This product is part of the RAND Corporation technical report series. Reports may include research findings on a specific topic that is limited in scope; present discussions of the methodology employed in research; provide literature reviews, survey instruments, modeling exercises, guidelines for practitioners and research professionals, and supporting documentation; or deliver preliminary findings. All RAND reports undergo rigorous peer review to ensure that they meet high standards for research quality and objectivity.

TECHNICAL
REPORT

Japanese Science and Technology Capacity

Expert Opinions and Recommendations

Anny Wong, Douglas Yeung, Silvia Montoya,
Sarah Olmstead, Aviva Litovitz, Lisa Klautzer,
Sarah Kups, Alison Raab Labonte

Sponsored by the Mitsubishi Research Institute

RAND

Transportation, Space, and Technology

A RAND INFRASTRUCTURE, SAFETY, AND ENVIRONMENT PROGRAM

This research was sponsored by the Mitsubishi Research Institute (MRI) of Japan and was conducted under the auspices of the Transportation, Space, and Technology (TST) Program within RAND Infrastructure, Safety, and Environment (ISE).

Published 2010 by the RAND Corporation
1776 Main Street, P.O. Box 2138, Santa Monica, CA 90407-2138
1200 South Hayes Street, Arlington, VA 22202-5050
4570 Fifth Avenue, Suite 600, Pittsburgh, PA 15213-2665
RAND URL: http://www.rand.org
To order RAND documents or to obtain additional information, contact
Distribution Services: Telephone: (310) 451-7002;
Fax: (310) 451-6915; Email: order@rand.org

Preface

This RAND Corporation technical report summarizes the views of 55 leading researchers in the United States, the European Union, Switzerland, and Russia regarding the competitiveness of Japanese research in 25 fields in the life sciences, environmental science, information and communication technology, and nanotechnology and materials science. Their responses cover several topics, including how the quality of research in Japan in these fields ranks against the world's leaders, strengths and weaknesses in the Japanese research and education system, and suggestions of approaches, models, and mechanisms to increase excellence in Japanese research in these 25 fields and in expanding Japan's science and technology capacity in general.

This research was conducted for the Mitsubishi Research Institute (MRI) of Japan to provide data and analysis toward the preparation of a report by MRI for the government of Japan in its current efforts to develop the next basic plan for science and technology for 2011 to 2015. MRI asked RAND to conduct interviews with leading scientists in the United States, the European Union, and Switzerland to address these issues. This is the second time RAND is providing research support to MRI and the government of Japan toward the formulation of its basic plan for science and technology. In 2004, RAND completed a study with a similar focus and approach (Wong et al., 2004). Those interested in the social and structural analysis of science, as well as individuals interested in developments in science and technology in Japan, may find this report of interest.

The RAND Transportation, Space, and Technology Program

This research was conducted under the auspices of the Transportation, Space, and Technology (TST) Program within RAND Infrastructure, Safety, and Environment (ISE). ISE's mission is to improve the development, operation, use, and protection of society's essential physical assets and natural resources and to enhance the related social assets of safety and security of individuals in transit and in their workplaces and communities. The TST research portfolio encompasses policy areas including transportation systems, space exploration, information and telecommunication technologies, nano- and biotechnologies, and other aspects of science and technology policy.

Questions or comments about this report should be sent to the project leader, Anny Wong (Anny_Wong@rand.org). Information about the Transportation, Space, and Technology Program is available online (http://www.rand.org/ise/tech). Inquiries about TST research should be sent to the following address:

Martin Wachs, Director
Transportation, Space, and Technology Program, ISE
RAND Corporation
1776 Main Street
P.O. Box 2138
Santa Monica, CA 90401-2138
310-393-0411, x7720
Martin_Wachs@rand.org

Contents

Preface iii
Tables vii
Summary ix
Acknowledgments xv
Abbreviations xvii

CHAPTER ONE
Introduction 1
Objective of the Study 1
Study Method 2
Characterizing Our Respondents 6
Caveats on Data and Analysis 8

