectations for its contributions to society are high. The aim is to extend healthy life expectancy, as exemplified by aging healthily. As society ages, however, illnesses that require constant care, such as Alzheimer's disease and Parkinson's disease are expected to become social problems, but in the search for cures, even basic understanding of their mechanisms is insufficient. Brain science research and so on must be further strengthened. In addition, expectations for solutions from life science are high not only for medical care and drug discovery, but also for food and population issues, as well as for food safety, environmental safety, and other issues related to peace of mind. Policy perspectives such as mere industrial and economic vitalization are insufficient, and these issues increasingly must be handled as global problems that extend beyond any single country. In the 21st century, the role of the life science field will be extremely large.

(2) Selection of areas for forecasting

Areas for which significant development in the future is expected were selected by experts, always bearing in mind society's expectations for life science and with the subcommittee fully recognizing the importance of basic research as the foundation for meeting those expectations. The committee thereby selected the important areas by considering a span from molecules and cells to individuals and populations, as well as healthcare, medical science, foods, the environment, and so on. In addition, continuity with the previous survey was also considered in the selection of overall areas.

(3) Overview of survey results

The survey was a Delphi analysis with questionnaires sent to experts. About 226 people responded, centered on researchers in life science fields. This includes respondents in the corporate sector. We examined the survey results based on these responses.

The results are first, regarding predictions for society 30 years from now, an overwhelming number of responses indicated that while there will be no major change in average longevity, healthy life expectancy will be greatly extended. This demonstrates the high expectations for life science regarding medical care, health, and environmental problems. On the other hand, expectations for obtaining

intellectual property rights are high for drug discovery research, technology for measuring biological substances, and so on. Demand for life science is strong not only for national health, but also as a foundation for industrial vitalization. Expectations are high for the development of new integrated areas such as nanobiology, regenerative medicine, and monitoring and sensor technology for biological substances and for the creation of new industries based on them. The survey also showed strong long-term expectations for the development of untapped areas such as the environmental and ecological biology, the brain research, and so on. In addition, the separate degree of importance survey showed a consciousness that topics related to conquering illnesses such as cancer, Alzheimer's disease, and allergic disease are particularly important. However, even though consciousness of the importance of curing brain diseases such as Alzheimer's disease and schizophrenia is high, brain science as a whole is extremely advanced and untapped. Therefore, although it is recognized as frontier work, in the questionnaire it was not necessarily recognized as having a high degree of importance at present.

Regarding Japan's research level related to these social or academic expectations, the survey results show that Japan is seen as trailing Europe and the United States somewhat, with the surrounding nations of Asia rapidly making up ground behind Japan. Comparing levels by country, the survey showed a belief that the USA has an overwhelming lead in the life science field as a whole, followed by Japan and then Europe. Japan is seen as having a lead in nanobiology, and monitoring and sensor technology for biological substances. In addition, overall Japan is seen as leading in chemical and technological aspects of life science. Government involvement to activate or support life science areas in response to growing social demands is strongly desired. Expectations are particularly high for active government involvement on overcoming disease, solving food problems, and so on. Social application of most technologies is predicted to require 20 to 25 years, but those related to brain science are expected to require an additional 5 years beyond that. Life science requires government support that takes a long-term outlook.

(4) Comments on the survey results

This Delphi analysis is a survey of experts, with responses from people who have a certain amount of understanding of the background, so the results should put to sufficient use. In fact, if we look at the results of the previous two surveys, we can see that they obtained a sufficiently high percentage of correct forecasts. We must point out, however, that the results provide overall average values and do not easily express the views of people with great insight into a particular area or with unique ways of thinking. This may be covered in part by the separate scenario survey. Below are some of the comprehensive analyses from expert perspectives of the subcommittee members.

- ◆ Progress in genomic analysis has increased speed and precision in the field of drug discovery, bringing some success in molecular-targeted cancer drugs, but deeper understanding of generation, cell cycles, apoptosis, and so on is required in order to develop more basic and universal drugs. Further completion and development of genome network analysis and other basic research are necessary.
- ◆ Japan lags behind in translation research and other clinical research, so prompt response is needed.
- ◆ With society aging, development of treatment methods and therapeutic medications for illnesses such as Alzheimer's disease and Parkinson's disease is an urgent task. Looking ahead 30 years, strong government support for research into molecular mechanisms and so on is needed right now.

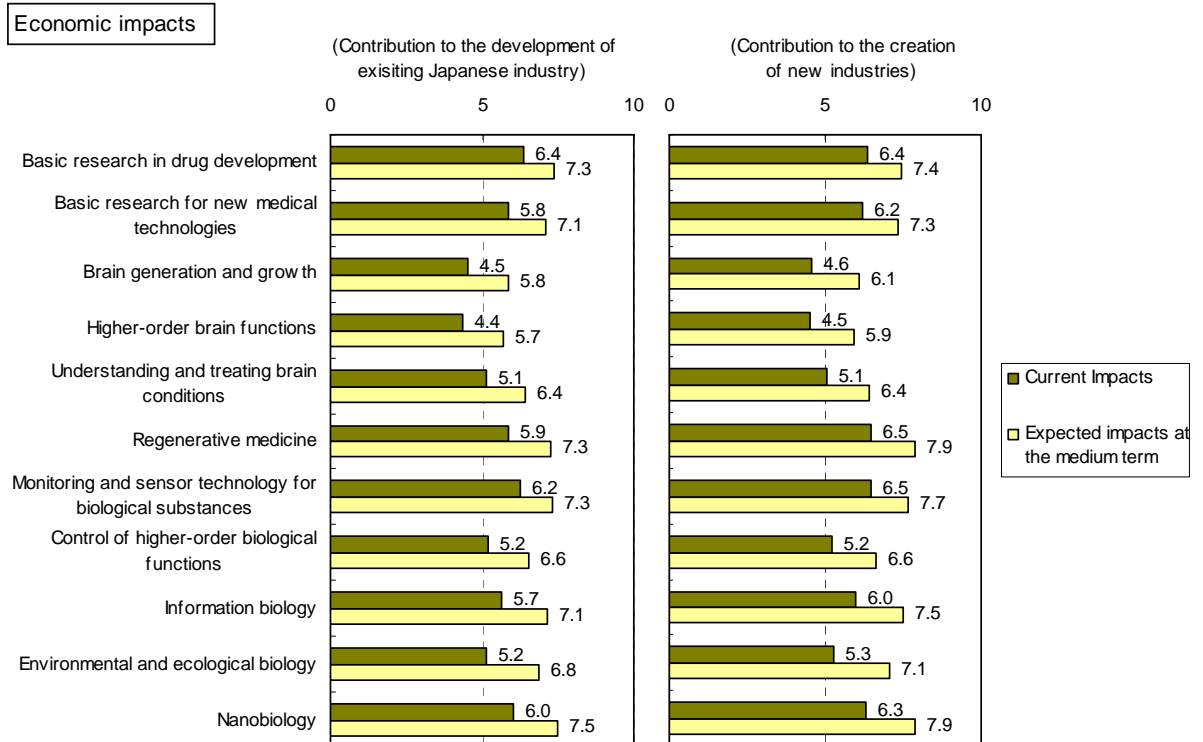
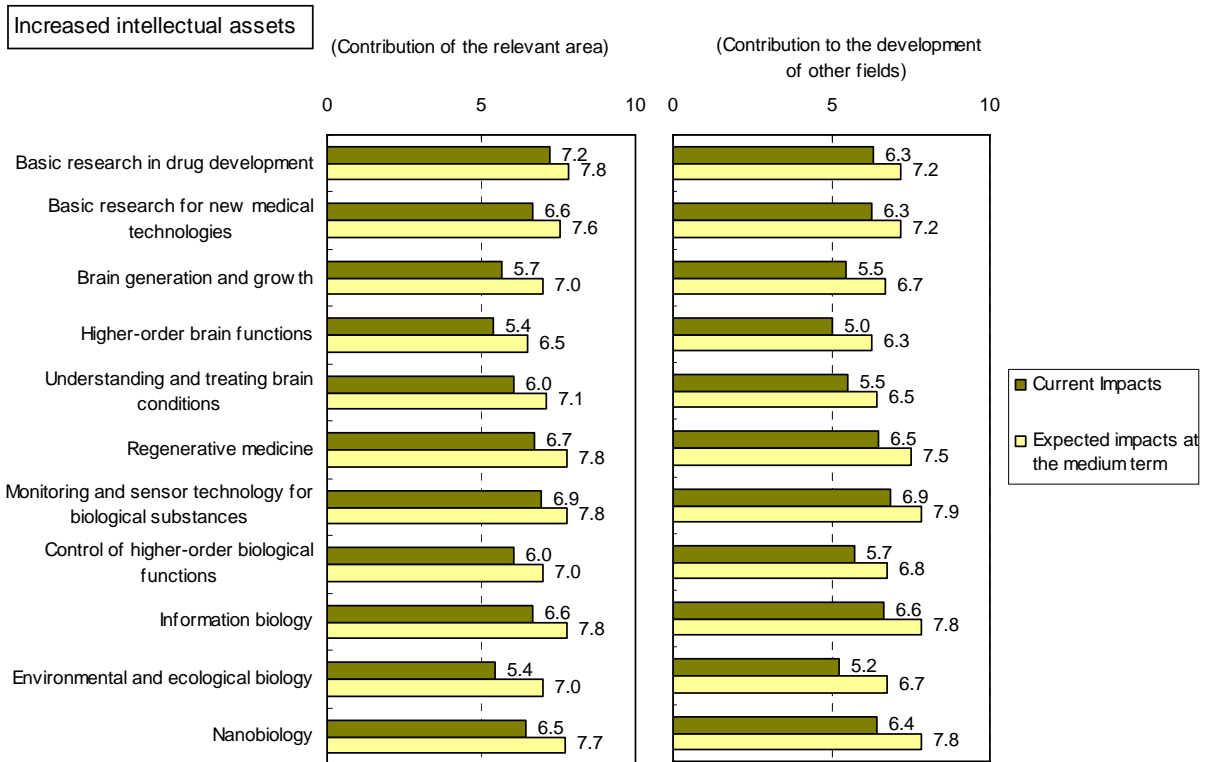
- ◆ Embryonic stem cells are important not only to medical science and healthcare, but to industrial applications as well. Regenerative medical science requires interdisciplinary initiatives in pharmaceutical science, materials engineering, nanotechnology, bioimaging, and so on.
- ◆ Japan is strong in technologies such as single-molecule measurement and sugar engineering, and in the future practical measurement in healthcare and function measurement in medical science and biology will also become important.
- ◆ Immunology will play an important role in addressing infectious disease, cancer, and allergies, and understanding natural immunity is an urgent task.
- ◆ In information biology and bioinformatics, human resources development is an urgent task.
- ◆ Expectations are high for the application of life science to environmental issues, improved basic research for the development of key technologies and national understanding are needed.
- ◆ Currently, Japan's level in nanobiology is high, leading the world, but developing systems to link this to industrial application will require large costs. There are limits to what individual corporations and research institutions can do, so national support is necessary.

Because the survey as a whole emphasized social contributions, it may not fully reflect the importance of basic research. As seen in the above opinions of working group members on trends in the field, life science research requires much time before its fruits can be realized or contribute to society. We wish to emphasize once again the necessity of a support system for basic research that gives this point due consideration.

(SAKAKI Yoshiyuki)

