Section 3 Future Improvements to the STI Policy ~ to Overcome the Problems Caused by the GEJE~

1 Promotion of STI in Response to Social Needs

Preceding section introduced some leading examples of STI aimed at overcoming various social issues after the GEJE and examples of R&D efforts contributing to industrial reconstruction and revival. They included:

- Examples in which technology has been advanced based on experience gained through past and present earthquakes,
- Examples in which numerous researchers brought together their wisdom beyond fields and organizations in order to solve these problems actually faced by their residents living in afflicted area, and
- Examples where the results of R&D by universities and others, are utilized to facilitate the community design of local governments.

All of these cases are good examples of the research which is well implemented in society.

In order to build a "Robust and Resilient Society" that is resistant to various risks and environmental changes, it is necessary to address appropriately various social issues and improve the social system so that it can quickly recover the lost functions. Even now, after being hit by the great earthquake, people still expect that S&T will take an important role in that process (refer to Figure 1-2-5).

In this section, we offer the direction to promote innovation which meets social needs, based on the results of discussions held at Council for Science and Technology and the results of the survey by science and technology experts.

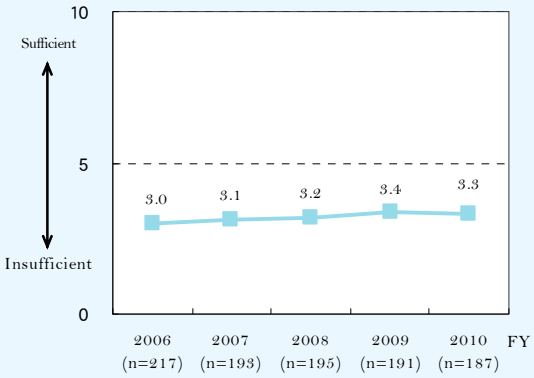
(1) In order to Promote Productive R&D

In the 3rd Basic Plan, the R&D have been promoted selectively in the 8 selected fields including four priority fields to be promoted (life sciences, information and telecommunications, environmental sciences and nanotechnology/materials) and four fields to be promoted (energy, MONOZUKURI technology, social Infrastructure and frontiers), which accumulated numerous world top class research results.

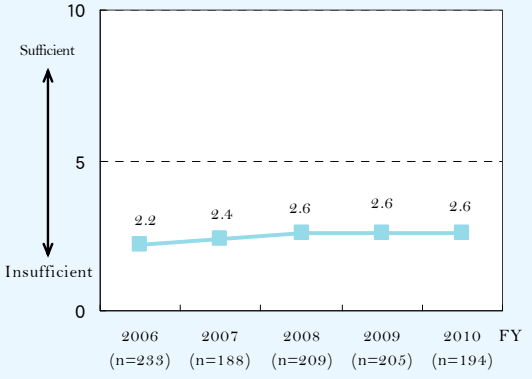
On the other hand, with regards to the GEJE, the results of R&D which have received significant governmental grants, are pointed out their inabilities to meet the demands in the emergency at afflicted area (refer to Chapter 1, Section 2, 2). Moreover, a lot of experts consider that the results of R&D in Japan do not very much bring about innovation or that they do not necessarily play a major role towards the resolution of various social problems. (Figure 1-2-15)

Figure 1-2-15
(1) Do R&D Results in Japan Contribute to Innovation or Resolution of Social Problems?

Q: Do you think the results of R&D including basic research in Japan sufficiently lead to innovation?

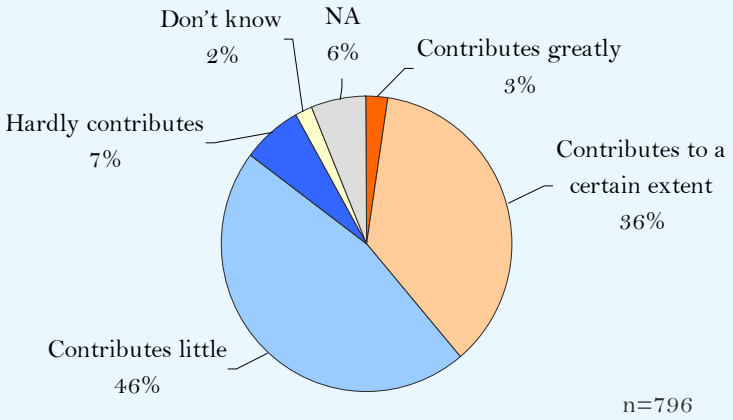


Q: Do you think the research funding system in Japan promotes applications of basic research?