CHAPTER TWO
Summary of Expert Responses 9
Sources of Information 9
Competitiveness of Japanese Research 10
Life Sciences 10
Environmental Science 12
Information and Communication Technology 13
Nanotechnology and Materials Science 14
Quality of Human Capital and Training, Research Organization and Management, Infrastructure, and National Policy 15
Human Capital and Training 15
Organization and Research Management 16
Research Infrastructure 16
National Policy to Promote Science and Technology 17
Major Strengths in Japanese Research 17
Top Scientists Are Well Funded 17
Japan Has Good Research Infrastructure 18
Japanese Researchers Are Hardworking and Meticulous 18
Japan Excels in Developing Technologies and Equipment-Driven Research 18
Major Hindrances to Greater Excellence 18
Low Proficiency in English 18
Cultural Barriers and Rigid Hierarchical Structure 19
Low Value Given to Fundamental Research 19

Absence of Women in Research ... 20
Japan Is Invisible and Insular ... 20
Recommendations from the Experts ... 21
Increase Proficiency in English ... 21
Emphasize Merit Above All Else ... 21
Further Open Japan to the International Scientific Community ... 22
Increase Outflow of Japanese Students and Researchers ... 22
Emphasize Critical and Independent Thinking in Japan's Secondary and Tertiary Education Systems ... 22
Continue to Fund Research, Including More Support for International R&D, and to Improve Research Facilities and Workplace Quality ... 23

CHAPTER THREE
Conclusions ... 25

APPENDIXES
A. Questionnaire for Interviews with Experts ... 27
B. Summaries of Individual Interviews ... 29

References ... 125

Tables

S.1. Categories and Fields ... x
S.2. Number of Respondents, by Key Attributes ... xi
1.1. Categories and Fields ... 2
1.2. Number of Respondents, by Key Attributes ... 6

Summary

The Japanese government places great emphasis on ensuring the country's vitality in science and technology (S&T) and remaining at the forefront of global science. It is in this spirit that Japan uses its five-year basic S&T plans, the first of which was introduced in 1996, to guide research and development (R&D) promotion (see Government of Japan, 2006).

This RAND report documents input and recommendations we received from 55 top researchers on their perceptions of the current state of Japanese S&T and priorities for improvement.

Study Objective

The current basic S&T plan—the third one—will run through 2010, and efforts are under way to develop the next basic S&T plan for 2011 to 2015. The Mitsubishi Research Institute (MRI) of Japan, which is providing research support to the Council for Science and Technology Policy (CSTP), an advisory body in the Office of the Prime Minister of Japan, in the formulation of the 2011–2015 basic S&T plan, asked the RAND Corporation to interview 50 top researchers in the United States, the European Union (EU), and Switzerland to learn from their perspective how well Japan performs in their fields and areas of research and to solicit their thoughts on what is essential to promote excellence and innovation in scientific research. The expert responses and recommendations collected would feed into analysis by MRI for the government of Japan in developing the fourth basic S&T plan, for 2011 to 2015.[1]

Study Method

Since the objective and scope of this study is the same as the 2004 RAND study for MRI, we employed the same study method used for the 2004 study. It is important to reiterate that the objective of this research is to collect qualitative feedback from U.S.- and European-based experts and to produce a summary of their responses in a final report. As such, we do not have

[1] This is the second time MRI asked RAND to provide research support toward the formulation of Japan's basic S&T plan. In 2004, RAND completed a study with the same objective and with a similar focus and approach (Wong et al., 2004). The main difference between the 2004 study and this one is that, for the former, we were directed only to interview experts based in the United States. A second difference is our inclusion of high-performing junior researchers in this 2008 study. More details on this are in the "Study Method" section.

the mandate or the time and resources to review literature on the current state of Japanese S&T or to produce a final report with anything beyond what we were tasked to do.

Our research began with the identification of experts in the designated 25 scientific fields under the four categories of life sciences, environmental science, information and communication technology (ICT), and nanotechnology and materials science (see Table S.1). These four categories and the 25 fields under them were the same as in the 2004 RAND study and provided to us by our research sponsor.

To identify and select experts for interviews, we utilized a combination of methods to draw on the strengths and mitigate the weaknesses of each to determine a researcher's prominence in his or her field. The results of searches using one method (e.g., searching databases on scientific publications and citations) were checked against the results of searches using another method (e.g., identifying recipients of major merit awards). We also cross-checked researchers recommended to us by respondents or colleagues to ascertain their professional achievements before we added them to our list of candidate respondents. In all, we identified more than 200 experts across the 25 fields.