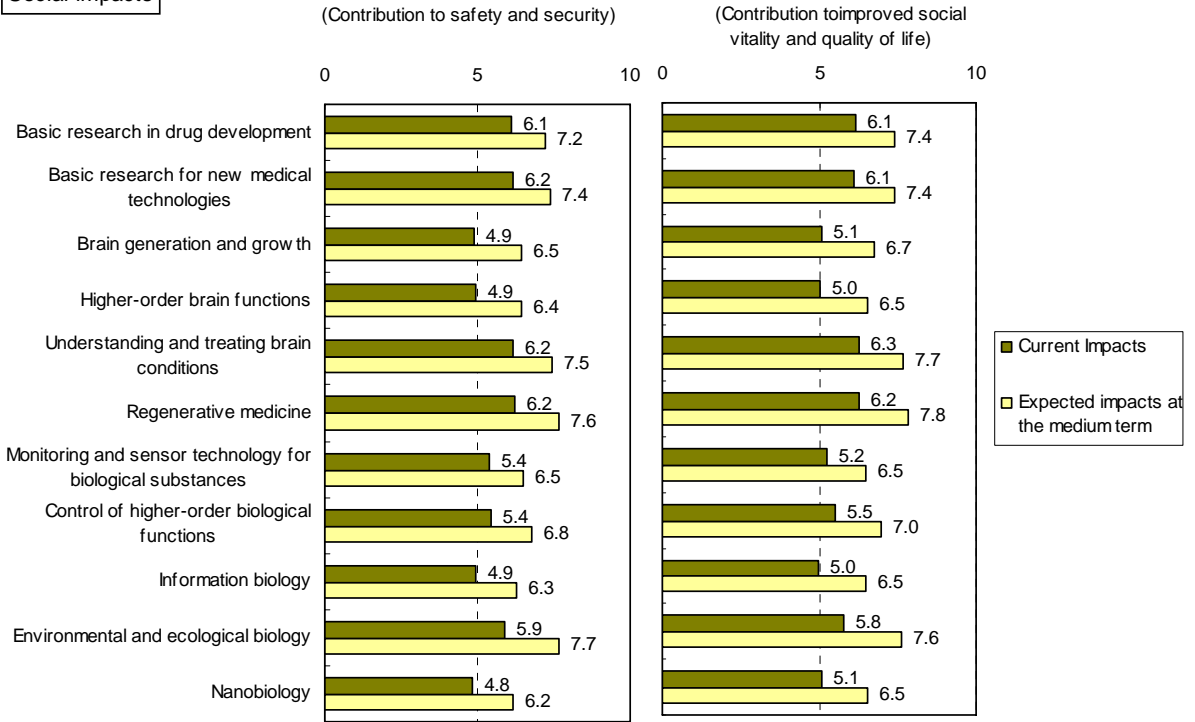
3.2. Main results

A. Impacts



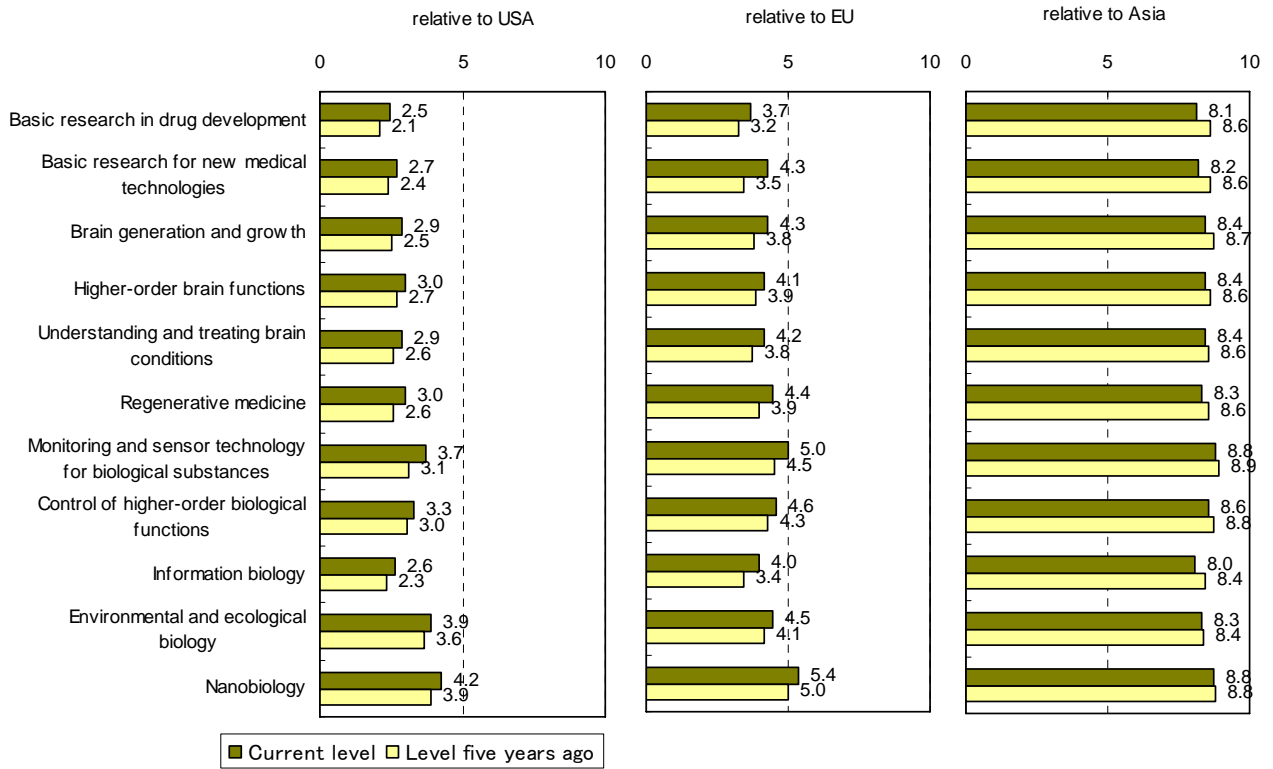
*Responses are indexed on a 10-point scale.

Social impacts



*Responses are indexed on a 10-point scale.

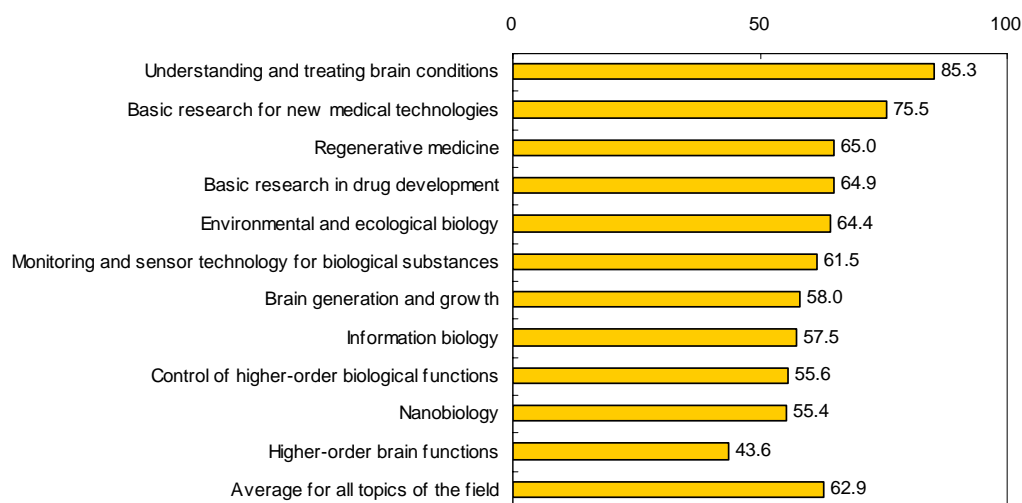
B. Japan's R&D Level



*Responses are indexed on a 10-point scale.

C. Importance to Japan

Average importance index by area



The most important 10 topics

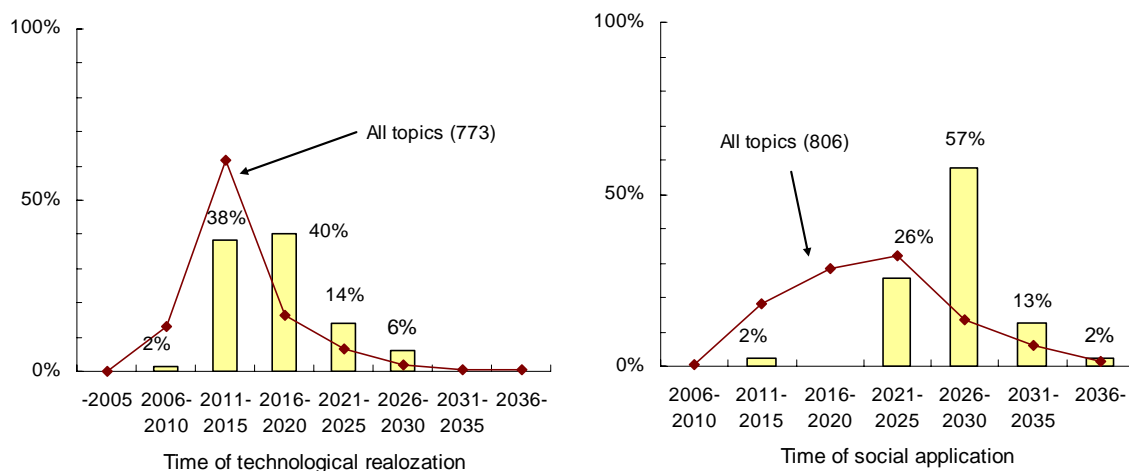
Topic	Index	Year T*	Year S*
1 12: Effective technology to prevent cancer metastasis.	89	2020	2030
2 10: Technology for immediate, complete control of allergies based on elucidation of the immunoregulatory mechanisms and environmental factors that lead to hay fever, atopic dermatitis, and other allergies.	88	2015	2027
3 22: Treatment for preventing the progression of Alzheimer's disease.	88	2019	2030
4 23: Elucidation of the etiology of manic-depressive psychosis at the molecular level.	84	2020	-
5 33: Technology to detect a cancerous tissue of the diameter smaller than 1 mm presenting anywhere in the body.	84	2014	2023
6 24: Elucidation of the etiology of schizophrenia at the molecular level.	84	2022	-
7 04: Technologies for drug development to predict bioactivities of proteins such as interactions between protein and protein, between proteins and DNA or RNA, and between proteins and synthetic compounds from their higher order structure.	83	2015	2026
8 57: Mass production technology for fuels and bioplastics utilizing plants and microorganisms.	81	2014	2024
9 29: Technology to manipulate stem cell differentiation and growth for induction of functional cells to use for therapy.	79	2016	2029
10 14: Effective cancer prevention measures can be implemented by clarifying the relationships among multiple environmental risk factors associated with cancer.	79	2020	2030

Year T: Time of technological realization Year S: Time of social application

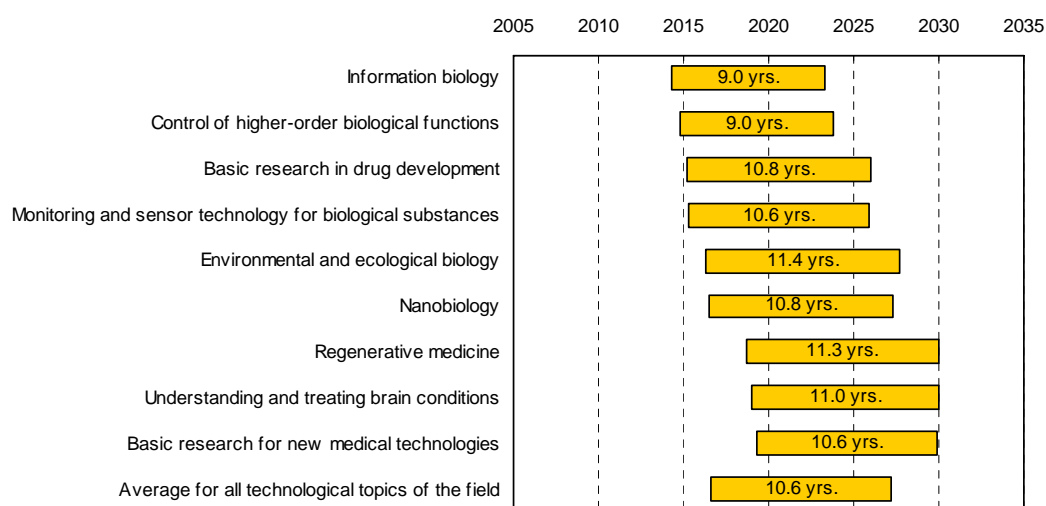
*Responses were indexed on a 100-point scale.

D. Time of realization

Distribution of topics



Gap between technological realization and social application



Topics with short or long periods until social application

Topic	Year T*	Period*	Area
28: Reprogramming technology to create stem cells from differentiated somatic cells.	2015	14	Regenerative medicine
29: Technology to manipulate stem cell differentiation and growth for induction of functional cells to use for therapy.	2016	13	Regenerative medicine
02: Technology to freely cause to survive or remove specialized cells in vivo, based on elucidation of the molecular mechanism of apoptosis, in vivo (for application to therapeutic agents for cancer and illnesses based on inability to maintain homeostasis).	2019	12	Basic research in drug development
05: For drug development, technology to directly control gene expression at the individual level by utilizing siRNA, etc.	2014	12	Basic research in drug development
10: Technology for immediate, complete control of allergies based on elucidation of the immunoregulatory mechanisms and environmental factors that lead to hay fever, atopic dermatitis, and other allergies.	2015	12	Basic research for new medical technologies

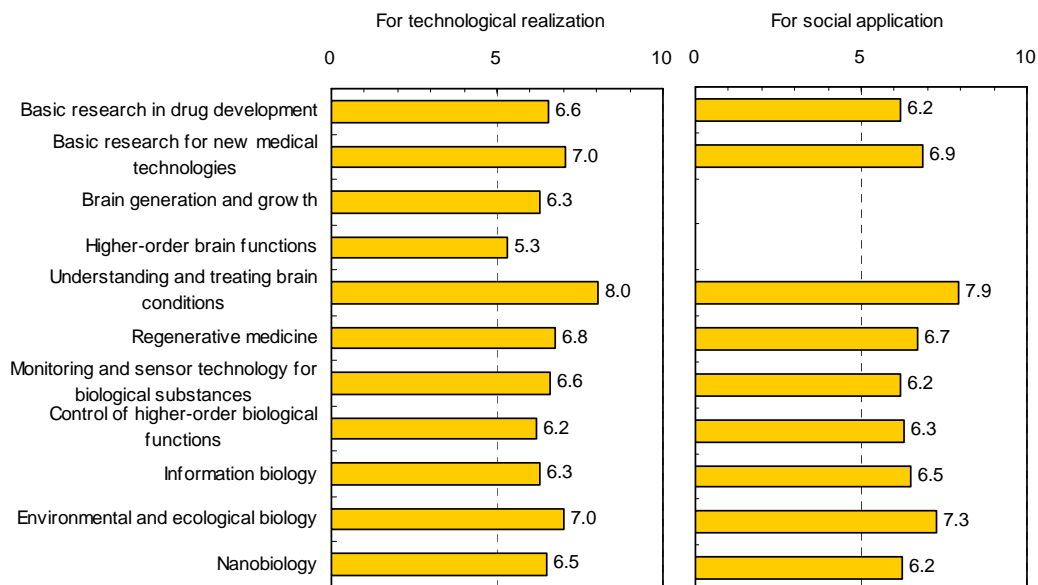
Topic	Year T*	Period*	Area
35: Technology to observe the interactions among various substances inside and outside of cells, to simultaneously identify those substances, and to monitor their distribution.	2016	12	Monitoring and sensor technology for biological substances
54: Technology to create practical plants resistant to cold and drought through elucidation of the molecular mechanisms of signal transductions in plants, from perception of low temperatures and other outside data to phenotypic expression.	2015	12	Environmental and ecological biology
55: Genetically-engineered plants and microorganisms that can remove NOx and other pollutants.	2015	12	Environmental and ecological biology
56: Plants with radically improvement in functions such as atmospheric nitrogen fixing and soil phosphate utilization through plant genome technology.	2015	12	Environmental and ecological biology
60: Technology to form cells with the minimum genetic set needed to produce substances.	2019	12	Environmental and ecological biology
62: Highly efficient energy conversion technology that utilizes motor proteins (molecular motors) that convert chemical energy to mechanical energy.	2018	12	Nanobiology