Note: The replies to the question were classified into 6 grades, based on selection by the respondents of the most suitable answer. (6 grade evaluation) The values for each FY are indexed with the 6 grade evaluation between 0 (insufficient) and 10 (sufficient) out of 10 points.
Source: Created by MEXT based on National Institute of Science and Technology Policy "Analytical Report for 2010 Experts Survey on Japanese S&T System and S&T Activities by Fields"

(2) Do R&D Results Contribute to Solutions of Social Problems?



Note: Same as Figure 1-1-18.
Source: National Institute of Science and Technology Policy "Survey regarding the Great East Japan Earthquake by Science and Technology Experts" (2nd edition) (conducted in September 2011)

Why do many experts then consider the results of R&D not to be utilized for the solution of these issues? Council for Science and Technology's Subdivision on R&D Planning and Evaluation (the 39th meeting held on January 24, 2012) indicated the following problems:

○ While there are some fields where S&T are evaluated based on whether they responded to social needs by reflecting the policy, effective utilization of research results has not been sufficient so far in deciding the policy.

○ The lack of communication to build consensus between scientists and stakeholders including

individual persons, groups, administrative organizations concerning the needs and technical seeds.

In "Basic Arguments concerning the Perspective for Studying the Future Policy for Science and Technology based on the Great East Japan Earthquake" discussed at the 38th General Meeting of Council for Science and Technology (February 29, 2012), the following points were also revealed:

(1) The need to sufficiently recognize social requirements

(2) Grasping social needs and reflecting them onto research tasks

(3) The need for systematizing S&T in Japan

Particularly in regards to the point of argument stated in (1) above, the importance "to improve their social literacy to recognize the social expectation for scientists" and "to fulfill their responsibilities to society as researchers working with public funds was pointed out." Moreover, with regards to the point of argument stated in (3) above, the necessity to improve the strategy for scientific results obtained in Japan to utilize was also pointed out, because Japan's results of science and technology did not necessarily meet the needs of society in face of the recent earthquake. As an example of these problems, Japanese robots (excluding some exceptional cases) initially were not used on the disaster site of the stricken nuclear power plant (robot shock) (refer to Table 1-1-25).

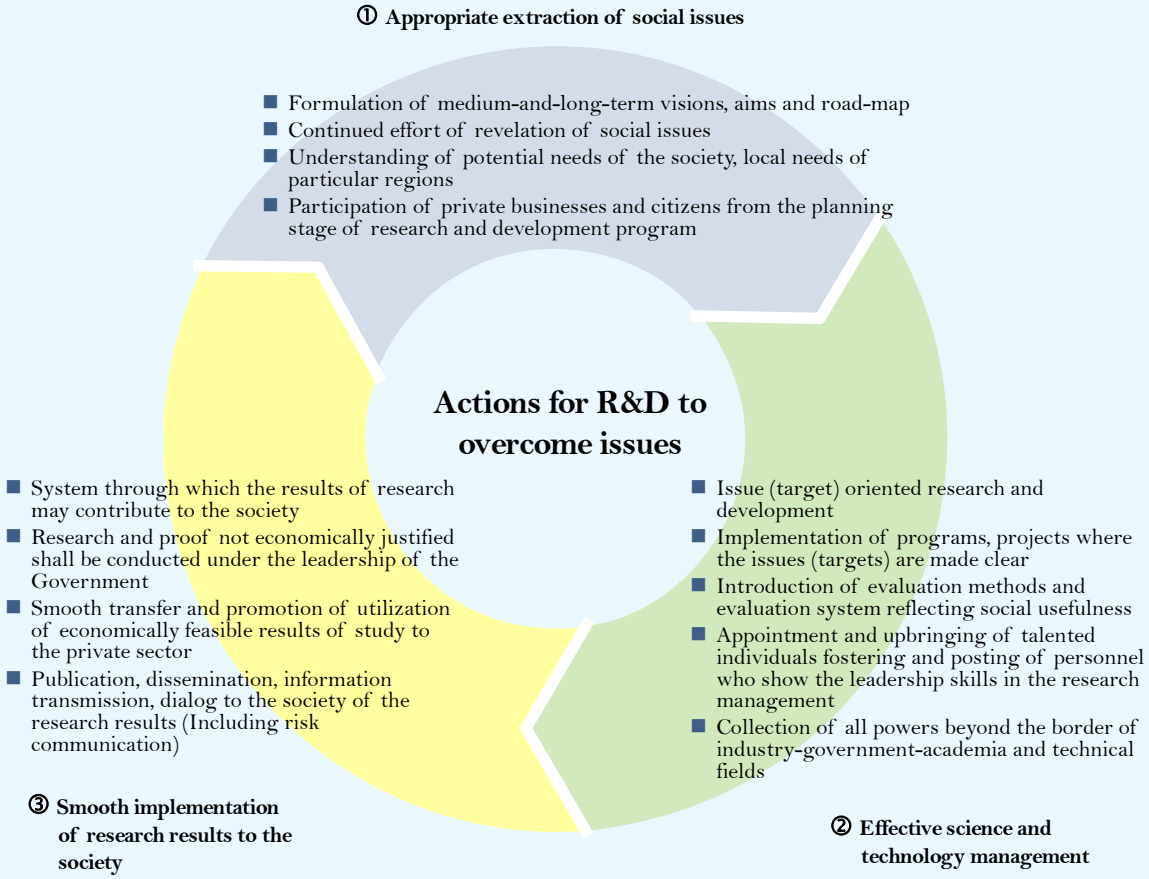
What approach could be taken in order to utilize the results of R&D for the resolution of these problems? The survey of the experts performed by the NISTP (previously mentioned), revealed the need for 1) appropriate extraction of social issues, 2) effective S&T management suitable for task-achieving type of research, and 3) development and smooth implementation of the results of R&D. The needs for various approaches were pointed out as indicated in Figure 1-2-16. With regards to the point 1) of social issues mentioned above, the followings were indicated.