For this study, our respondents included junior scientists who are "rising stars" in their own fields. The decision to include such junior scientists was made in consultation with our sponsor. By *rising stars*, we mean those younger and high-performing researchers who work at the cutting edge of their fields. We thought that the perspectives and experience of rising stars may well complement those of senior, more-established researchers who represent the more-conventional definition of *top expert*. With increased Japanese government efforts to expand opportunities for young international researchers to work in Japan under its current and previ-

Table S.1
Categories and Fields

Category	Field
Life sciences	Agricultural science Biology and biochemistry Clinical medicine Immunology Microbiology Molecular biology and genetics Neuroscience and behavior Pharmacology and toxicology Plant and animal science
Environmental science	Environment/ecology Energy engineering Geoscience
ICT	Computer science, basic Computer science, applied Electrical and electronics engineering Mechanical engineering Mathematics
Nanotechnology and materials science	Chemical, basic Chemical, applied Materials science, metals Materials science, polymers Materials science, ceramics Materials science, semiconductors Physics, basic Physics, applied

ous basic S&T plans, rising stars could inform us of their experience in Japan or their reasons for choosing (or not choosing) to work in Japan.

In the end, 55 experts out of nearly 100 contacted spoke with us. We gave priority to contacting those with the highest professional qualifications (e.g., top scientific prize winners and those regarded as the most influential in their fields) for interviews. We also tried to collect data from experts in each of the 25 fields. Since participation was strictly voluntary and research had to be completed within a time frame and with the resources available, we could not have, say, one expert each from the United States or Europe for each of the 25 fields or have one expert each who is male or female for each of the 25 fields. All interviews were conducted via telephone, and all the information we received was treated as confidential. Table S.2 shows the number of respondents for each field and some attributes of our respondents.

First, in terms of the number of respondents for each category, the largest number is in the life sciences, followed by nanotechnology and materials science, environmental science, and ICT. By location, 19 of our 55 respondents are U.S.-based, 24 are EU-based, and one each is in Switzerland and Russia. By category, an even number of respondents in the life sciences and ICT are based in the United States and Europe, while, in the environmental science and nanotechnology and materials science categories, the number of European-based respondents significantly outnumbers the U.S.-based ones. (Although our sponsor did not name Russia as

Table S.2
Number of Respondents, by Key Attributes

Category/Field (number of respondents)	Location	Career Point	Gender	Professional Experience in Japan or with Japanese Research
Life sciences (18)	U.S. (9)	Senior (14)	Male (12)	Low (7)
Agricultural science (3)	EU (9)	Junior (4)	Female (6)	Moderate (6)
Biology and biochemistry (4)				High (5)
Clinical medicine (1)				
Immunology (1)				
Microbiology (1)				
Molecular biology and genetics (1)				
Neuroscience and behavior (3)				
Pharmacology and toxicology (1)				
Plant and animal science (3)				
Environmental science (11)	U.S. (2)	Senior (8)	Male (9)	Low (8)
Environment/ecology (6)	EU (8)	Junior (3)	Female (2)	Moderate (2)
Energy engineering (2)	Switzerland (1)			High (1)
Geoscience (3)				
ICT (10)	U.S. (5)	Senior (7)	Male (8)	Low (6)
Computer science, basic (0)	EU (5)	Junior (3)	Female (2)	Moderate (3)
Computer science, applied (4)				High (1)
Electrical and electronics engineering (2)				
Mechanical engineering (1)				
Mathematics (3)				
Nanotechnology and materials science (16)	U.S. (3)	Senior (13)	Male (15)	Low (7)
Chemical, basic (2)	EU (12)	Junior (3)	Female (1)	Moderate (3)
Chemical, applied (2)	Russia (1)			High (6)
Materials science, metals (3)				
Materials science, polymers (1)				
Materials science, ceramics (0)				
Materials science, semiconductors (2)				
Physics, basic (3)				
Physics, applied (3)				

a location, our effort to identify top experts pointed to a few Russia-based scientists, and one accepted our request for interview.)