Topic	Year T*	Period*	Area
41: Technology to select cells (clones) to produce specific useful antibodies.	2010	5	Control of higher-order biological functions
52: Methods to predict various genome functions from DNA sequencing data.	2014	8	Information biology
08: Effective therapeutic agents for protozoan disease (malaria, trypanosomiasis, leishmaniasis, filariasis, etc.).	2013	9	Basic research in drug development
33: Technology to detect a cancerous tissue of the diameter smaller than 1 mm presenting anywhere in the body.	2014	9	Monitoring and sensor technology for biological substances
47: Through bioinformatics, the integration and sharing of vast amounts of data is made possible, and the data may be used for the implementation of life science research carried out over networks of virtual laboratories.	2014	9	Information biology
48: Remote technology systems applying advanced virtual reality technology.	2013	9	Information biology
49: Bioinformatics that can predict the risk of cancer and lifestyle diseases based on genetic background, etc.	2014	9	Information biology
64: Nanochamber arrays that enable simultaneous detection of many biological reactions by concentrating thousands or tens of thousands of receptors on a single semiconductor chip.	2014	9	Nanobiology

*Year T: Time of technological realization Period: Period until social application (years)

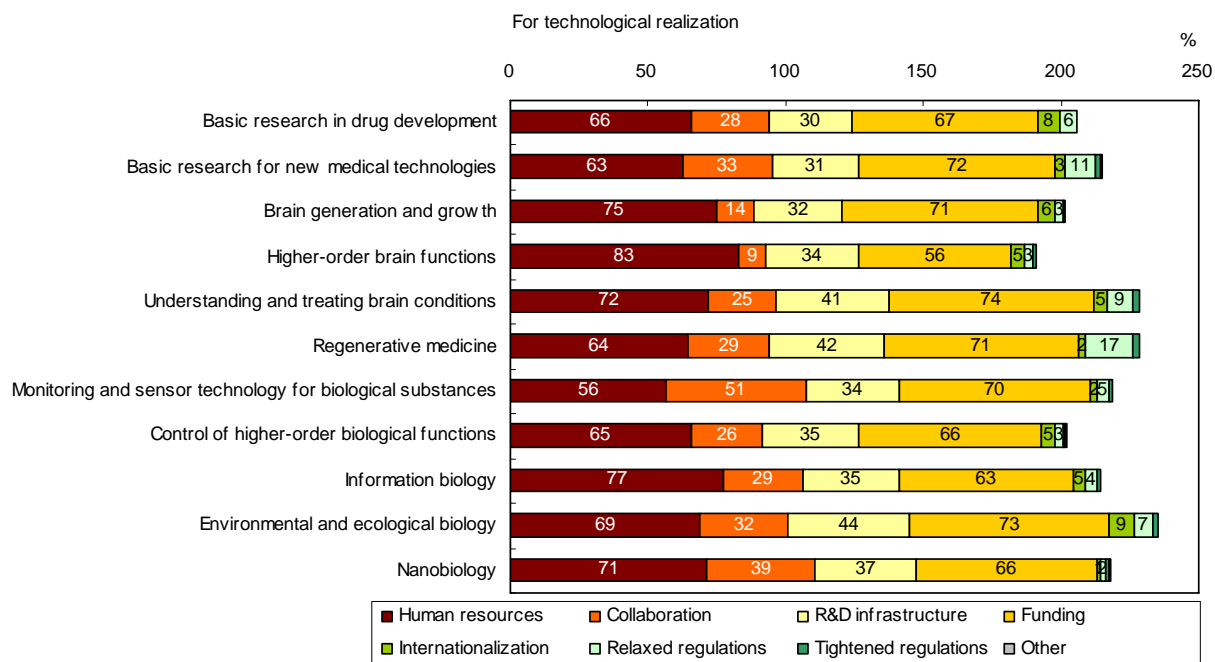
E. Effective measures that should taken by government

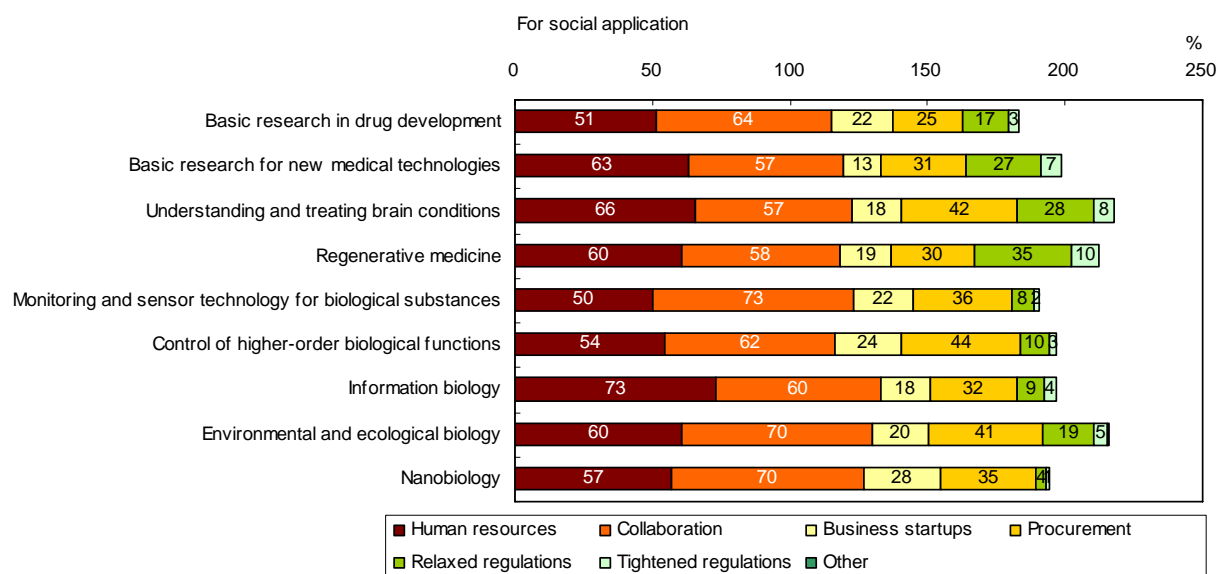
Necessity of government involvement



*Responses were indexed on a 10-point scale

Effective measures





F. Time-line of topics

Technological realization

year	topic
2010	41: Technology to select cells (clones) to produce specific useful antibodies.
2013	08: Effective therapeutic agents for protozoan disease (malaria, trypanosomiasis, leishmaniasis, filariasis, etc.). 48: Remote technology systems applying advanced virtual reality technology.
2014	05: For drug development, technology to directly control gene expression at the individual level by utilizing siRNA, etc. 06: Artificial antibody manufacturing technology based on elucidation of the antigen-recognition mechanism of antibodies. 30: Long-term organ cultivation and preservation technology for organ transplants. 33: Technology to detect a cancerous tissue of the diameter smaller than 1 mm presenting anywhere in the body. 40: Elucidation of the molecular mechanism of floral differentiation in higher-order plants. 47: Through bioinformatics, the integration and sharing of vast amounts of data is made possible, and the data may be used for the implementation of life science research carried out over networks of virtual laboratories. 49: Bioinformatics that can predict the risk of cancer and lifestyle diseases based on genetic background, etc. 52: Methods to predict various genome functions from DNA sequencing data. 57: Mass production technology for fuels and bioplastics utilizing plants and microorganisms.
2015	64: Nanochamber arrays that enable simultaneous detection of many biological reactions by concentrating thousands or tens of thousands of receptors on a single semiconductor chip. 01: Elucidation of all molecular mechanisms to explain the cell cycle in higher animals (human, mouse; for application to cancer treatment). 04: Technologies for drug development to predict bioactivities of proteins such as interactions between protein and protein, between proteins and DNA or RNA, and between proteins and synthetic compounds from their higher order structure. 10: Technology for immediate, complete control of allergies based on elucidation of the immunoregulatory mechanisms and environmental factors that lead to hay fever, atopic dermatitis, and other allergies. 28: Reprogramming technology to create stem cells from differentiated somatic cells. 34: Technology for molecular imaging in the body with the precision of single molecule detection. 36: Technology that can sequence the whole human genome in one day. 37: Equipment that can sample a single cell and measure all kinds of mRNAs with their copy numbers within the cell. 38: Equipment to automatically analyze the sequences of sugar chains with 20 or more linked sugars with their branching and linkage patterns.

year	topic
2016	42: Regulation of autoimmune disease such as chronic rheumatoid arthritis based on the elucidation of the mechanisms for self-disposal of mutant cell components.
	54: Technology to create practical plants resistant to cold and drought through elucidation of the molecular mechanisms of signal transductions in plants, from perception of low temperatures and other outside data to phenotypic expression.
	55: Genetically-engineered plants and microorganisms that can remove NOx and other pollutants.
	56: Plants with radically improvement in functions such as atmospheric nitrogen fixing and soil phosphate utilization through plant genome technology.
	63: Chemical sensor technology that mimics the ion selection function of the ion channels that exist in cell membranes.
2017	07: Technology for the in-silico development of pharmaceuticals through technology to simulate drug disposition and effects on targets.
	13: Tailor-made treatment based on elucidation of major single nucleotide polymorphisms (SNPs) that bring risk of lifestyle disease.
	29: Technology to manipulate stem cell differentiation and growth for induction of functional cells to use for therapy.
2018	32: Self-propelled micromachines for diagnosis and treatment inside the body (organ lumina).
	44: Elucidation of the mechanisms regulating the balance between immune system activation and suppression.
	53: Technology to radically improve photosynthesis function in order to increase food production and protect the environment.
	59: Elucidation of the basic genetic networks that control growth and development of plants such as shape, size, and bloom period.
2019	39: Technology to voluntarily control prostheses by using computers to convert movement-related brain activity to signals and transmit them via the spinal cord and peripheral nerves.
	43: Elucidation of immune system repair and regeneration mechanisms.
	62: Highly efficient energy conversion technology that utilizes motor proteins (molecular motors) that convert chemical energy to mechanical energy.
2020	02: Technology to freely cause to survive or remove specialized cells in vivo, based on elucidation of the molecular mechanism of apoptosis, in vivo (for application to therapeutic agents for cancer and illnesses based on inability to maintain homeostasis).
	09: Transplant technology free of side effects through clarification of most of the immune function molecules that contribute to transplant rejection.
	22: Treatment for preventing the progression of Alzheimer's disease.
	27: Technology to utilize animals as a bioreactor to produce organs and tissues to transplant into humans.
	46: Protein design methods with voluntary molecular recognition mechanisms through the application of bioinformatics.
	58: Technology to prevent eutrophication in marine and fresh water by measuring microorganism populations in natural environments and controlling their group compositions.
	60: Technology to form cells with the minimum genetic set needed to produce substances.
	61: Based on genome sequence research in many species, elucidation of the diversity and evolution of environmental response mechanisms in organisms, such as metabolic capacity and ability to respond to stress.
	65: Biofuel cells that reconstruct the reactions of enzyme molecules in bodies on a nano scale.
	03: Technology for integrated analysis of the gene expression cascade and signaling cascade of molecular processes in higher animals such as mice from zygote to adult.
2021	12: Effective technology to prevent cancer metastasis.
	14: Effective cancer prevention measures can be implemented by clarifying the relationships among multiple environmental risk factors associated with cancer.
	23: Elucidation of the etiology of manic-depressive psychosis at the molecular level.
	31: Artificial retinas to give sight to the visually impaired.
	50: Verification testing to elucidate the evolutionary mechanisms of organisms.
2021	26: Artificial organs (pancreases, kidneys, livers, etc.) incorporating human cells and tissue.
	51: Based on compete gene function data for unicellular organisms, technology to simulate all cell functions such as multiplication and environmental response.

year	topic
2022	11: Treatment methods that normalize cancerous cells by controlling signaling and leading cancer cells towards proper differentiation. 24: Elucidation of the etiology of schizophrenia at the molecular level. 45: Elucidation of the influence of weightlessness on generation and the endocrine and immune systems.
2023	15: Technology to repair at the individual level abnormal genes that cause hereditary disease, etc.
2024	18: Elucidation of the cellular and molecular mechanisms whereby the juvenile brain has much greater plasticity and ability to compensate for organic damages than the adult brain. 21: Elucidation of the mechanisms for generating the functional asymmetry of the left and right cerebral hemispheres.
2025	20: Elucidation of the regulatory mechanisms for expression of emotional behavior such as anger and aggression.
2026	17: Elucidation of the relationship between memory and synaptic plasticity. 25: Synthetic technology for artificial cells to replace functions such as cell membrane transport and conversion of matter and energy. Synthetic technology for artificial cells with functions such as cell membrane transport, material transfer, and energy conversion.
2028	16: Nearly complete elucidation of the molecular mechanisms for neural network formation. 19: Elucidation of neural mechanisms of dreaming.