- First, the social issues extracted by researchers do not necessarily match the actual demands.
- Therefore it is necessary to have viewpoint of society when extracting the issues.
- In addition to the knowledge of natural sciences, human and social sciences are necessary to extracting social issues.

Many experts pointed out difficulties and importance of extracting social issues. "Research projects that society needs may not necessarily be attractive for a researcher and vice versa." "Various research projects which have been implemented were not well established in society because the issues in those projects were based on researchers' point of view, not society's." "It is necessary to help identify potential or obvious problems, and to construct a system to support such approach." They also pointed out the necessity to form middle-and-long term national objectives, use the knowledge of social sciences and participation of stakeholders and personnel of industry in order to extract social issues.

In the above opinion survey, it was indicated that to implement 1) to 3) effectively, many scientists should cooperate beyond organizations and their fields, and for this purpose, many scientists believe that cooperation of scientists to the scientists engaged in the applied science, and wide variety of fields including human and social sciences. Moreover, such cooperation is meaningful, not simply in the stage for implementing the results of research, but also in the stage where the potential needs of society and the social issues are sought and extracted, and where R&D program is established.

Figure 1-2-16/ Necessary Approaches for the Appropriate and Effective Utilization of the Results of R&D to Overcome Problems



Note: Same as Figure 1-1-18.
Source: Created by MEXT based on the results of the National Institute of Science and Technology Policy "Survey regarding the Great East Japan Earthquake by S&T experts (2nd edition)" (held in September 2011)

Further, in the 4th Science and Technology Basic Plan, the government should establish a collaboration system that enables the proactive participation of various persons concerned in a wide range of areas, including industry, university and government, and the sharing of future visions among them. Moreover, the government will build a platform that supports the full process of crafting strategies for essential issues, including examination and promotion. "Science and Technology Innovation Strategy Council (tentative name)" will be established for each essential issue in order to ensure integrated promotion of STI, and provide opportunities of close cooperation through participation of various persons concerned from a wide range of areas, including relevant ministries and agencies, fund distribution organizations, universities, public research institutions, and industrial sectors, and NPOs. The Strategy Council will consider from various viewpoints the desirable approaches to specific R&D, regulatory / institutional reforms, performance targets, promotion systems, and fund distribution to be promoted in each of the phases of basic research, application, development, industrialization, and commercialization Furthermore, according to the said Basic Plan in order to promote STI, the government will implement efforts to further advance cooperation between industry, university and government in order to strengthen "knowledge" networks for promoting innovation via S&T and

approaches to establish "places" for industry-university-government collaboration.

