TECHNICAL
REPORT

Science and Technology Research and Development Capacity in Japan

Observations from Leading U.S. Researchers and Scientists

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Summary

To become and remain competitive in the international arena of science and technology, nations and industries must determine how to distribute the resources available to support research and development across fields of study and how to create the institutional and social structures and incentives needed to support innovative work. To some extent, decisionmaking in this area involves international comparisons to gauge the standing of researchers, research institutions, and research achievements across nations.

Purpose of This report

This report characterizes science and technology research and development capacity in Japan from the perspective of researchers and scientists in the United States. RAND was asked by the Mitsubishi Research Institute (MRI) of Japan to interview 50 leading researchers in the United States across 25 scientific fields in life science, environmental science, information and communication technology, and nanotechnology and materials science.

The results of this report are intended to help MRI prepare a report to the Japanese Council for Science and Technology Policy (CSTP). CSTP, a component of the Office of the Prime Minister of Japan, is responsible for shaping science and technology policy in Japan. Results of the MRI report will help CSTP formulate its "Basic Science and Technology Plan for 2006–2010."

Methods

MRI, in consultation with CSTP, defined the 25 fields and placed them in four major categories, as shown in Table S.1. These fields and categories were chosen because they are priorities in the current science and technology basic plan of Japan (2001–2005) and the Japanese government has the explicit goal of improving Japanese world standing in these fields.[1] Findings from this study will influence which priority fields are selected for the next basic science and technology plan (2006–2010). We recognize that the selected fields and categories do not represent a definitive taxonomy of all scientific research and they are not exclusive

[1] Visit the Council for Science and Technology Policy website for an unofficial English translation of the second plan at http://www8.cao.go.jp/cstp/english/basicplan01-05.pdf.

Table S.1
Categories and Fields Included in Survey

Life Science	Environmental Science	Information and Communication Technology	Nanotechnology and Materials Science
Agricultural science	Environment/ecology	Computer science—basic	Chemical—basic
Biology and biochemistry	Energy engineering	Computer science—applied	Chemical—applied
Clinical medicine	Geoscience	Electrical and electronics engineering	Materials science—metals
Immunology		Mechanical engineering	Materials science—polymers
Microbiology		Mathematics	Materials science—ceramics
Molecular biology and genetics			Materials science—semiconductors
Neuroscience and behavior			Physics—basic
Pharmacology and toxicology			Physics—applied
Plant and animal science			

of one another. The boundaries of science and technology fields are always fuzzy, and increasingly so as research becomes more interdisciplinary.

MRI and CSTP also asked RAND to conduct only two interviews for each field. We recognize that the viewpoints of two researchers provide only a limited perspective on an entire field or even on more specific research areas. Nevertheless, within each of the four major categories, these interviews provide sufficient information to highlight important issues relevant to the quality, structure, dynamics, and visibility of the Japanese scientific enterprise.

RAND was asked by MRI and CSTP to focus on four topics that would be presented as open-ended questions in our interviews:

- important and interesting accomplishments of Japanese institutions observed by respondents in their field of expertise
- evaluation of the level of research conducted at Japanese institutions in the respondent's field of expertise, with a particular emphasis on Japan's performance compared to that of other countries considered the best in the field
- evaluation of the performance of Japanese institutions over time
- examples that show Japan as an important research player in the respondent's field of expertise.

We identified interviewees through a five-step process designed to create a pool of respondents who were, themselves, top-flight researchers and scientists. The main criteria used were the number and amount of federal research grants potential respondents had received in FY1998 through FY2002, major scientific merit awards they had received in the same period, and number of publications and citations to their publications. In addition, we asked for nominations by experts and also received recommendations from the researchers we contacted.

In contacting researchers and scientists for interviews, RAND-approved human subject protection protocols were used. The overwhelming majority of our respondents (50 out of 52) were university researchers and scientists; only two were from industry, and the comments we collected focused heavily on research at Japanese universities. Respondents did not find the distinction between basic and applied research helpful in defining their work. These distinctions, specifically for computer science, chemistry, and physics, were defined for the project by MRI and CSTP in the 25 fields selected. Respondents reported that researchers and scientists rarely do only pure basic or applied research and that the lines further blur as interdisciplinary research increases.

Finally, we also gave respondents an opportunity to provide additional comments that they felt were pertinent to considerations about science and technology research and development capacity in Japan but were not covered by the four interview questions.

Major Findings by Topic, Category, and Field

Responses to the four interview questions are organized in this summary by the main topic, category, and field. Additional comments from respondents that tie to the four topics addressed in the interview questions are incorporated here also.