Social application

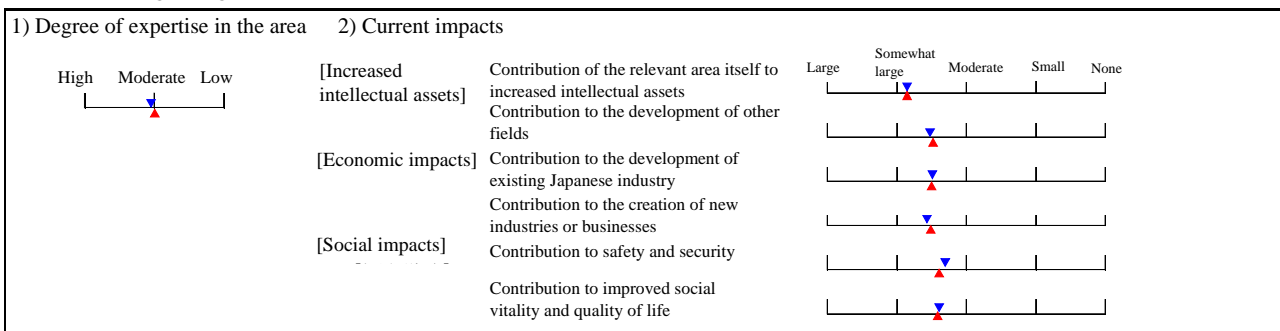
year	topic
2015	41: Technology to select cells (clones) to produce specific useful antibodies.
2022	08: Effective therapeutic agents for protozoan disease (malaria, trypanosomiasis, leishmaniasis, filariasis, etc.). 48: Remote technology systems applying advanced virtual reality technology. 52: Methods to predict various genome functions from DNA sequencing data.
2023	33: Technology to detect a cancerous tissue of the diameter smaller than 1 mm presenting anywhere in the body. 47: Through bioinformatics, the integration and sharing of vast amounts of data is made possible, and the data may be used for the implementation of life science research carried out over networks of virtual laboratories. 49: Bioinformatics that can predict the risk of cancer and lifestyle diseases based on genetic background, etc. 64: Nanochamber arrays that enable simultaneous detection of many biological reactions by concentrating thousands or tens of thousands of receptors on a single semiconductor chip.
2024	06: Artificial antibody manufacturing technology based on elucidation of the antigen-recognition mechanism of antibodies. 30: Long-term organ cultivation and preservation technology for organ transplants. 57: Mass production technology for fuels and bioplastics utilizing plants and microorganisms.
2025	34: Technology for molecular imaging in the body with the precision of single molecule detection. 38: Equipment to automatically analyze the sequences of sugar chains with 20 or more linked sugars with their branching and linkage patterns.
2026	04: Technologies for drug development to predict bioactivities of proteins such as interactions between protein and protein, between proteins and DNA or RNA, and between proteins and synthetic compounds from their higher order structure. 05: For drug development, technology to directly control gene expression at the individual level by utilizing siRNA, etc. 36: Technology that can sequence the whole human genome in one day. 37: Equipment that can sample a single cell and measure all kinds of mRNAs with their copy numbers within the cell. 42: Regulation of autoimmune disease such as chronic rheumatoid arthritis based on the elucidation of the mechanisms for self-disposal of mutant cell components. 63: Chemical sensor technology that mimics the ion selection function of the ion channels that exist in cell membranes.
2027	07: Technology for the in-silico development of pharmaceuticals through technology to simulate drug disposition and effects on targets. 10: Technology for immediate, complete control of allergies based on elucidation of the immunoregulatory mechanisms and environmental factors that lead to hay fever, atopic dermatitis, and other allergies.

year	topic
	13: Tailor-made treatment based on elucidation of major single nucleotide polymorphisms (SNPs) that bring risk of lifestyle disease.
	54: Technology to create practical plants resistant to cold and drought through elucidation of the molecular mechanisms of signal transductions in plants, from perception of low temperatures and other outside data to phenotypic expression.
	55: Genetically-engineered plants and microorganisms that can remove NOx and other pollutants.
	56: Plants with radically improvement in functions such as atmospheric nitrogen fixing and soil phosphate utilization through plant genome technology.
2028	32: Self-propelled micromachines for diagnosis and treatment inside the body (organ lumina).
	35: Technology to observe the interactions among various substances inside and outside of cells, to simultaneously identify those substances, and to monitor their distribution.
	53: Technology to radically improve photosynthesis function in order to increase food production and protect the environment.
2029	28: Reprogramming technology to create stem cells from differentiated somatic cells.
	29: Technology to manipulate stem cell differentiation and growth for induction of functional cells to use for therapy.
	39: Technology to voluntarily control prostheses by using computers to convert movement-related brain activity to signals and transmit them via the spinal cord and peripheral nerves.
	46: Protein design methods with voluntary molecular recognition mechanisms through the application of bioinformatics.
2030	09: Transplant technology free of side effects through clarification of most of the immune function molecules that contribute to transplant rejection.
	12: Effective technology to prevent cancer metastasis.
	14: Effective cancer prevention measures can be implemented by clarifying the relationships among multiple environmental risk factors associated with cancer.
	22: Treatment for preventing the progression of Alzheimer's disease.
	27: Technology to utilize animals as a bioreactor to produce organs and tissues to transplant into humans.
	58: Technology to prevent eutrophication in marine and fresh water by measuring microorganism populations in natural environments and controlling their group compositions.
	62: Highly efficient energy conversion technology that utilizes motor proteins (molecular motors) that convert chemical energy to mechanical energy.
	65: Biofuel cells that reconstruct the reactions of enzyme molecules in bodies on a nano scale.
2031	02: Technology to freely cause to survive or remove specialized cells in vivo, based on elucidation of the molecular mechanism of apoptosis, in vivo (for application to therapeutic agents for cancer and illnesses based on inability to maintain homeostasis).
	26: Artificial organs (pancreases, kidneys, livers, etc.) incorporating human cells and tissue.
	31: Artificial retinas to give sight to the visually impaired.
	60: Technology to form cells with the minimum genetic set needed to produce substances.
2032	11: Treatment methods that normalize cancerous cells by controlling signaling and leading cancer cells towards proper differentiation.
2033	15: Technology to repair at the individual level abnormal genes that cause hereditary disease, etc.
2036	25: Synthetic technology for artificial cells to replace functions such as cell membrane transport and conversion of matter and energy. Synthetic technology for artificial cells with functions such as cell membrane transport, material transfer, and energy conversion.

Appendix: Results of R1 and R2

I. Basic research in drug development

1. Questions regarding the relevant area

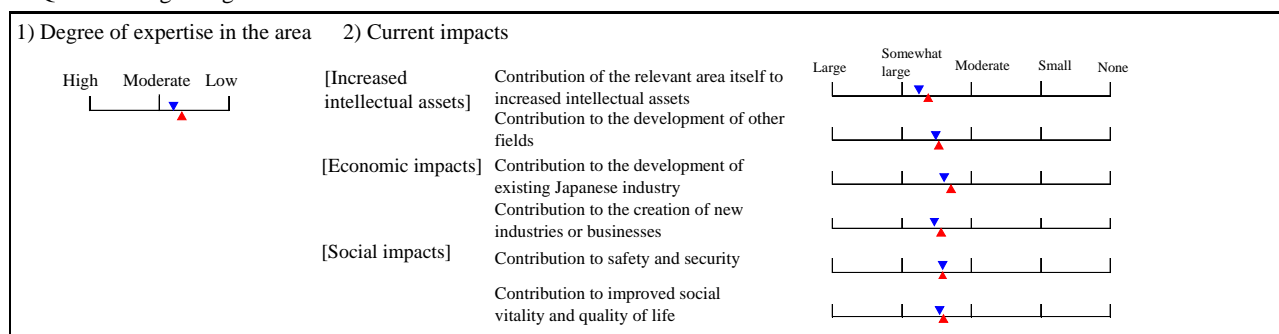


2. Questions regarding topics

No	Topic	Questionnaire	Respondents (persons)	Degree of expertise				Importance to Japan				Time of technological realization								
				High	Moderate	Low	None	Index	High	Moderate	Low	None	Already realized	2006-2010	2011-2015	2016-2025	2026-2035	2036-	Will not be realized	Do not know
				(%)				(%)				(%)								
1	Elucidation of all molecular mechanisms to explain the cell cycle in higher animals (human, mouse; for application to cancer treatment).	1	222	14	40	46	-	68	43	46	10	1							3	6
		2	177	13	40	47	-	64	31	64	4	1							2	3
		E	23	100	0	0	-	80	66	30	0	4							4	0
2	Technology to freely cause to survive or remove specialized cells in vivo, based on elucidation of the molecular mechanism of apoptosis, in vivo (for application to therapeutic agents for cancer and illnesses based on inability to maintain homeostasis).	1	222	13	42	45	-	69	43	47	10	0							5	5
		2	176	10	42	48	-	64	31	64	5	0							1	2
		E	18	100	0	0	-	86	78	11	11	0							0	0
3	Technology for integrated analysis of the gene expression cascade and signaling cascade of molecular processes in higher animals such as mice from zygote to adult.	1	215	21	30	49	-	67	39	51	10	0							2	4
		2	173	17	34	49	-	58	20	71	8	1							1	2
		E	29	100	0	0	-	66	38	52	7	3							0	0
4	Technologies for drug development to predict bioactivities of proteins such as interactions between protein and protein, between proteins and DNA or RNA, and between proteins and synthetic compounds from their higher order structure.	1	244	29	39	32	-	79	61	36	3	0							0	2
		2	202	19	44	37	-	83	66	31	3	0							0	2
		E	39	100	0	0	-	96	92	5	3	0							0	0
5	For drug development, technology to directly control gene expression at the individual level by utilizing siRNA, etc.	1	228	21	31	48	-	73	49	45	6	0							3	5
		2	185	17	31	52	-	72	47	48	5	0							1	3
		E	32	100	0	0	-	88	75	25	0	0							0	0
6	Artificial antibody manufacturing technology based on elucidation of the antigen-recognition mechanism of antibodies.	1	211	17	37	46	-	65	41	40	19	0							0	5
		2	182	12	35	53	-	63	32	57	11	0							0	4
		E	21	100	0	0	-	77	57	38	5	0							0	0
7	Technology for the in-silico development of pharmaceuticals through technology to simulate drug disposition and effects on targets.	1	193	11	28	61	-	68	43	41	15	1							3	6
		2	163	7	28	65	-	69	43	47	10	0							1	2
		E	11	100	0	0	-	93	91	0	9	0							0	0
8	Effective therapeutic agents for protozoan disease (malaria, trypanosomiasis, leishmaniasis, filariasis, etc.).	1	155	8	32	60	-	50	21	38	38	3							1	11
		2	154	3	25	72	-	45	13	44	42	1							0	3
		E	4	100	0	0	-	63	25	75	0	0							0	0

II. Basic research for new medical technologies

1. Questions regarding the relevant area

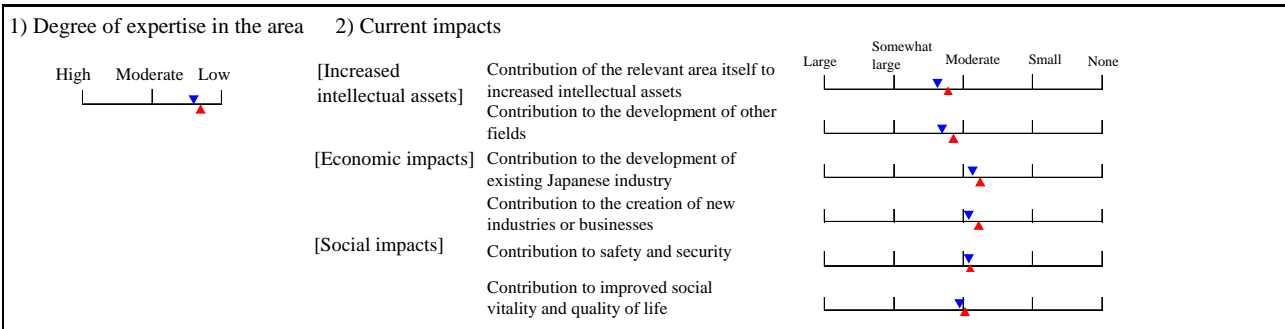


2. Questions regarding topics

No	Topic	Questionnaire	Degree of expertise				Importance to Japan				Time of technological realization								
			Respondents (persons)				Index				Already realized	2006-2010	2011-2015	2016-2025	2026-2035	2036-	Will not be realized	Do not know	
			High	Moderate	Low	None	High	Moderate	Low	None	(%)								
9	Transplant technology free of side effects through clarification of most of the immune function molecules that contribute to transplant rejection.	1	180	12	38	50	-	68	42	46	11	1						8	6
		2	161	6	34	60	-	64	32	62	6	0						4	3
		E	9	100	0	0	-	78	56	44	0	0						0	0
10	Technology for immediate, complete control of allergies based on elucidation of the immunoregulatory mechanisms and environmental factors that lead to hay fever, atopic dermatitis, and other allergies.	1	181	16	31	53	-	81	65	29	6	0						3	4
		2	170	8	31	61	-	88	78	20	2	0						1	2
		E	14	100	0	0	-	96	93	7	0	0						0	7
11	Treatment methods that normalize cancerous cells by controlling signaling and leading cancer cells towards proper differentiation.	1	206	18	33	49	-	75	56	33	9	2						10	8
		2	174	12	31	57	-	78	60	35	4	1						5	4
		E	21	100	0	0	-	88	81	14	0	5						14	0
12	Effective technology to prevent cancer metastasis.	1	189	15	33	52	-	83	67	31	2	0						1	7
		2	173	9	27	64	-	89	80	18	2	0						1	5
		E	16	100	0	0	-	100	100	0	0	0						6	0
13	Tailor-made treatment based on elucidation of major single nucleotide polymorphisms (SNPs) that bring risk of lifestyle disease.	1	227	22	32	46	-	73	51	40	8	1						2	7
		2	185	12	38	50	-	71	45	48	6	1						2	5
		E	22	100	0	0	-	84	68	32	0	0						0	0
14	Effective cancer prevention measures can be implemented by clarifying the relationships among multiple environmental risk factors associated with cancer.	1	181	19	29	52	-	74	54	35	11	0						4	7
		2	164	9	24	67	-	79	60	35	4	1						3	4
		E	14	100	0	0	-	96	93	7	0	0						0	0
15	Technology to repair at the individual level abnormal genes that cause hereditary disease, etc.	1	202	23	30	47	-	62	34	48	16	2						11	13
		2	177	18	31	51	-	59	24	65	10	1						8	5
		E	31	100	0	0	-	68	42	52	0	6						3	3