In order to promote such task-oriented type of STI, it is necessary to formulate an STI policy through evidence based processes. For example, attempts to evaluate the effects of investment for STI based on objective evidence, have been performed recently in Europe and the US. In the US, with Science and Technology for America's Reinvestment Measuring the Effect of Research on Innovation, Competitiveness and Science (STAR METRICS) Program, attempts were made to measure a wide range of effects of R&D investment such as economic growth, employment, scientific knowledge, or social outcome. Prior analysis and assessment as to the effect of policy including research and investment using various quantitative and qualitative measures were performed in the European Union (EU), when Framework Program 7 (FP7)[1] was designed. In Japan, "Science of Science, Technology and Innovation Policy program" was also launched in FY 2011 by MEXT. It contains grasping and analysis of multilateral viewpoints the condition of society and economy, aiming to realize "Policy formulation based on objective grounds (evidence)" to plan effective policy in order to address various social issues. This project is composed of publicly invited research and conducted by researchers such as university scholars. It is structured on human development and centered around post-graduate schools, developing data-infrastructure for investigation and research.

In order to plan policies based on objective grounds (evidence) and reflect results of policy evaluation and verifications in policies

(2) Aiming for the collection of knowledge from different fields in order to overcome social issues

It has been pointed out previously that[2] the integration of human and social sciences, which study humanity and the human society, and natural sciences, which investigate the human being and the surroundings, is quite important since it brings about a variety of novel research results.

Due to the great earthquake and tsunami, followed by the nuclear power plant accident, people - particularly in Japan - have deeply realized the connection between nature and human society. It is expected that the research linking these two fields will become increasingly important for sustainable growth of human society in harmony with nature.

Moreover, as mentioned above, to encourage innovation, it is necessary to collect expertise of various fields through collaboration of scientists in various sectors.

However, so far as the actual situation in Japan is concerned, interdisciplinary research between different universities, and collaboration and integration between different fields are not necessarily widespread. (Figure 1-2-17)

In Japan research is categorized based on the traditional academic fields, and is not designed to engage in the needs of society or industry.

For example, the number of papers published in Journals of the Institute of Electrical and Electronics Engineering, Inc. (IEEE), the world biggest academic organization, shows that the electric and electronic

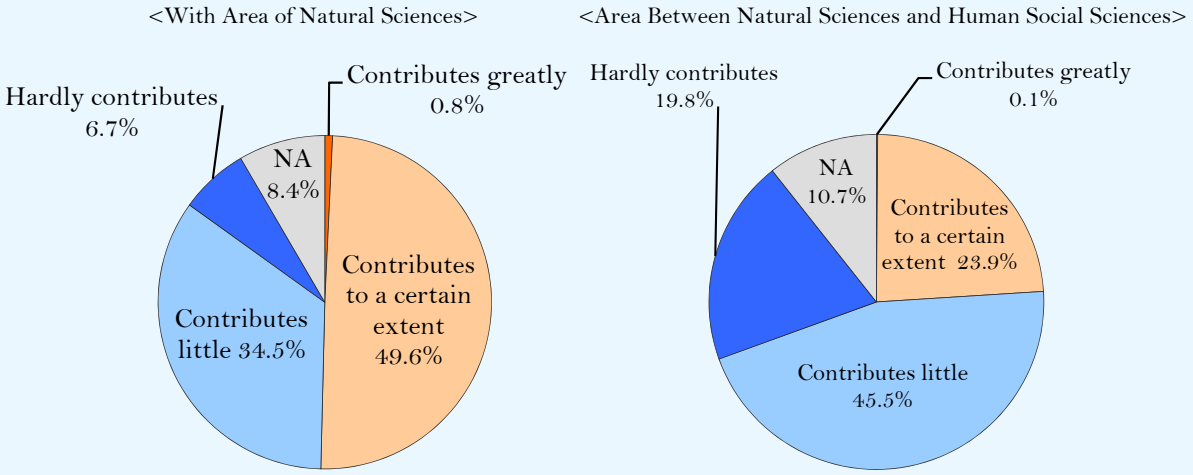
1 During 7 year period from 2007 to 2013, a total amount exceeding 50 billion Euro was invested for research innovation