By career point, 42 senior and 13 junior researchers spoke with us. Among the senior researchers, 14 are in the life sciences, eight in environmental science, seven in ICT, and 13 in nanotechnology and materials science. For the junior researchers, their numbers for these categories are four, three, three, and three, respectively. Further, by career point and location, senior European-based researchers are the largest subgroup, followed by senior U.S.-based researchers (15), junior European-based researchers (nine), and junior U.S.-based researchers (four).

In terms of gender alone, there were 44 male and 11 female respondents. Female researchers made up half of all respondents in the life sciences, but they were in far smaller numbers in the other three categories. Combining gender and career point, senior male researchers lead (37), followed by junior male (seven), junior female (six), and senior female (five) researchers.

As for their level of professional experience in Japan or with Japanese research, we designated 28 respondents as low, 14 as moderate, and 13 as high. The greatest number and share of respondents with high designations are found in the life sciences and nanotechnology and materials science. These designations are based on a combination of respondent self-assessment and the content of their responses. *Low* means that one has had little or no current or prior collaborations with Japanese researchers and institutions, few or no visits to Japan, and minimal awareness of Japanese research in their research areas. *Moderate* means that one has had had some prior collaborations with Japanese researchers or institutions, some visits to Japan and interactions with Japanese researchers at professional forums in Japan or elsewhere, and some awareness of Japanese research in their research areas. *High* means that one has had or has current or recent collaborations with Japanese researchers or institutions; multiple visits to Japan; experience teaching, doing research, or participating in advisory panels in Japan; and in-depth awareness of Japanese research in their research areas.

Finally, all questions in our telephone interviews were open-ended, and respondents could choose to answer all or none of them as they pleased. Our questions focus on these areas provided by MRI and CSTP:

- competitiveness of Japanese S&T institutions, especially how Japan compares with other scientifically advanced nations
- important scientific research accomplishments in Japan, with a particular focus on the past five years
- quality of Japanese science education
- ideas for Japan or lessons learned from experience on how to increase excellence in national S&T capacity.

Expert Responses and Recommendations

Considering the small sample size and that the expert comments we received are subjective and may be more reflective of individual experiences, observations, and impressions than any collective truth about Japan or Japanese S&T, we appreciate the need for caution in interpreting their responses. We recognize that other research and data (e.g., citations and patent data) can provide a useful context to interpret the responses we collected. However, it is not within the scope of this study to assess the validity of the viewpoints or the appropriateness of the recommendations provided by our respondents.

Overall, 22 of our 55 respondents reported that Japan is at the forefront, among the top five leaders, or has demonstrated significant improvement in their specific research areas. Another dozen reported that Japan is doing very well, produces high-quality research, or is among the ten leaders in the world. This compares well with the responses received in our 2004 study. Similarly, though, respondents frequently qualified their assessments that Japan's excellence is in technology development, applied research, or areas in which expensive equipment is required rather than in theoretical or fundamental research.

Consistent with a major observation from experts interviewed for the 2004 study, too, is the widespread view that significant institutional and cultural problems hinder excellence in Japanese S&T. More than two-thirds of our respondents across all fields and other attributes made comments to this effect. Also, despite observations of improved performance (e.g., more Japanese research articles published in major international academic journals, more substantive Japanese participation in international conferences and seminars, more opportunities for international researchers in Japan, and positive changes, such as special grants for young scientists and less hierarchical environments at places like RIKEN), our respondents generally emphasized that Japan has to do more and hasten the speed of change. In this regard, about one-quarter of all respondents highlighted, in particular, their perception of rapid improvements in S&T in China and India overall or within their own fields, and several commented that Chinese and Indian researchers were more independent and bold in their approach to research than Japanese researchers. These traits, in their view, will help to propel Chinese and Indian researchers to the forefront of global science.

Also, our respondents did not generally characterize Japanese research as creative or innovative, even though it was invariably described as good or on par with the top one, two, or three leaders in the world. About one-fifth of the respondents attributed their perception of lack of creativity and critical thinking in Japanese research to rigidities in Japanese culture.

On research funding in Japan, respondents in general perceived Japan to provide a high level of R&D support. Their criticisms lie in how the funds are allocated. About half a dozen respondents explicitly criticized the bias in funding for older, established researchers, and about half spoke of a need to move away from top-down–driven funding in R&D and the need for merit-based awards and urged special grants to support young researchers.