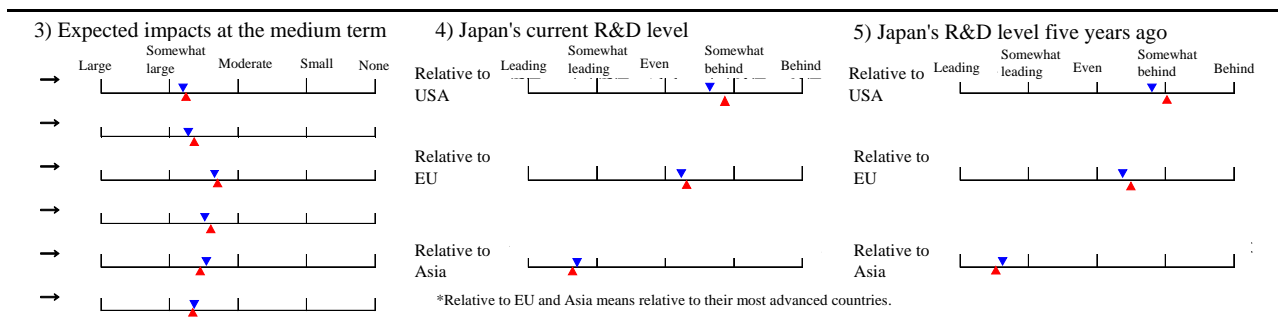
III. Brain generation and growth

1. Questions regarding the relevant area



2. Questions regarding topics

No	Topic	Questionnaire	Degree of expertise				Importance to Japan				Time of technological realization								
			Respondents (persons)				Index				Already realized	2006-2010	2011-2015	2016-2025	2026-2035	2036-	Will not be realized		
			High	Moderate	Low	None	High	Moderate	Low	None									
			(%)				(%)				(%)								
16	Nearly complete elucidation of the molecular mechanisms for neural network formation.	1	163	18	22	60	-	67	42	42	15	1						5	12
		2	152	7	21	72	-	61	29	57	14	0						3	7
		E	10	100	0	0	-	85	70	30	0	0						0	0
17	Elucidation of the relationship between memory and synaptic plasticity.	1	159	15	23	62	-	66	39	46	14	1						2	10
		2	150	9	21	70	-	55	17	71	12	0						1	5
		E	14	100	0	0	-	81	62	38	0	0						0	0
18	Elucidation of the cellular and molecular mechanisms whereby the juvenile brain has much greater plasticity and ability to compensate for organic damages than the adult brain.	1	150	12	30	58	-	66	40	43	17	0						3	9
		2	144	7	16	77	-	57	23	60	17	0						3	3
		E	10	100	0	0	-	85	70	30	0	0						0	0



Countries at the leading edge	Regarding technological realization										Time of social application					Regarding social application															
	Necessity of gov't involvement				Effective measures that should be taken by gov't						2006-2010	2011-2015	2016-2025	2026-2035	2036-	Will not be applied	Do not know	Necessity of gov't involvement				Effective measures that should be taken by gov't									
Japan	USA	EU	Asia	Other	High	Moderate	Low	None	Human resources development	Strengthened industry-academic-government and interdisciplinary collaboration								Development of R&D infrastructure	Expansion of R&D funding	Internationalization of R&D activities	Relaxation or elimination of relevant regulations	Tightened or new regulations	Other	High	Moderate	Low	None	Human resources development	Strengthened industry-academic-government and interdisciplinary collaboration	Improvement of environment for business startups	Support through taxation, subsidies, and procurement
(%)					(%)				(%)						(%)					(%)											
1	98	1	0	0	29	45	20	6	61	19	43	63	14	6	1	1															
1	99	0	0	0	14	65	18	3	74	13	31	71	6	3	1	0															
0	100	0	0	0	20	60	20	0	50	10	50	100	10	0	0	0															
3	93	4	0	0	26	46	20	8	57	21	39	59	14	6	1	1															
1	98	1	0	0	9	71	18	2	76	15	30	69	8	3	1	0															
0	100	0	0	0	23	69	8	0	46	31	46	85	15	0	0	0															
4	92	4	0	0	30	43	20	7	57	17	45	60	13	9	1	1															
1	99	0	0	0	12	66	21	1	74	14	34	73	5	4	1	0															
0	100	0	0	0	50	40	10	0	40	30	40	100	10	0	0	0															

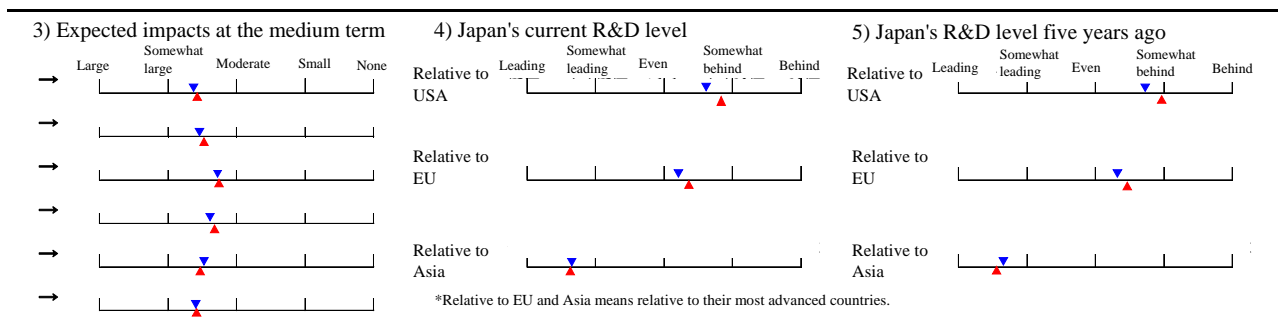
IV. Higher-order brain functions

1. Questions regarding the relevant area

1) Degree of expertise in the area	2) Current impacts
	<p>[Increased intellectual assets] Contribution of the relevant area itself to increased intellectual assets</p> <p>[Economic impacts] Contribution to the development of existing Japanese industry</p> <p>[Social impacts] Contribution to safety and security</p>
	<p>Contribution to the development of other fields</p> <p>Contribution to the creation of new industries or businesses</p> <p>Contribution to improved social vitality and quality of life</p>

2. Questions regarding topics

No	Topic	Questionnaire	Respondents (persons)	Degree of expertise				Importance to Japan				Time of technological realization								
				High	Moderate	Low	None	Index	High	Moderate	Low	None	Already realized	2006-2010	2011-2015	2016-2025	2026-2035	2036-	Will not be realized	Do not know
				(%)				(%)				(%)								
19	Elucidation of neural mechanisms of dreaming.	1	106	6	24	70	-	40	9	41	43	7							5	19
		2	122	2	7	91	-	34	2	33	63	2							2	6
		E	2	100	0	0	-	50	0	100	0	0							0	0
20	Elucidation of the regulatory mechanisms for expression of emotional behavior such as anger and aggression.	1	117	11	24	65	-	63	36	44	20	0							2	9
		2	126	4	13	83	-	56	23	56	21	0							1	6
		E	5	100	0	0	-	90	80	20	0	0							0	0
21	Elucidation of the mechanisms for generating the functional asymmetry of the left and right cerebral hemispheres.	1	119	8	22	70	-	47	17	43	35	5							2	12
		2	128	2	10	88	-	41	2	58	38	2							1	6
		E	3	100	0	0	-	50	0	100	0	0							0	0



Countries at the leading edge	Regarding technological realization										Time of social application					Regarding social application														
	Necessity of gov't involvement					Effective measures that should be taken by gov't					2006-2010	2011-2015	2016-2025	2026-2035	2036-	Will not be applied		Do not know		Necessity of gov't involvement		Effective measures that should be taken by gov't								
Japan	USA	EU	Asia	Other	High	Moderate	Low	None	Human resources development	Strengthened industry-academic-government and interdisciplinary collaboration						Development of R&D infrastructure	Expansion of R&D funding	Internationalization of R&D activities	Relaxation or elimination of relevant regulations	Tightened or new regulations	Other	High	Moderate	Low	None	Human resources development	Strengthened industry-academic-government and interdisciplinary collaboration	Improvement of environment for business startups	Support through taxation, subsidies, and procurement	Relaxation or elimination of relevant regulations
(%)					(%)					(%)					(%)															
2	94	4	0	0	12	34	41	13	60	10	36	45	12	6	1	2														
1	96	3	0	0	4	37	51	8	84	8	31	50	5	4	1	0														
0	100	0	0	0	0	50	50	0	100	0	0	0	0	0	0	0														
3	90	7	0	0	27	36	32	5	64	12	41	57	14	7	6	2														
2	94	4	0	0	17	50	31	2	83	12	39	60	6	3	1	0														
20	60	20	0	0	60	40	0	0	20	40	40	100	0	0	0	0														
7	87	5	0	1	12	37	41	10	57	10	35	54	12	7	2	2														
2	96	2	0	0	6	49	42	3	81	8	31	58	3	3	1	0														
0	100	0	0	0	0	67	33	0	0	0	0	100	33	0	0	0														

V. Understanding and treating brain conditions

1. Questions regarding the relevant area

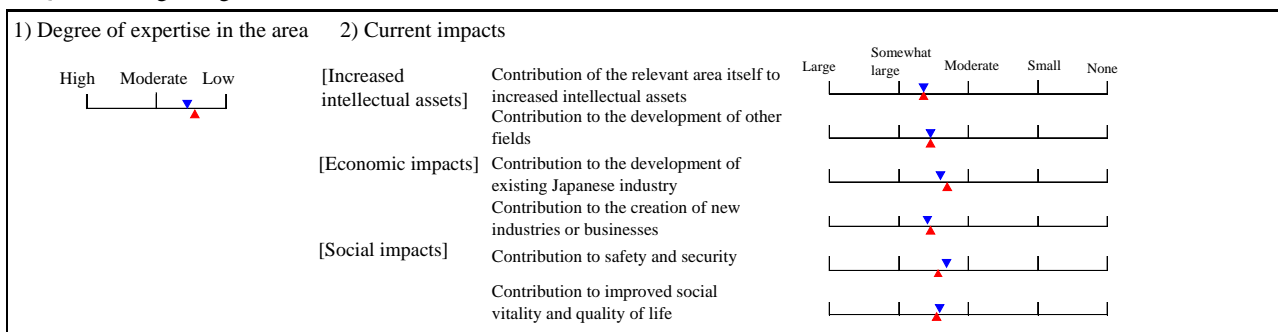
1) Degree of expertise in the area		2) Current impacts	
High	Moderate	Low	
[Increased intellectual assets]		Contribution of the relevant area itself to increased intellectual assets	Large
		Contribution to the development of other fields	Somewhat large
[Economic impacts]		Contribution to the development of existing Japanese industry	Moderate
		Contribution to the creation of new industries or businesses	Small
[Social impacts]		Contribution to safety and security	None
		Contribution to improved social vitality and quality of life	

2. Questions regarding topics

No	Topic	Questionnaire	Degree of expertise				Importance to Japan				Time of technological realization								
			Respondents (persons)				Index				Already realized	2006-2010	2011-2015	2016-2025	2026-2035	2036-	Will not be realized		Do not know
			High	Moderate	Low	None	High	Moderate	Low	None							(%)	(%)	
22	Treatment for preventing the progression of Alzheimer's disease.	1	169	12	27	61	-	81	63	33	4	0						1	5
		2	154	6	19	75	-	88	77	21	2	0						0	3
		E	9	100	0	0	-	94	89	11	0	0						0	0
23	Elucidation of the etiology of manic-depressive psychosis at the molecular level.	1	136	11	26	63	-	80	63	30	7	0						2	5
		2	143	3	14	83	-	84	71	23	6	0						1	2
		E	5	100	0	0	-	90	80	20	0	0						0	0
24	Elucidation of the etiology of schizophrenia at the molecular level.	1	132	12	20	68	-	79	61	30	9	0						2	9
		2	141	4	13	83	-	84	71	24	5	0						1	3
		E	6	100	0	0	-	100	100	0	0	0						0	0

VI. Regenerative medicine

1. Questions regarding the relevant area



2. Questions regarding topics

No	Topic	Questionnaire	Degree of expertise				Importance to Japan				Time of technological realization								
			Respondents (persons)				Index				Already realized	2006-2010	2011-2015	2016-2025	2026-2035	2036-	Will not be realized	Do not know	
			High	Moderate	Low	None	High	Moderate	Low	None	(%)								
25	Synthetic technology for artificial cells to replace functions such as cell membrane transport and conversion of matter and energy. Synthetic technology for artificial cells with functions such as cell membrane transport, material transfer, and energy	1	150	8	30	62	-	57	27	48	22	3						5	14
		2	152	3	22	75	-	47	9	66	23	2						7	5
		E	4	100	0	0	-	63	25	75	0	0						0	0
26	Artificial organs (pancreases, kidneys, livers, etc.) incorporating human cells and tissue.	1	163	14	22	64	-	71	45	49	6	0						1	9
		2	153	5	22	73	-	68	38	57	4	1						1	4
		E	8	100	0	0	-	88	75	25	0	0						0	0
27	Technology to utilize animals as a bioreactor to produce organs and tissues to transplant into humans.	1	161	12	26	62	-	64	39	42	15	4						8	9
		2	150	7	19	74	-	57	23	63	12	2						5	3
		E	11	100	0	0	-	68	46	45	0	9						9	0
28	Reprogramming technology to create stem cells from differentiated somatic cells.	1	176	19	25	56	-	71	46	45	8	1						1	8
		2	160	11	18	71	-	70	44	50	6	0						0	6
		E	17	100	0	0	-	90	80	20	0	0						0	0
29	Technology to manipulate stem cell differentiation and growth for induction of functional cells to use for therapy.	1	180	20	29	51	-	77	57	37	5	1						1	6
		2	162	15	19	66	-	79	61	35	4	0						1	3
		E	25	100	0	0	-	93	88	8	4	0						0	0
30	Long-term organ cultivation and preservation technology for organ transplants.	1	151	10	29	61	-	68	42	47	10	1						1	10
		2	148	7	16	77	-	63	31	60	8	1						1	3
		E	11	100	0	0	-	73	55	27	18	0						0	0
31	Artificial retinas to give sight to the visually impaired.	1	128	9	26	65	-	70	46	42	10	2						2	12
		2	136	2	18	80	-	70	44	50	5	1						1	6
		E	3	100	0	0	-	100	100	0	0	0						0	0