On the whole, Japan was seen to be on par with the United States in many specific research areas within fields of study and leading the world in some areas. Japan was also perceived to excel, in particular, in areas closely associated with problems significant to health and safety in Japan or closely tied to Japan's industrial competitiveness and policy priorities. Japanese research was regarded as solid and high-quality and Japanese researchers and scientists as committed and careful in their work. However, respondents observed a lack of depth in Japanese science and technology research and development capacity and a shortage of original and high-risk research. The best Japanese research was frequently regarded as comparable to the best in the world, but the disparity between the best and the rest within Japan was seen as a hindrance to improving Japan's competitive position in global science and technology.

Accomplishments of Japanese Scientific Institutions

Respondents were asked to comment on important accomplishments observed in their field of expertise in the past 5 to 10 years. With rare exceptions, respondents spoke about Japanese capacity within a specific research area within a field. In most cases, Japan was considered on par with the United States and Europe.

Japan was seen as an important actor in life science, in general, and was described as having made significant contributions in many research areas. However, respondents did not think that Japan had produced groundbreaking discoveries. Japanese research was considered solid, but not exceptional. Japanese efforts in environmental science were regarded as consistently good and much advancement in capacity was observed in recent years. Respondents thought highly of Japanese applied research and said that Japan was making important scientific contributions. Japanese scientists in information and communication technology (ICT) were seen as doing solid, high-quality research and making important contributions in a wide range of areas, but Japanese research on the whole was not characterized as groundbreaking. Japanese research in nanotechnology and materials science was seen to be of consistently high quality and to excel in many fields, including world leadership in some areas. However, the lack of depth in capacity in general was observed as well.

Quality of Japanese Research

Respondents were asked to compare the quality of research in Japan with that of the best countries in their fields. Japan's best research in life science compared favorably with that in the United States and Europe but, taken as a whole, Japan's published research was seen to be more limited in scope and volume. Japan's best research in agricultural science, microbiology, neuroscience and behavior studies, and plant and animal research was regarded as on par with that in the United States and Europe. One respondent thought that Japan was equal to the United States in biology and biochemistry; the other thought that Japan was behind the United States. The same opposite views were reported for molecular genetics. One respondent thought that Japan was ahead of the United States in pharmacology and toxicology; the other thought that Japan was on par with the United States. One respondent thought that Japanese capacity in clinical medicine had slipped over time.

Japan was viewed as still lagging behind the leading countries in environmental science but improvements were observed in fundamental research, in particular. However, the scope of research and truly original work were more restricted than in leading countries such as the United States. Japan was regarded as on par or ahead of the United States in energy engineering (both respondents spoke about hybrid automotive engines). Significant improvement was noted in ecology, although Japan is still thought to be behind the United States. In geoscience, the Earth Simulator was regarded as a major achievement, putting Japan on par with the United States.

Japan was seen as a leader in several research areas in ICT. Japanese ability to insert technology into products was underscored as a significant strength, but fundamental research capacity and high-risk research were both lacking. Japan was seen as on par with the United States in computer science and electrical and electronics engineering, and ahead of the United States in mechanical engineering (where construction research is concerned). However, Japan was seen as being behind the United States in math. More important, Japanese capacity in math was seen to have declined over time.

Japan was seen as on par with the United States and Europe in most areas of nanotechnology and materials science. The clearest example of Japanese success and world leadership is in carbon nanotube development, which was cited by several respondents. Other areas of world leadership were high-energy physics and high-pressure physics. Improvement was observed in metals research and Japan was seen as being on equal footing with the United States in chemistry and semiconductors research. Only in polymers research and physical chemistry was Japan regarded as being behind the United States.

Longitudinal Trends in Performance of Japanese Scientific Institutions

Respondents reported slow and steady growth in capabilities in life science, including agricultural science and pharmacology and toxicology, but they also saw decline in a few areas such as biology and biochemistry and clinical medicine. Overall improvement was also observed in environmental science. Respondents saw innovation and a good balance between basic and applied research. In ICT, greater progress was observed in academia than in industry and world leadership was emerging in some areas, but poor physical infrastructure was still noted as a significant problem. In nanotechnology and materials science, there was overall improvement across the fields covered and dramatic improvement in some such as neutrino physics, in which Japan was observed to have come from behind to become the world leader in 15 years. Also, greater progress was reported in universities than in industry or the national laboratories.

Importance of Japanese Research Institutions in the International Arena

The general opinion was that Japan is an important actor in life science, environmental science, and ICT, but not in the same league as the United States and Europe. Japan has shown itself able to produce high-quality and sometimes innovative scientific research. However, Japanese research has not become more innovative on the whole and capacity has not grown in breadth or depth. So, although the top Japanese researchers do world-class research, Japan is not quite a world leader yet. Respondents also saw institutional and cultural barriers as hindrances to more high-risk research, which have potentially bigger payoffs for Japan if it aims to become a world leader in science. In nanotechnology and materials science, Japan's excellence was seen primarily in the applied areas. Japan's lesser strength in basic research was a main reason for the view that Japan does not represent a major actor in the international arena.