Finally, more than half of our respondents saw the general absence of female researchers in Japan and low proficiency in English and communication skills as serious weaknesses in any effort to improve Japan's S&T performance.

Feedback from our 55 respondents does not appear to differ by location or career points. As for gender, both male and female respondents across all fields, locations, and career points spoke of the need to expand opportunities for female and junior researchers in Japan. Generally, those respondents identified as having a high level of experience in Japan or with Japanese research have a more positive opinion of Japanese research (e.g., lauding the achievements of a particular Japanese research team or noting the success of special programs that target young researchers). Yet, they were no less critical of perceived shortcomings and weaknesses in the Japanese S&T institutions and communities.

Recommendations from our respondents focused on six points (presented by frequency with which they were mentioned and not in order of sequence or hierarchy). They are consistent with those recommended by the experts we interviewed for our 2004 study.

1. Prioritize proficiency in oral and written English to improve communication and interactions with the international scientific community at meetings, submissions to academic journals, in online dialogues, and the like.
2. Emphasize merit in research funding, promotion, hiring, and all else to mitigate social and institutional barriers that permeate research organizations and management bodies in Japan.
3. Increase the number of short-term visits by international scientists (e.g., to attend conferences and through fixed-term fellowships in Japan), and fully integrate foreign students, faculty, and researchers into the Japanese system.
4. Increase the number of students, faculty, and researchers Japan sends overseas for education, exchanges, and short-term stays (e.g., one- to two-year postdoctoral fellowships and yearlong sabbaticals).
5. Emphasize critical, independent thinking skills in Japan's secondary and tertiary education systems.
6. Continue to fund research, including more support for international R&D, and to improve research facilities and workplace quality.

Acknowledgments

We are grateful to MRI and the National Institute of Science and Technology Policy of Japan's Ministry of Education, Culture, Sports, Science and Technology (MEXT) for this opportunity to provide research support to the Japanese government in its formulation of its next national basic science and technology plan.

We also thank the 55 experts who accepted our request for input. Their experiences and insights, gained from years to decades of work in scientific research, are the foundation for the thoughtful comments they shared with us.

Abbreviations

AIST	National Institute of Advanced Industrial Science and Technology
ATR	Advanced Telecommunications Research Institute International
CERN	European Organization for Nuclear Research
CSTP	Council for Science and Technology Policy
DFG	Deutsche Forschungsgemeinschaft
DNA	deoxyribonucleic acid
DOE	U.S. Department of Energy
ERC	European Research Council
EU	European Union
ICT	information and communication technology
JAIST	Japan Advanced Institute of Science and Technology
JAMSTEC	Japan Agency for Marine-Earth Science and Technology
JSPS	Japan Society for the Promotion of Science
MEXT	Ministry of Education, Culture, Sports, Science and Technology
MRI	Mitsubishi Research Institute
NASA	National Aeronautics and Space Administration
NIH	National Institutes of Health
NII	National Institute of Informatics
NIMS	National Institute for Materials Science
NSF	National Science Foundation
NTT	Nippon Telegraph and Telephone
PISA	Programme for International Student Assessment
R&D	research and development

S&T	science and technology
TIMSS-R	Third International Mathematics and Science Study—Repeat
WPI	World Premier International Research Center

CHAPTER ONE

Introduction

Japan introduced its first five-year basic science and technology (S&T) plan (1996–2000) in 1996. The second basic plan (2001–2005) and the third basic plan (2006–2010) (Government of Japan, 2006) followed, and preparations are now under way to formulate the fourth basic plan (2011–2015). These basic plans support Japanese government efforts to promote research and development (R&D) activities—specifically, according to the Japanese government, to meet social and economic needs, create intellectual assets for Japan, enable Japan to contribute to global science and international development, and define measures necessary to achieve these goals.

The Japanese government places great emphasis on ensuring the country's vitality in S&T and on remaining at the forefront of global science. It is in this spirit that the Japanese government uses its basic S&T plans to guide R&D promotion.