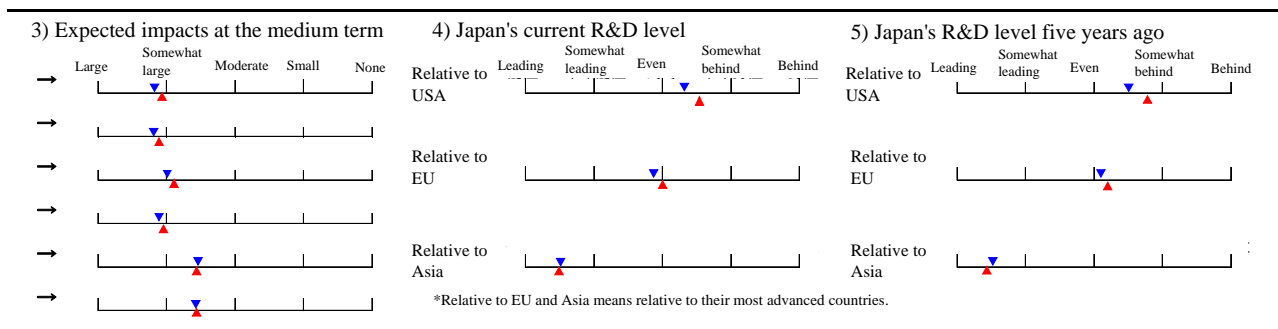
VII. Monitoring and sensor technology for biological substances

1. Questions regarding the relevant area

1) Degree of expertise in the area		2) Current impacts	
High	Moderate	Low	
[Increased intellectual assets]	Contribution of the relevant area itself to increased intellectual assets		
	Contribution to the development of other fields		
[Economic impacts]	Contribution to the development of existing Japanese industry		
	Contribution to the creation of new industries or businesses		
[Social impacts]	Contribution to safety and security		
	Contribution to improved social vitality and quality of life		

2. Questions regarding topics

No	Topic	Questionnaire	Degree of expertise				Importance to Japan				Time of technological realization																				
			Respondents (persons)				Index				Already realized	2006-2010	2011-2015	2016-2025	2026-2035	2036-	Will not be realized		Do not know												
			High	Moderate	Low	None	High	Moderate	Low	None							(%)	(%)													
32	Self-propelled micromachines for diagnosis and treatment inside the body (organ lumina).	1	116	8	18	74	-	65	38	47	15	0							2	138	3	9	88	-	62	28	64	8	0	2	8
		E	4	100	0	0	-	88	75	25	0	0							0	0	0	0	0	0	0	5					
33	Technology to detect a cancerous tissue of the diameter smaller than 1 mm presenting anywhere in the body.	1	129	9	26	65	-	76	55	37	7	1							2	148	1	15	84	-	84	69	30	1	0	0	5
		E	1	100	0	0	-	100	100	0	0	0							0	0	0	0	0	0	0	3					
34	Technology for molecular imaging in the body with the precision of single molecule detection.	1	181	17	36	47	-	63	34	50	15	1							2	173	5	39	56	-	56	18	73	8	1	2	7
		E	8	100	0	0	-	61	29	57	14	0							0	0	0	0	0	0	3						
35	Technology to observe the interactions among various substances inside and outside of cells, to simultaneously identify those substances, and to monitor their distribution.	1	182	21	31	48	-	63	35	49	15	1							2	165	4	37	59	-	58	20	71	9	0	2	7
		E	6	100	0	0	-	92	83	17	0	0							0	0	0	0	0	0	3						
36	Technology that can sequence the whole human genome in one day.	1	203	23	36	41	-	61	35	42	19	4							2	182	14	40	46	-	61	30	55	13	2	6	7
		E	26	100	0	0	-	72	46	50	4	0							0	0	0	0	0	0	3						
37	Equipment that can sample a single cell and measure all kinds of mRNAs with their copy numbers within the cell.	1	196	23	38	39	-	63	36	46	16	2							2	182	13	37	50	-	57	22	61	17	0	4	8
		E	24	100	0	0	-	64	38	41	21	0							0	0	0	0	0	0	2						
38	Equipment to automatically analyze the sequences of sugar chains with 20 or more linked sugars with their branching and linkage patterns.	1	148	16	30	54	-	60	30	51	18	1							2	147	5	24	71	-	53	14	70	15	1	1	9
		E	8	100	0	0	-	69	38	62	0	0							0	0	0	0	0	0	3						



Countries at the leading edge	Regarding technological realization										Time of social application					Regarding social application																		
	Necessity of gov't involvement				Effective measures that should be taken by gov't						2006-2010	2011-2015	2016-2025	2026-2035	2036-	Will not be applied		Necessity of gov't involvement				Effective measures that should be taken by gov't												
Japan	USA	EU	Asia	Other	High	Moderate	Low	None	Human resources development	Strengthened industry-academic-government and interdisciplinary collaboration						Development of R&D infrastructure	Expansion of R&D funding	Internationalization of R&D activities	Relaxation or elimination of relevant regulations	Tightened or new regulations	Other	(%)	(%)	High	Moderate	Low	None	Human resources development	Strengthened industry-academic-government and interdisciplinary collaboration	Improvement of environment for business startups	Support through taxation, subsidies, and procurement	Relaxation or elimination of relevant regulations	Tightened or new regulations	Other
30	67	2	0	1	27	48	21	4	40	58	35	55	9	13	3	1						3	12	27	38	29	6	40	52	38	29	25	8	1
30	67	2	0	1	17	68	14	1	52	60	29	66	2	9	2	0						0	4	15	66	18	1	49	72	25	33	17	2	0
50	25	0	0	25	50	50	0	0	25	50	0	25	0	25	0	0						0	0	25	75	0	0	25	50	0	0	25	0	0
22	77	1	0	0	33	48	16	3	45	54	46	62	7	15	2	0						1	5	29	43	21	7	40	51	39	40	25	6	0
17	82	0	1	0	23	66	10	1	51	62	36	68	2	6	1	0						0	3	17	68	14	1	46	74	23	45	12	1	0
0	100	0	0	0	100	0	0	0	100	0	100	100	0	0	0	0						0	0	0	100	0	0	0	100	0	100	0	0	0
42	53	4	0	1	25	46	26	3	53	42	37	63	9	5	1	1						3	12	18	44	29	9	48	51	29	38	9	3	3
51	48	1	0	0	14	71	13	2	64	44	31	74	2	3	1	0						3	4	12	64	21	3	56	71	20	34	5	1	0
87	13	0	0	0	25	62	13	0	75	38	25	50	13	0	0	0						0	0	13	87	0	0	50	88	13	13	13	13	0
14	83	3	0	0	28	47	22	3	50	41	37	68	10	3	1	1						2	12	20	40	29	11	47	48	31	40	6	4	2
6	94	0	0	0	13	72	13	2	64	41	29	76	1	3	1	0						2	4	10	65	20	5	59	73	20	37	5	1	0
33	67	0	0	0	17	83	0	0	50	67	0	83	0	0	0	0						0	0	0	100	0	0	50	83	0	50	0	0	0
9	88	2	0	1	28	41	22	9	41	52	42	59	11	6	2	1						5	13	23	38	27	12	39	54	34	39	11	12	1
6	92	1	1	0	16	68	14	2	47	57	36	69	2	4	2	0						4	3	17	60	20	3	40	73	22	36	8	5	0
8	92	0	0	0	35	53	12	0	50	81	42	58	4	0	0	0						0	8	27	61	12	0	38	85	23	35	4	0	0
10	87	2	0	1	27	47	21	5	44	47	47	63	8	7	2	1						3	13	19	45	25	11	41	53	29	39	8	9	1
4	96	0	0	0	14	67	17	2	52	53	34	70	1	3	1	0						4	3	12	62	22	4	43	75	17	33	6	2	0
17	83	0	0	0	29	54	17	0	35	74	48	61	4	4	0	0						8	4	25	54	21	0	30	87	9	35	4	0	0
34	62	4	0	0	24	46	25	5	48	43	50	65	7	4	1	1						1	12	22	36	31	11	40	60	36	43	8	5	1
37	63	0	0	0	12	63	24	1	63	42	42	64	4	4	1	1						1	5	8	60	26	6	57	73	24	35	3	1	0
62	38	0	0	0	49	38	13	0	88	50	75	88	38	13	13	13						0	0	49	38	13	0	75	75	50	75	13	13	0

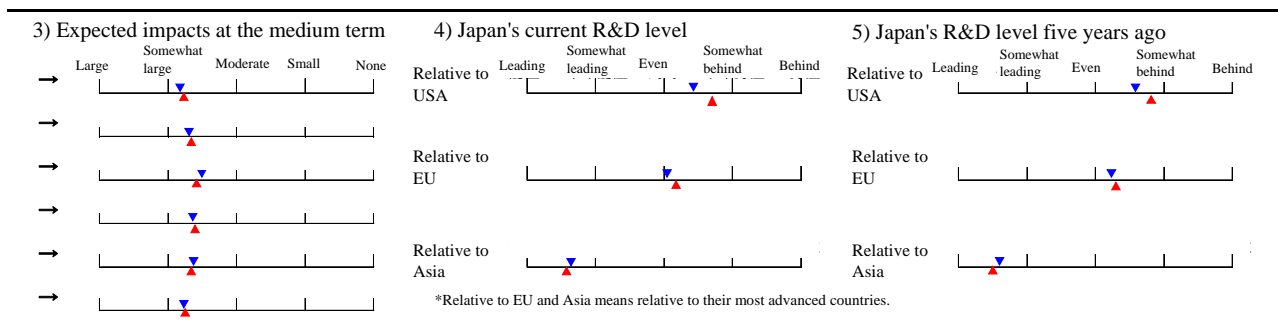
VIII. Control of higher-order biological functions

1. Questions regarding the relevant area

1) Degree of expertise in the area		2) Current impacts	
High	Moderate	Low	
[Increased intellectual assets]	Contribution of the relevant area itself to increased intellectual assets		
	Contribution to the development of other fields		
[Economic impacts]	Contribution to the development of existing Japanese industry		
	Contribution to the creation of new industries or businesses		
[Social impacts]	Contribution to safety and security		
	Contribution to improved social vitality and quality of life		

2. Questions regarding topics

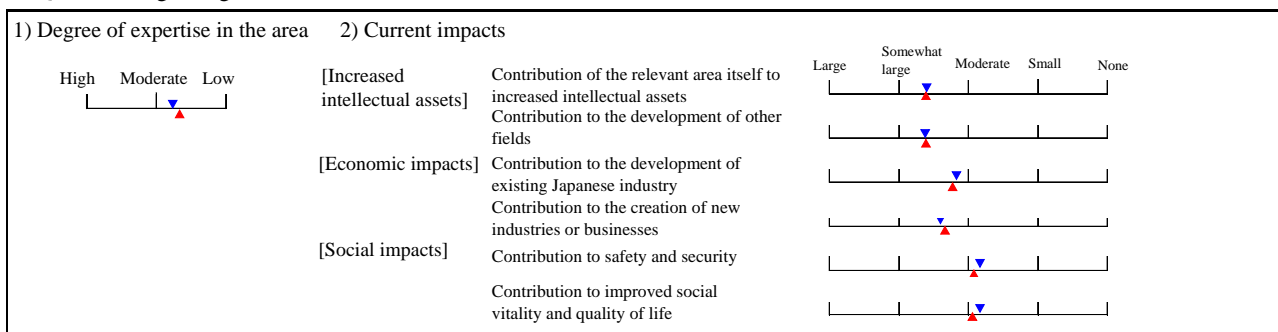
No	Topic	Questionnaire	Degree of expertise				Importance to Japan				Time of technological realization																				
			Respondents (persons)				Index				Already realized	2006-2010	2011-2015	2016-2025	2026-2035	2036-	Will not be realized		Do not know												
			High	Moderate	Low	None	High	Moderate	Low	None							(%)	(%)													
39	Technology to voluntarily control prostheses by using computers to convert movement-related brain activity to signals and transmit them via the spinal cord and peripheral nerves.	1	112	12	21	67	-	65	40	43	15	2							2	132	3	14	83	-	59	23	67	9	1	2	13
		E	4	100	0	0	-	75	50	50	0	0							0	0	0	0	0	0	0	0					
40	Elucidation of the molecular mechanism of floral differentiation in higher-order plants.	1	105	15	26	59	-	47	16	44	35	5							2	129	12	10	78	-	42	7	53	35	5	0	12
		E	15	100	0	0	-	60	20	80	0	0							0	0	0	0	0	0	0						
41	Technology to select cells (clones) to produce specific useful antibodies.	1	165	18	33	49	-	59	32	46	20	2							2	163	7	35	58	-	55	17	71	11	1	0	2
		E	12	100	0	0	-	58	25	58	17	0							0	0	0	0	0	0	0						
42	Regulation of autoimmune disease such as chronic rheumatoid arthritis based on the elucidation of the mechanisms for self-disposal of mutant cell components.	1	155	18	34	48	-	73	48	46	6	0							2	150	6	31	63	-	73	48	48	4	0	0	7
		E	9	100	0	0	-	75	56	33	11	0							0	0	0	0	0	0							
43	Elucidation of immune system repair and regeneration mechanisms.	1	159	19	31	50	-	67	41	44	15	0							2	153	8	29	63	-	63	31	61	7	1	1	6
		E	13	100	0	0	-	79	61	31	8	0							0	0	0	0	0	0	0						
44	Elucidation of the mechanisms regulating the balance between immune system activation and suppression.	1	160	18	33	49	-	68	44	43	13	0							2	155	10	27	63	-	65	33	61	5	1	0	5
		E	15	100	0	0	-	83	67	33	0	0							0	0	0	0	0	0	0						
45	Elucidation of the influence of weightlessness on generation and the endocrine and immune systems.	1	109	5	25	70	-	35	9	25	53	13							2	122	2	13	85	-	32	4	23	65	8	3	13
		E	2	100	0	0	-	50	50	0	0	50							0	0	0	0	0	0	0						