2 Science Council Science Research System Special Committee Working Group on Human and Social Science Research "How to promote Human and Social Science Research and Integrated Research (Summary of Deliberation) (November 28, 2000), Statement by Science Academy of Japan "Role of Human and Social Science in the 21st century and its importance—New way to grasp "Science and Technology" and for a New Social and Cultural system— (April 26, 2001) etc.

areas were the principal field in the world in the 1990s, but in 2000s, the number of papers in the area of information communication increased. In Japan, on the other hand, the majority of papers is published in the fields of electric and electronic field including magnetic, electronic devices and photonics. As was already explained, although the direction of R&D in the world, is influenced by the changes in society and industrial structure, in Japan it is not to be necessarily corresponding to such changes. (Figure 1-2-18)

Moreover, looking at the examples of STI introduced in the previous section, interdisciplinary research, especially the combination of human and social sciences and natural sciences is very limited at present.

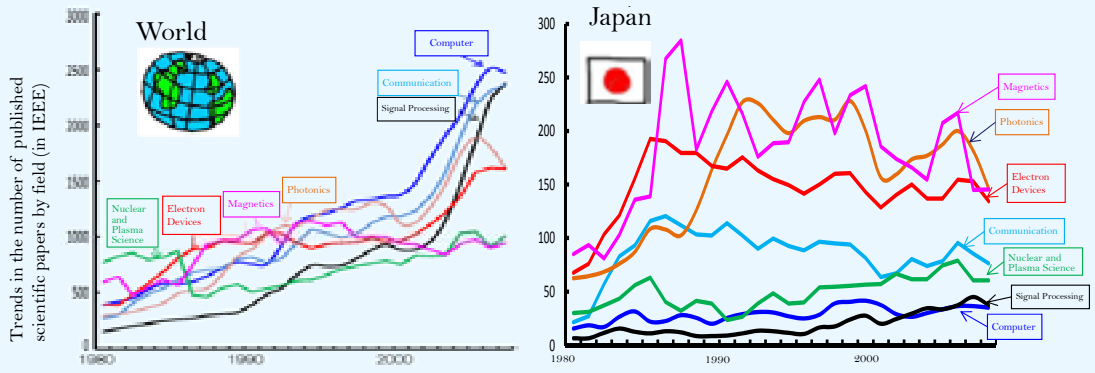
Figure 1-2-17 / Present Approaches of Research Collaboration Aiming at Solving Social Issues



Note: Same as Figure1-1-18.

Source: National Institute of Science and Technology Policy "Survey regarding the Great East Japan Earthquake by S&T experts (2nd edition) (held in September 2011)

Figure 1-2-18 / Incongruence between R&D Development and the Changes in the Japanese Industrial System



Since the beginning of the 2000s, the number of papers covering information communication field increased sharply in other parts of the world.

In Japan, the number of papers covering the electrical and electronic fields is constantly great, and no big change is observed in the distribution of papers in each field.

Source: Created by MEXT based on the Reports by National Institute of Science and Technology Policy "An Extensive Quantitative Analysis of IEEE Publications" (June 2011) and "The Field Trends in IEEE Periodicals An Extensive Quantitative Analysis of IEEE Publications" (October 2010)

The survey of the experts also revealed the following points with regards to the reasons why interdisciplinary study and collaborative research between different fields have not been promoted in Japan: (Table 1-2-19)

Table 1-2-19 / The Reasons why Interdisciplinary Research or Interdisciplinary Collaboration have not been Promoted.

(Problems related to opportunities for interchange, creation of fields for cooperation and coalescence)
- University majors and academic societies are narrowly fragmented in vertically divided fields
- Since the mentality and methodology are different in different fields, there are few points of mutual contact and so, cooperation is difficult.
- Formation of a "space" that could serve as a "mechanism for collaboration" between different fields is insufficient, and "There are no opportunities for scientists of different fields to interact".

(Problems related to research evaluation methods and distribution of funds)
- Evaluation of scientists is principally based on the number of scientific papers presented and the number of quotations of papers in the conventional specialized fields, and originality of the study. As a result, it is difficult to present papers in the integrated field of research focused on solving social issues, and gaining research grants in such field is difficult.

(Problems related to training of scientists able to engage in interdisciplinary or collaborative research.)
- With the progress of diversification of specialties and division of work, the number of scientists able to practice R&D of mission-oriented type fusing together the knowledge of different aiming at its implementation into society is decreasing.