Objective of the Study

The Mitsubishi Research Institute (MRI) of Japan, which is providing research support to the Japanese government in the formulation of the next basic S&T plan, asked the RAND Corporation to interview 50 top researchers across 25 scientific fields in the life sciences, environmental science, information and communication technology (ICT), and nanotechnology and materials science in the United States, the European Union (EU), and Switzerland. Our task is to collect their personal assessments of how well Japan performs in their fields and areas of research, including major R&D accomplishments; strengths and weaknesses of Japanese research institutions; quality of students, young scientists, and researchers in Japan; and to solicit interviewees' input on what is essential to promote excellence and innovation in scientific research.

The expert responses and recommendations collected would feed into analysis by MRI for the government of Japan, specifically the Council for Science and Technology Policy (CSTP), to formulate the fourth basic S&T plan.[1] CSTP, located in the Office of the Prime Minister of Japan, is responsible for shaping S&T policy in Japan.

[1] This is the second time MRI asked RAND to provide research support toward the formulation of Japan's basic S&T plan. In 2004, RAND completed a study for MRI with the same objective and focus and similar approach (Wong et al., 2004). The main difference between the 2004 study and this one is that, for the former, we were directed only to interview experts based in the United States. A second difference is our inclusion of high-performing junior researchers in this 2008 study. More details on this are in the "Study Method" section.

Study Method

MRI, in consultation with CSTP, defined the 25 fields and placed them in the four major categories shown in Table 1.1. These fields and categories were chosen because they are priorities in the current S&T basic plan of Japan (2006–2010) and because the Japanese government has the explicit goal of improving Japan's world standing in these fields. (We recognize that these fields and categories do not necessarily represent a definitive taxonomy of all scientific research. Nor are they exclusionary of one another, because the boundaries of S&T fields are always fuzzy and are becoming increasingly so as research becomes more interdisciplinary.)

Since the objective and scope of this study is the same as the 2004 RAND study for MRI, we employed the same study method used for the 2004 project. It is important to reiterate that the objective of this research is to collect qualitative feedback from U.S.- and European-based experts and to produce a summary of their responses in a final report. As such, we do not have the mandate or the time and resources to review literature on the current state of Japanese S&T or to produce a final report with anything beyond what we were tasked to do.

Participation in the interviews was strictly voluntary. Respondents were asked open-ended questions that focused on four topics chosen by MRI and CSTP:[2]

- competitiveness of Japanese S&T institutions, especially how Japan compares with other scientifically advanced nations

Table 1.1
Categories and Fields

Category	Field
Life sciences	Agricultural science Biology and biochemistry Clinical medicine Immunology Microbiology Molecular biology and genetics Neuroscience and behavior Pharmacology and toxicology Plant and animal science
Environmental science	Environment/ecology Energy engineering Geoscience
ICT	Computer science, basic Computer science, applied Electrical and electronics engineering Mechanical engineering Mathematics
Nanotechnology and materials science	Chemical, basic Chemical, applied Materials science, metals Materials science, polymers Materials science, ceramics Materials science, semiconductors Physics, basic Physics, applied

[2] Appendix A shows the semistructured questionnaire we used to guide our interviews.

- important scientific research accomplishments in Japan, with a particular focus on the past five years
- quality of Japanese science education
- ideas for Japan or lessons learned from experience on how to increase excellence in national S&T capacity (e.g., other institutional models or national mechanisms that are perceived as most successful to foster excellent research so that extensive experience with the Japanese system was not a requirement for identifying leading researchers).

All information received is treated with confidentiality. Respondents had the prerogative to answer any or none of the questions as they pleased. They could also provide comments on other matters or issues that they believed were pertinent to S&T capacity building in general and for Japan in particular.

For this study, our respondents included junior scientists who are "rising stars" in their own fields. The decision to include such junior scientists was made in consultation with our sponsor. By *rising stars*, we mean those younger and high-performing researchers who work at the cutting edge of their fields. We thought that the perspectives and experience of rising stars could complement those of senior, more-established researchers who represent the more-conventional definition of *top expert*. With increased Japanese government efforts to expand opportunities for young international researchers to work in Japan under its current and previous basic S&T plans, rising stars could inform us of their experience in Japan or their reasons for choosing (or not choosing) to work in Japan.