Countries at the leading edge	Regarding technological realization													Time of social application					Regarding social application																				
	Necessity of gov't involvement					Effective measures that should be taken by gov't								Will not be applied	Do not know	Necessity of gov't involvement					Effective measures that should be taken by gov't																		
Japan	USA	EU	Asia	Other	High	Moderate	Low	None	Human resources development	Strengthened industry-academic-government and interdisciplinary collaboration	Development of R&D infrastructure	Expansion of R&D funding	Internationalization of R&D activities			Relaxation or elimination of relevant regulations	Tightened or new regulations	Other	2006-2010	2011-2015	2016-2025	2026-2035	2036-	High	Moderate	Low	None	Human resources development	Strengthened industry-academic-government and interdisciplinary collaboration	Improvement of environment for business startups	Support through taxation, subsidies, and procurement	Relaxation or elimination of relevant regulations	Tightened or new regulations	Other					
(%)					(%)								(%)					(%)					(%)																
17	83	0	0	0	34	41	22	3	49	49	55	56	8	7	2	2						2	11	35	44	18	3	45	48	39	49	25	12	2					
9	91	0	0	0	18	70	11	1	66	45	45	65	2	3	1	0						2	2	17	67	14	2	63	58	26	45	14	4	0					
0	100	0	0	0	50	50	0	0	50	50	25	50	0	0	0	0						0	0	75	25	0	0	50	25	25	25	25	25	0					
16	74	9	0	1	16	46	31	7	48	17	38	61	4	5	1	3																							
7	93	0	0	0	7	62	26	5	77	11	28	70	2	2	0	2																							
14	86	0	0	0	20	67	13	0	100	14	36	86	7	0	0	0																							
10	84	5	0	1	14	39	36	11	38	37	38	56	7	9	1	2						1	3	19	33	34	14	38	51	36	40	18	7	3					
3	96	1	0	0	8	59	29	4	55	34	28	68	1	6	2	0						1	1	9	52	34	5	43	63	27	39	9	2	0					
17	83	0	0	0	17	41	17	25	44	33	44	100	0	0	0	0						0	0	8	58	17	17	30	70	30	50	20	0	0					
11	87	1	0	1	30	48	19	3	47	34	47	64	9	6	1	1						1	8	28	49	19	4	42	55	28	44	15	5	2					
5	93	1	1	0	20	70	10	0	66	28	33	75	2	3	2	0						0	2	19	68	12	1	57	66	19	47	8	2	0					
33	67	0	0	0	33	56	11	0	78	44	56	78	0	0	0	0						0	0	45	33	22	0	89	67	33	67	11	0	0					
5	92	3	0	0	27	44	26	3	51	28	45	65	12	8	1	1																							
1	97	1	1	0	15	71	13	1	70	21	38	71	1	2	1	0																							
8	92	0	0	0	38	47	15	0	92	31	62	85	0	0	0	0																							
9	89	2	0	0	26	46	26	2	49	28	45	63	12	5	1	1																							
3	96	1	0	0	15	72	12	1	66	22	33	73	2	3	1	0																							
13	87	0	0	0	46	47	7	0	87	20	47	93	0	7	0	0																							
2	97	0	0	1	17	35	32	16	36	29	42	37	28	3	1	5																							
1	99	0	0	0	9	42	37	12	58	19	43	43	22	2	1	1																							
0	100	0	0	0	50	0	0	50	100	0	100	100	0	0	0	0																							

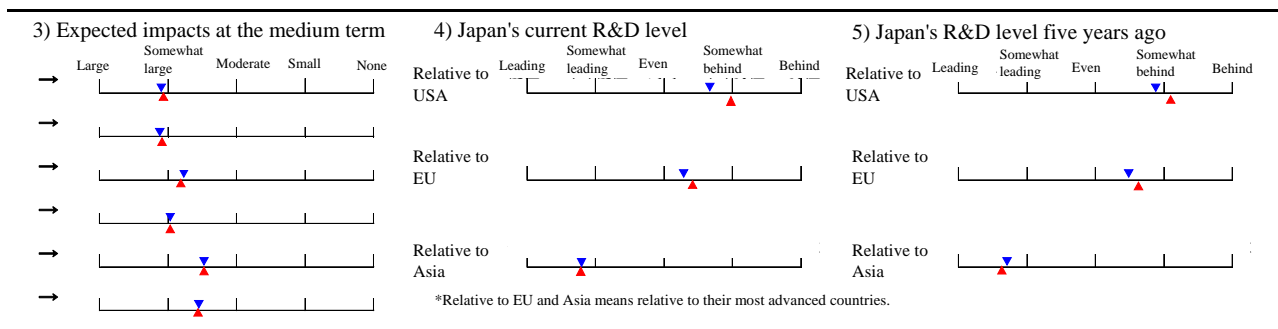
IX. Information biology

1. Questions regarding the relevant area



2. Questions regarding topics

No	Topic	Questionnaire	Degree of expertise				Importance to Japan				Time of technological realization								
			Respondents (persons)				Index				Already realized	2006-2010	2011-2015	2016-2025	2026-2035	2036-	Will not be realized	Do not know	
			High	Moderate	Low	None	High	Moderate	Low	None								(%)	
			(%)				(%)												
46	Protein design methods with voluntary molecular recognition mechanisms through the application of bioinformatics.	1	187	22	30	48	-	66	39	50	10	1						3	9
		2	175	14	26	60	-	61	27	63	10	0						2	2
		E	24	100	0	0	-	87	74	26	0	0						0	0
47	Through bioinformatics, the integration and sharing of vast amounts of data is made possible, and the data may be used for the implementation of life science research carried out over networks of virtual laboratories.	1	189	18	37	45	-	60	32	47	19	2						2	10
		2	170	11	25	64	-	55	19	64	16	1						1	2
		E	18	100	0	0	-	75	50	50	0	0						0	0
48	Remote technology systems applying advanced virtual reality technology.	1	117	6	23	71	-	60	32	46	20	2						2	9
		2	131	2	8	90	-	55	18	69	12	1						0	2
		E	2	100	0	0	-	100	100	0	0	0						0	0
49	Bioinformatics that can predict the risk of cancer and lifestyle diseases based on genetic background, etc.	1	201	21	33	46	-	74	53	37	10	0						0	5
		2	174	10	29	61	-	77	60	30	10	0						0	1
		E	17	100	0	0	-	94	88	12	0	0						0	0
50	Verification testing to elucidate the evolutionary mechanisms of organisms.	1	168	11	31	58	-	42	12	35	49	4						13	22
		2	163	6	24	70	-	37	4	37	56	3						6	6
		E	10	100	0	0	-	63	30	60	10	0						0	20
51	Based on complete gene function data for unicellular organisms, technology to simulate all cell functions such as multiplication and environmental response.	1	187	12	33	55	-	51	20	47	29	4						5	12
		2	175	5	28	67	-	46	8	61	30	1						5	2
		E	9	100	0	0	-	72	44	56	0	0						0	11
52	Methods to predict various genome functions from DNA sequencing data.	1	220	28	38	34	-	69	45	44	10	1						3	9
		2	188	24	36	40	-	71	47	44	9	0						1	2
		E	45	100	0	0	-	92	85	13	2	0						0	2



Countries at the leading edge	Regarding technological realization										Time of social application					Regarding social application															
	Necessity of gov't involvement					Effective measures that should be taken by gov't					2006-2010	2011-2015	2016-2025	2026-2035	2036-	Will not be applied		Necessity of gov't involvement					Effective measures that should be taken by gov't								
Japan	USA	EU	Asia	Other	High	Moderate	Low	None	Human resources development	Strengthened industry-academic-government and interdisciplinary collaboration						Development of R&D infrastructure	Expansion of R&D funding	Internationalization of R&D activities	Relaxation or elimination of relevant regulations	Tightened or new regulations	Other	(%)	(%)	High	Moderate	Low	None	Human resources development	Strengthened industry-academic-government and interdisciplinary collaboration	Improvement of environment for business startups	Support through taxation, subsidies, and procurement
6	92	1	0	1	27	47	23	3	61	44	42	57	5	3	2	2			3	10	23	42	29	6	57	53	28	38	8	4	2
1	98	1	0	0	12	71	16	1	77	34	33	64	1	2	1	0			2	5	10	67	21	2	71	62	18	30	5	1	0
4	96	0	0	0	38	49	13	0	96	33	46	79	0	0	0	0			0	0	21	66	13	0	83	63	33	46	0	0	0
5	93	1	0	1	23	46	26	5	59	40	47	58	14	5	2	1			3	12	19	44	29	8	57	52	25	37	10	4	1
1	98	0	1	0	11	71	17	1	78	31	41	63	6	2	1	0			1	4	8	74	16	2	79	59	22	27	4	1	0
0	100	0	0	0	39	55	6	0	78	39	44	67	22	0	0	0			0	0	18	70	12	0	81	50	25	19	0	0	0
9	88	2	0	1	26	47	22	5	52	48	44	56	13	13	6	2			4	10	26	42	26	6	54	56	20	42	29	12	2
7	93	0	0	0	13	72	13	2	73	48	37	54	2	9	3	0			1	4	13	73	12	2	71	64	15	32	16	6	0
0	100	0	0	0	100	0	0	0	100	0	50	50	0	0	0	0			0	0	50	50	0	0	100	0	0	0	0	0	0
9	88	2	0	1	40	45	14	1	56	41	46	56	11	17	8	2			1	6	37	43	18	2	50	48	23	35	24	21	1
4	96	0	0	0	34	56	9	1	76	40	38	65	5	8	1	0			1	2	26	59	14	1	72	57	16	37	17	11	0
12	88	0	0	0	65	35	0	0	94	53	29	71	12	6	0	0			0	0	47	53	0	0	76	53	6	18	24	0	0
12	73	12	0	3	12	26	48	14	51	17	39	52	11	5	2	3															
6	90	4	0	0	6	36	53	5	74	9	28	64	7	3	1	1															
11	78	11	0	0	20	50	30	0	80	10	40	60	0	0	0	0															
15	80	2	0	3	19	37	34	10	59	25	41	57	8	4	2	2															
8	91	1	0	0	6	54	36	4	79	13	31	64	4	1	1	1															
22	78	0	0	0	33	56	11	0	78	22	44	67	22	0	0	0															
5	92	2	0	1	33	41	21	5	62	36	44	59	16	5	1	1			3	12	26	38	29	7	53	50	30	40	10	8	1
2	96	2	0	0	24	64	11	1	84	28	36	68	6	3	1	0			1	3	19	60	19	2	74	57	19	34	5	3	0
2	96	2	0	0	53	45	2	0	90	29	43	74	12	5	0	0			2	5	40	42	16	2	80	59	20	36	0	5	0

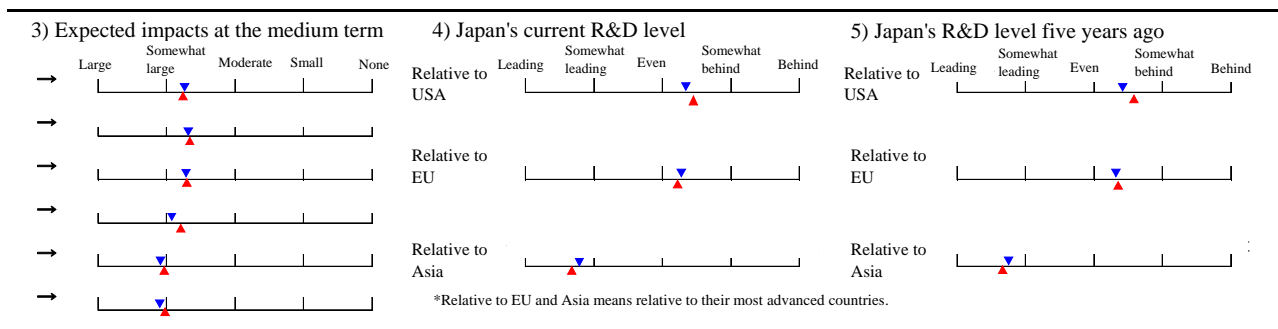
X. Environmental and ecological biology

1. Questions regarding the relevant area

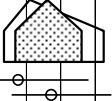
1) Degree of expertise in the area		2) Current impacts	
High	Moderate	Low	
[Increased intellectual assets]	Contribution of the relevant area itself to increased intellectual assets		
	Contribution to the development of other fields		
[Economic impacts]	Contribution to the development of existing Japanese industry		
	Contribution to the creation of new industries or businesses		
[Social impacts]	Contribution to safety and security		
	Contribution to improved social vitality and quality of life		

2. Questions regarding topics

No	Topic	Questionnaire	Respondents (persons)	Degree of expertise				Importance to Japan				Time of technological realization									
				High	Moderate	Low	None	Index	High	Moderate	Low	None	Already realized	2006-2010	2011-2015	2016-2025	2026-2035	2036-	Will not be realized	Do not know	
				(%)				(%)				(%)									
53	Technology to radically improve photosynthesis function in order to increase food production and protect the environment.	1	112	18	22	60	-	69	49	32	16	3								6	15
		2	135	11	7	82	-	76	59	33	7	1								5	4
		E	15	100	0	0	-	95	93	0	7	0								7	0
54	Technology to create practical plants resistant to cold and drought through elucidation of the molecular mechanisms of signal transductions in plants, from perception of low temperatures and other outside data to phenotypic expression.	1	110	19	26	55	-	67	41	44	14	1								2	6
		2	129	13	9	78	-	65	35	55	9	1								2	2
		E	17	100	0	0	-	82	65	35	0	0								0	0
55	Genetically-engineered plants and microorganisms that can remove NOx and other pollutants.	1	114	21	20	59	-	66	41	42	15	2								2	8
		2	132	11	13	76	-	67	41	48	9	2								2	1
		E	14	100	0	0	-	79	57	43	0	0								0	0
56	Plants with radically improvement in functions such as atmospheric nitrogen fixing and soil phosphate utilization through plant genome technology.	1	109	19	25	56	-	66	42	39	18	1								1	8
		2	128	11	8	81	-	69	45	43	10	2								4	2
		E	14	100	0	0	-	93	86	14	0	0								14	7
57	Mass production technology for fuels and bioplastics utilizing plants and microorganisms.	1	109	10	27	63	-	76	57	34	9	0								1	5
		2	129	7	11	82	-	81	66	29	5	0								0	2
		E	9	100	0	0	-	94	89	11	0	0								0	0
58	Technology to prevent eutrophication in marine and fresh water by measuring microorganism populations in natural environments and controlling their group compositions.	1	95	12	22	66	-	66	44	40	13	3								9	4
		2	120	5	11	84	-	69	45	43	11	1								2	3
		E	6	100	0	0	-	83	67	33	0	0								0	17
59	Elucidation of the basic genetic networks that control growth and development of plants such as shape, size, and bloom period.	1	116	20	24	56	-	58	30	44	25	1								0	4
		2	129	15	8	77	-	50	12	67	20	1								1	3
		E	19	100	0	0	-	76	53	47	0	0								0	0
60	Technology to form cells with the minimum genetic set needed to produce substances.	1	128	8	34	58	-	52	23	44	28	5								4	11
		2	138	4	16	80	-	50	12	66	20	2								4	7
		E	6	100	0	0	-	67	33	67	0	0								0	17