Note: Same as Figure1-1-18.
Source: Created by MEXT based on the results of the National Institute of Science and Technology Policy "Survey regarding the Great East Japan Earthquake by S&T experts (2nd edition) (held in September 2011)

In addition to these policy-oriented problems, the survey also pointed out mentality of the scientists as an obstacle for interdisciplinary studies. For example,

- Since the practice (research method, presentation of the results, etc.) is far different between human and social sciences and natural sciences, such collaboration is not worth taking trouble to manage, and this fact discourages scientists from engaging in such cooperation.
- Because scientific research is further specialized in each field, scientists have no choice but to study only in their own research field, and are less interested in other disciplines.
- Scientists are already satisfied by the current situation, and do not feel the need to establish new collaboration.

It can be assumed that the mentality of the scientists themselves is partly responsible.

Furthermore, in that survey, the importance of the approaches in Table 1-2-20 is pointed out for the promotion of interdisciplinary study of various fields in Japan.

For example, the introduction of a system to support research collaboration between different fields would be effective for the promotion of interdisciplinary research. By introducing projects to support interdisciplinary collaboration between the different fields, and creating special programs to induce integrated research, it is considered necessary to create a "space" for collaboration and fusion, or construct such a mechanism. Knowledge gained through human and social sciences on human behavior and economic trends is indispensable to extract potential social issues. In the future, it will be necessary

to build a system, in which scientists of human and social sciences would play leading role in analyzing and suggesting social issues to overcome, and in that system, the collaboration of various fields including natural sciences and business community would be encouraged.

On the review process, the necessity to create a new indicator which could reflect the more diverse activity of scientists instead of the so-called "impact factor[1]" which is conventionally used in research evaluation, was also pointed out. 0In addition, the necessity for reforming budget system to encourage collaborative study based on that indicator was also pointed out.

In addition, to challenge such research, an excellent insight into society and broader and international view is necessary. To foster such scientists, universities and graduate school need to implement educational programs to both - natural and human and social sciences. High school level education, too, needs to give its students basic knowledge in both natural and social sciences.

Table 1-2-20 / Necessary Approaches for Promoting Interdisciplinary Research and Collaboration between Different Fields

(Structuring mechanisms for collaboration and fusion)
- Implementation of horizontal type national projects on a level exceeding ministries (Examples: research projects, counter-disaster measure research projects, etc.)
- Creation of a system or mechanism working in a top-down manner on all relevant stages: from identifying social issues, which need to be solved, up to specifying fields of research, where collaboration is required.
- Establishing programs or projects supporting collaborative or interdisciplinary study with clearly identified social issues, attractive to participating scientists and engineers.
- Mission-oriented research should be constructed of activities from basic research to practice, and implemented and evaluated by society as a consistent system. Moreover, attempts should be made to encourage local community and stakeholders to collaborate in such research.
- Establishing budget for special research expenses within the national budget to induce interdisciplinary or fusion research

(Reform of R&D system: research evaluation method and budget distribution)
- The Government should firmly establish new evaluation standards suitable for evaluating interdisciplinary and collaborative research focused on for solving problems.
- System evaluating contribution to solving a problems is required, instead of conventional evaluation methods, which use number of papers in the expert field or impact factor (too great a priority is given to theses) .
- Reviewing research plans based on initial and intermediate feedback of the project, post-evaluation of projects leading to new project proposal. (Conducting thorough PDCA Cycle)
- Interdisciplinary collaboration study is time-consuming. Since too much time is given to evaluating past projects, there is little time left to engage in new activities. Therefore, the evaluation system needs to be improved.
- In order to encourage scientists to participate in multidisciplinary research ,it is necessary to create a mechanism improving research evaluation and funds distribution, such as financial incentives.

(Development and use of human resources)
- Development of human resources having a wide perspective and broad horizons.
- Development of human resources able to coordinate interdisciplinary collaboration
- Development of leading scientists and engineers able to resolutely take on challenges aiming to solve difficult social issues (Utilization of young talented personnel with a bold and flexible world-view)
- Development of talented persons with international mentality through encouraging young people to study abroad (i.e. postgraduate programs)
- Preparing educational programs fusing various research fields of both natural sciences and human and social sciences on the undergraduate and postgraduate levels, long term development of talented personnel with a broad knowledge in both areas. (Examples: reviving, enhancement, establishment of liberal arts education, etc. in universities)
- Theory (class room education and experiments) and practice at the site (fieldwork)
- Securing personnel willing to gain knowledge in both liberal culture and sciences, securing jobs for personnel taking on challenges of interdisciplinary collaboration, and active recruitment of such personnel by public institutions and industrial circles.
- It is necessary to give education that will provide basic knowledge in both liberal and natural sciences at high school level.