We identified respondents using a combination of methods because each method has strengths and limitations and affords us different metrics to gauge a researcher's prominence in his or her field. The results of searches using one method were checked against the results of searches using one or several other methods to ascertain whether an individual researcher would meet our definition of *expert*. Alternatively, the results of searches using one method might be used to generate searches using another tool or method. In general, each potential respondent must be considered a highly influential scientist by more than one method.

First, we made use of databases on scientific publications and citations. Specifically, we used two ISI Web of Knowledge databases: the Science Citation Index and the Journal Citation Reports. Results generated by searches in these two databases were then compared against individuals identified through other methods described to ascertain their expert status.

In utilizing the Science Citation Index, the main search criteria were number of publications and citations. The results show how often, in what journal, and by whom a scholarly article is published or cited. The citation criterion suggests whether a researcher has published influential research. Quality outweighs quantity in determining whether particular researchers should be regarded as leaders or experts in their fields or subfields.

The Journal Citation Reports differ from the Science Citation Index in that they rank journals by field, number of citations, and other factors, including timeliness of the research, editorial content, and international diversity of authors. This allowed the RAND team to gauge the impact of particular research publications, as well as the extent to which publications are the results of collaborations involving individuals from different institutions and countries.

For the purpose of this research, we narrowed our search to researchers who are *based* in the United States, Canada, EU, and Switzerland. It is the location of their institutional affiliation that interests us, not their country of birth, ethnicity, or citizenship, because that is where the system of S&T best practices occurs. In searching for agricultural-science experts, for example, we used the keywords "agriculture" and "agricultural science," then filtered the results by subject areas defined by Web of Knowledge. These subject areas for agricultural-science experts were "agriculture," "multidisciplinary," "agronomy," "food science and technology," and "agricultural engineering." Then the results were sorted by country, to produce a total of 3,010 articles in agriculture. We further refined our sorting by criteria that included "the most-cited authors" and "the most-published authors" based on information provided in the citation databases. Journals in which these most-cited authors and most-published authors are named were compared with the elite, top-tier journals in this field. The most-elite, top-tier journals for agricultural research in 2007 were the *Journal of Agricultural and Food Chemistry* and *Agriculture Ecosystems and Environment*. The same method was repeated for other research areas, producing several hundred names in total as potential candidates for our interviews.

Second, we identified researchers by going directly to particular elite, top-tier general and field-specific scientific journals (e.g., *Nature*, *Science*, *Physical Review Letters*). General ones, such as *Nature* and *Science*, are widely known, while expertise within the RAND research team guided selection of field-specific ones.[3] We used names of researchers who have published in these elite, top-tier journals to generate additional searches using the Science Citation Index and the Journal Citation Reports with the method just described and cross-checked them against the initial list generated.

We did this because a major weakness of the two ISI Web of Knowledge databases is that they do not discriminate well between scientists with similar names—that is, a search may identify not only the works of the intended scientist but also those belonging to other scientists with similar names. Another weakness is that the frequency with which a paper is cited is not a true indication of its quality. A paper might be cited many times over because it is used to illustrate what is not done right in research, for example. Also, when publications have multiple authors—and they frequently do—citation databases do not tell us the level or quality of contribution made by a particular author. Thus, we use authorship in these top-tier journals as a means to refine our search for researchers responsible for the most-influential or -innovative work.

Third, in addition to citations, we used major merit awards as another way to identify and refine our search for top researchers. By *major merit awards*, we mean those that are intended to honor the professional stature or contributions of their recipients, and they may or may not include monetary grants for research. We also consider induction into prestigious bodies, such as membership in the National Academy of Sciences or the Royal Society, as a type of major merit award. We believe that to be selected to receive a major merit award is a clear reflection of professional success in the eyes of one's peers. Some major merit awards honor cumulative accomplishments or general reputation; some are more specific to a field or type of accomplishment. Since awards often honor a career body of work, we do not impose a five-year time frame on them. These awards include the Comstock Prize in Physics, the David Adler Lectureship Award in the Field of Materials Physics, the J. J. Sakurai Prize for Theoretical Particle Physics, and the Wolf Foundation Prize in Physics, as well other awards given by the Alexander von Humboldt Foundation, the Association for Computing Machinery, the Centre National de la Recherche Scientifique, the International Mathematical Union, and the Royal Swedish Academy of Sciences. For junior researchers, we focused on field-specific awards (e.g., the Beckman

[3] Several members of the RAND research team had completed undergraduate and graduate training in fields under the four major categories.