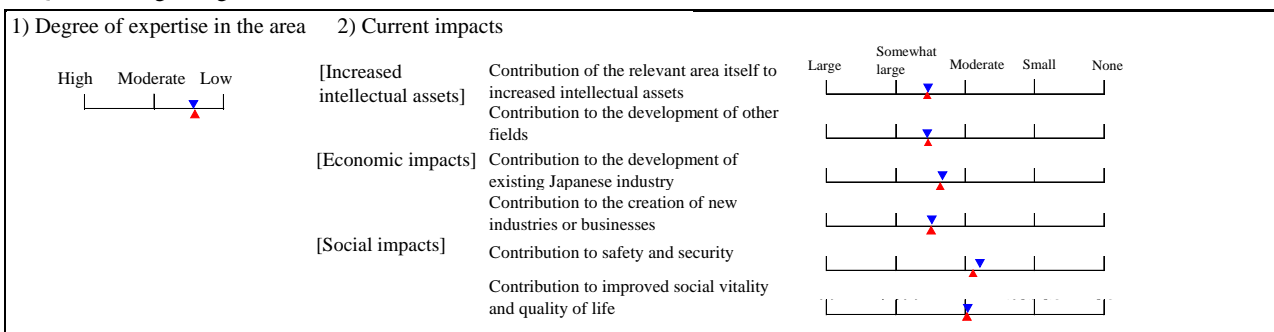
Countries at the leading edge						Regarding technological realization										Time of social application						Regarding social application													
						Necessity of gov't involvement				Effective measures that should be taken by gov't												Necessity of gov't involvement				Effective measures that should be taken by gov't									
Japan	USA	EU	Asia	Other	High	Moderate	Low	None	Human resources development	Strengthened industry-academic-government and interdisciplinary collaboration	Development of R&D infrastructure	Expansion of R&D funding	Internationalization of R&D activities	Relaxation or elimination of relevant regulations	Tightened or new regulations	Other	2006-2010	2011-2015	2016-2025	2026-2035	2036-	Will not be applied	Do not know	High	Moderate	Low	None	Human resources development	Strengthened industry-academic-government and interdisciplinary collaboration	Improvement of environment for business startups	Support through taxation, subsidies, and procurement	Relaxation or elimination of relevant regulations	Tightened or new regulations	Other	
(%)						(%)				(%)						(%)						(%)				(%)									
23	71	5	1	0	41	35	18	6	45	39	56	66	18	13	3	0							4	21	41	38	15	6	43	56	26	39	29	13	2
17	82	0	1	0	40	50	7	3	65	35	48	73	15	8	2	0							4	6	41	49	7	3	69	73	18	42	23	4	1
29	71	0	0	0	53	40	7	0	73	33	80	93	40	13	7	0							7	0	73	20	7	0	87	67	20	53	53	7	7
26	69	5	0	0	34	47	18	1	51	34	50	69	15	14	5	1							1	9	35	44	19	2	40	51	27	40	33	9	5
22	78	0	0	0	27	63	9	1	67	33	44	78	13	10	2	0							2	3	28	62	9	1	63	73	19	40	23	4	1
41	59	0	0	0	53	41	6	0	65	35	76	88	35	12	6	0							0	0	59	35	6	0	65	71	24	53	53	6	6
24	73	2	0	1	36	43	17	4	48	44	50	66	12	19	4	0							4	15	36	46	14	4	39	58	31	48	33	10	2
15	84	1	0	0	32	59	8	1	64	38	46	76	9	12	5	0							2	2	37	54	7	2	59	71	22	45	26	6	1
21	72	7	0	0	57	43	0	0	71	43	71	93	29	14	7	0							7	0	64	36	0	0	71	64	29	57	50	7	7
18	77	3	1	1	35	43	21	1	45	40	45	63	12	16	6	0							3	11	36	45	17	2	42	56	31	41	29	14	1
9	88	2	1	0	25	65	9	1	68	32	44	71	10	9	2	0							2	3	32	57	9	2	61	69	19	40	24	6	1
21	72	7	0	0	43	57	0	0	79	21	64	79	29	14	7	0							8	8	57	43	0	0	64	57	21	50	50	7	7
26	67	7	0	0	41	43	12	4	47	55	46	67	13	12	4	0							1	9	43	42	12	3	37	58	43	49	25	11	2
22	77	1	0	0	43	48	8	1	59	51	43	75	9	7	2	0							0	3	45	45	9	1	48	70	29	45	18	4	2
22	78	0	0	0	67	33	0	0	56	56	44	89	22	22	0	0							0	0	67	33	0	0	44	67	67	56	33	11	11
16	73	6	0	5	36	45	16	3	48	44	45	61	16	9	4	2							10	12	36	42	15	7	44	49	30	49	14	13	1
15	83	2	0	0	26	64	8	2	66	38	48	72	13	5	1	0							3	7	30	62	6	2	57	68	21	46	11	5	0
17	83	0	0	0	67	33	0	0	83	50	33	100	67	33	0	0							0	17	67	33	0	0	50	67	33	67	67	33	0
17	79	3	0	1	30	38	28	4	51	26	43	64	13	8	3	1																			
6	94	0	0	0	11	68	20	1	75	25	38	70	6	5	0	0																			
6	94	0	0	0	50	50	0	0	83	28	61	89	28	6	0	0																			
6	91	2	0	1	19	43	32	6	48	31	48	65	7	5	2	1																			
1	99	0	0	0	7	73	19	1	74	20	42	67	4	4	2	0																			
17	83	0	0	0	17	66	17	0	83	33	50	67	0	0	0	0																			

No	Topic	Questionnaire	Degree of expertise				Importance to Japan					Time of technological realization								
			Respondents (persons)				Index	High	Moderate	Low	None	Already realized	2006-2010	2011-2015	2016-2025	2026-2035	2036-	Will not be realized	Do not know	
			High	Moderate	Low	None														(%)
61	Based on genome sequence research in many species, elucidation of the diversity and evolution of environmental response mechanisms in organisms, such as metabolic capacity and ability to respond to stress.	1	156	13	27	60	-	56	26	46	25	3							3	10
		2	148	8	16	76	-	51	12	69	18	1							0	5
		E	12	100	0	0	-	79	58	42	0	0							0	8

Countries at the leading edge					Regarding technological realization										Time of social application					Regarding social application														
					Necessity of gov't involvement					Effective measures that should be taken by gov't										Necessity of gov't involvement					Effective measures that should be taken by gov't									
Japan	USA	EU	Asia	Other	High	Moderate	Low	None	Human resources development	Strengthened industry-academic-government and interdisciplinary collaboration	Development of R&D infrastructure	Expansion of R&D funding	Internationalization of R&D activities	Relaxation or elimination of relevant regulations	Tightened or new regulations	Other	2006-2010	2011-2015	2016-2025	2026-2035	2036-	Will not be applied	Do not know	High	Moderate	Low	None	Human resources development	Strengthened industry-academic-government and interdisciplinary collaboration	Improvement of environment for business startups	Support through taxation, subsidies, and procurement	Relaxation or elimination of relevant regulations	Tightened or new regulations	Other
(%)					(%)					(%)					(%)					(%)														
9	86	4	0	1	22	43	30	5	52	26	43	60	13	4	3	1																		
3	96	0	1	0	11	67	21	1	78	21	41	71	4	3	0	0																		
17	83	0	0	0	82	18	0	0	100	27	82	91	27	9	0	0																		

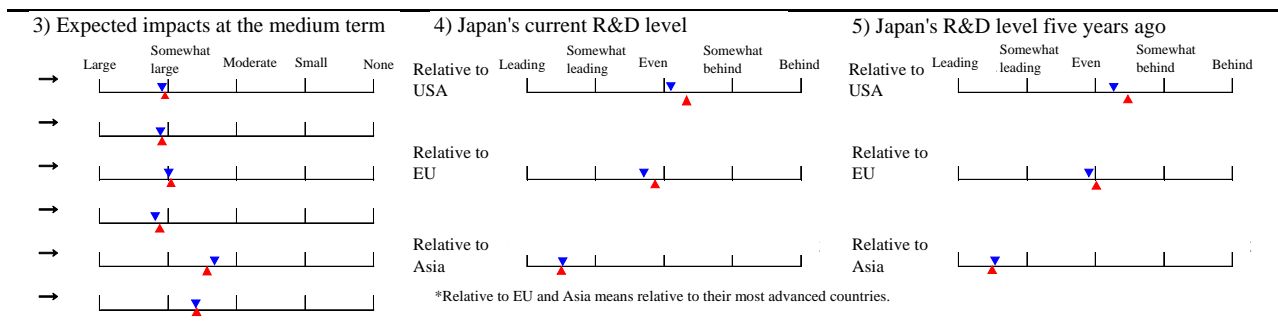
XI. Nanobiology

1. Questions regarding the relevant area



2. Questions regarding topics

No	Topic	Questionnaire	Degree of expertise				Importance to Japan					Time of technological realization								
			Respondents (persons)				Index	High	Moderate	Low	None	Already realized	2006-2010	2011-2015	2016-2025	2026-2035	2036-	Will not be realized		Do not know
			High	Moderate	Low	None												(%)	(%)	
62	Highly efficient energy conversion technology that utilizes motor proteins (molecular motors) that convert chemical energy to mechanical energy.	1	127	15	35	50	-	62	37	43	17	3							7	13
		2	137	5	23	72	-	56	20	67	12	1							5	4
		E	7	100	0	0	-	57	29	42	29	0							29	0
63	Chemical sensor technology that mimics the ion selection function of the ion channels that exist in cell membranes.	1	141	16	33	51	-	58	27	50	22	1							1	6
		2	150	5	25	70	-	54	15	73	11	1							1	1
		E	8	100	0	0	-	79	57	43	0	0							0	0
64	Nanochamber arrays that enable simultaneous detection of many biological reactions by concentrating thousands or tens of thousands of receptors on a single semiconductor chip.	1	137	18	29	53	-	64	37	47	16	0							1	7
		2	149	7	23	70	-	58	22	67	10	1							1	3
		E	11	100	0	0	-	70	40	60	0	0							0	0
65	Biofuel cells that reconstruct the reactions of enzyme molecules in bodies on a nano scale.	1	116	11	27	62	-	61	32	50	15	3							4	13
		2	133	2	14	84	-	53	14	73	11	2							6	5
		E	3	100	0	0	-	67	33	67	0	0							0	0



Countries at the leading edge						Regarding technological realization										Time of social application					Regarding social application														
						Necessity of gov't involvement				Effective measures that should be taken by gov't											Necessity of gov't involvement				Effective measures that should be taken by gov't										
Japan	USA	EU	Asia	Other	High	Moderate	Low	None	Human resources development	Strengthened industry-academic-government and interdisciplinary collaboration	Development of R&D infrastructure	Expansion of R&D funding	Internationalization of R&D activities	Relaxation or elimination of relevant regulations	Tightened or new regulations	Other	2006-2010	2011-2015	2016-2025	2026-2035	2036-	Will not be applied	Do not know	High	Moderate	Low	None	Human resources development	Strengthened industry-academic-government and interdisciplinary collaboration	Improvement of environment for business startups	Support through taxation, subsidies, and procurement	Relaxation or elimination of relevant regulations	Tightened or new regulations	Other	
(%)						(%)				(%)						(%)					(%)				(%)										
45	50	3	0	2	32	43	21	4	59	37	49	68	11	5	1	2						7	12	26	41	24	9	47	56	36	41	7	3	2	
47	52	1	0	0	19	65	14	2	77	28	38	67	2	2	1	1							5	6	13	66	17	4	64	64	27	32	3	1	0
86	14	0	0	0	50	17	33	0	67	33	33	67	0	0	0	0							29	0	14	29	43	14	50	67	17	17	0	0	0
21	72	5	0	2	23	51	23	3	53	44	39	66	6	4	2	1							1	11	16	50	28	6	42	57	37	42	6	2	2
18	82	0	0	0	12	71	16	1	68	37	32	68	1	2	1	1							1	3	9	70	18	3	57	68	24	34	3	1	0
50	50	0	0	0	38	62	0	0	38	38	25	88	0	0	0	0							0	0	36	38	13	13	43	43	29	43	14	14	0
21	76	2	0	1	32	43	23	2	52	51	48	62	9	6	1	1							1	9	24	42	29	5	46	59	44	41	6	2	2
12	88	0	0	0	15	68	16	1	68	46	40	65	1	2	1	1							2	3	8	73	16	3	52	74	34	35	4	1	0
36	64	0	0	0	36	55	9	0	64	36	27	91	0	0	0	0							0	0	9	73	9	9	40	70	50	30	10	0	0
18	80	0	0	2	31	51	14	4	53	49	46	63	11	5	1	2							5	14	25	50	19	6	42	58	39	45	5	3	2
9	91	0	0	0	12	71	15	2	71	46	37	63	1	2	1	1							5	5	8	73	14	5	55	73	26	38	4	2	0
33	67	0	0	0	33	67	0	0	33	33	0	100	0	0	0	0							0	0	0	34	33	33	50	50	50	50	0	0	0