Note: Same as Figure1-1-18.

Source: Created by MEXT based on the results of the National Institute of Science and Technology Policy "Survey regarding the Great East Japan Earthquake by S&T experts (2nd edition) (held in September 2011)

[1] Index expressing the impact of an academic Journal_

Column 1-9

Renewing Scientific Community's contract with Society: How should scientists fulfill their social responsibilities to society?

The Japanese government's 4th Science and Technology Basic Plan formulated in August 2011 marked a change in direction from the policy of previous plans promoting R&D by priority fields, to a new policy of promoting R&D directed at finding solutions to the various problems confronting Japan and humanity. Japan needs, especially after the great earthquake, a society that can minimize the damage resulting from natural disasters and accidents, recover quickly from such disasters, and maintain sustainable development that is in harmony with nature. The question for scientists living and working in this new world is how they should interact with and fulfill their responsibilities to society?

"Science is the exploration of truth in nature and as such has eternal cultural value. The technology that we gain from our scientific knowledge is the foundation of a civilized society. Creative innovation derived from outstanding science-based technology is what makes us internationally competitive and is an essential aspect of our international contribution to assuring the continued survival of humanity."

These were RIKEN President Ryoji Noyori's opening remark for his January 30, 2012 lecture at Meijo University titled, "Renewing the Academic Research Community's Contract with society." He continued, "Louis Pasteur said, 'Science has no boarders, but scientists have their homelands.' Japan's scientific infrastructure is the second best in the world, but it only ranks 27 in terms of overall competitiveness as a country (IMD World Competitiveness Yearbook, 2010). Japan's science and technology, and the higher education that supports its science and technology, are inner-directed and closed. Will Japan's contemporary science community be able to open itself up enough to cope with competitive trends similar to the Trans-Pacific Strategic Economic Partnership (TPP) or with binational Free Trade Agreements? We must face the reality and maintain a sense of crisis." He also pointed out to the assembled students and faculty that "Yukichi Fukuzawa, who played a major role in Japan's modernization and who fostered many talented leaders, once posed the question, 'What is the wisdom required by our times?' The relationship between science and society is defined by the times. Nevertheless, I feel there is a big gap between the values held by scientists and the needs of society. The whole of Japanese academia must rethink its responsibilities to society and must renew its contract with society in terms of those responsibilities.. Otherwise, neither the research community nor the universities will be able to attain a sound and healthy state of existence." Noyori added further "Academia sticks to conventional values. But while tradition is important, what our country and society need is innovative reform. We should actively strive to place outstanding young people, women and foreigners in leadership positions.. And we need to promote dialogue with the general public." Finally, Noyori concluded with the question, "Will future generations empathize with the values of contemporary academia and be grateful our activities?"

The essence of scientific activity is exploring the truth. Nothing changed in this regard. Scientists should devote themselves to deliving ever-deeper into science and making further advances in science and technology. However, contemporary scientists must also learn to communicate with society and to apply their highly developed expertise in various fields to tackling the many complicated issues confronting humanity. Scientists at universities and public research institutes, in particular, must keep in mind that their research activities and achievements are adequately meeting society's needs, and whether they are fulfilling the responsibilities of their contract with society.

As we have observed in this section, in order to encourage mission-oriented type STI for a robust and resilient society, it is indispensable to have a mechanism that can flexibly respond to social issues, which may vary from time to time due changes in social and economic situation, risks and crises. Therefore, it is insufficient to conduct R&D based on the outdated academic discipline. It will be necessary to provide a place for collaboration study of different fields, as well as renovation of review process of research and budget distribution, development of human resources who will take charge of collaborative research. A wide variety of policy approaches will be required.

At the same time, in order to improve scientists' attitude, every scientist is expected to make an effort to inform to public about their own research results, and scientists are expected to understand social needs through communication with society.

To overcome various social issues, it is necessary to improve "Society Literacy." And through appropriate indicator, the Japanese government must support scientists taking on challenges in new fields, interdisciplinary collaboration, to overcome various problems. Constructing a mechanism to support and encourage such scientists is needed.