Young Investigators Program) and those that target outstanding young scientists in all research fields worldwide (e.g., the European Young Investigator Awards).

Again, researchers identified via this method were cross-checked against others used to determine their expert status. For example, we would search the publication record of recipients of major awards and against the results of our citation and publication searches.

Fourth, we looked for those individuals who hold top leadership positions at major professional societies and the editorial boards of journals with the highest impact factors in their fields (as indicated by the Journal Citation Reports) or serve on selection committees for major merit awards. To serve in such capacities, experts must have a deep awareness of what is the state of the art in research. They must also (in theory, at least) understand what has helped advance their field and what may chart its path into the future. Internet searches for the websites of major professional societies, top-tier journals, and awards enabled us to identify experts who fall into this category. We also utilized online access to a database of scientists from all over the world that the European Science Foundation compiles and maintains to identify peer reviewers for its research-grant selections. And again, the names for individuals identified using this method were subject to searches using other methods described here.

Our final, and fifth, method involved referrals from the researchers we contacted for interviews. The researchers we contacted, identified through the above steps, were deemed to have the expertise necessary to address the questions raised in this study or know about R&D in Japan. Considering their expertise and professional networks within their fields, we believe that they are in a good position to give us additional candidates for interviews. In this manner, we received a small number of suggestions, and their professional qualifications were vetted using the methods described before their names were added to our list of researchers to contact for interviews.

In contacting researchers for interviews, RAND-approved human subject–protection protocols were used to ensure compliance with federal regulations for the protection of personal data. This includes a data-safeguarding plan that describes how the data collected for this investigation will be stored, how long they will be kept, and when they will be destroyed. All RAND researchers on this project signed a data confidentiality agreement, which states the responsibilities involved in data collection, storage, transfer, and use. Finally, we provided respondents information on the purpose of this study and how the data collected would be handled and used, and we obtained their oral consent prior to beginning our telephone interviews with them.

Interviews were completed between November 2008 and February 2009. Participation in this study was strictly voluntary, and a semistructured questionnaire (see Appendix A) was used to guide our conversations with them. Respondents were free to answer any of the questions (or none at all) and in an open-ended fashion. All interviews were done via telephone subsequently to initial contact via email. The interviews lasted between 45 and 60 minutes on average. Most were conducted in English and some in German, French, Italian, and Spanish. Summaries for each interview—stripped of all personally identifiable data, in the interest of confidentiality—can be found in Appendix B.

Characterizing Our Respondents

We completed interviews with a total of 55 researchers after contacting about 100 of the researchers identified. We gave priority to contacting those with the highest professional qualifications (e.g., top scientific prize winners and those regarded as most influential in their fields). We also tried to collect data from experts for each of the 25 fields. Since participation was voluntary, the number of researchers for each category and field, as well as by other attributes shown in Table 1.2, is strictly the result of individual researchers accepting our request for input. Thus, having more respondents in the life sciences than other categories or more female researchers in the life sciences than other categories may be happenstance. We caution against any assumptions without more in-depth investigation.

All 55 respondents are affiliated with universities or publicly funded research laboratories or both. By location, a total of 20 respondents are based in the United States, 33 in the EU, one in Switzerland, and one in Russia. (Although our sponsor did not name Russia as a location, our effort to identify top experts pointed to a few Russia-based ones, and one accepted our request for interview.) More than two-thirds of them had received graduate education, did postdoctoral research, or had held professorships outside their birth countries or in mul-

Table 1.2
Number of Respondents, by Key Attributes

Category/Field (number of respondents)	Location	Career Point	Gender	Professional Experience in Japan or with Japanese Research
Life sciences (18)	U.S. (9)	Senior (14)	Male (12)	Low (7)
Agricultural science (3)	EU (9)	Junior (4)	Female (6)	Moderate (6)
Biology and biochemistry (4)				High (5)
Clinical medicine (1)				
Immunology (1)				
Microbiology (1)				
Molecular biology and genetics (1)				
Neuroscience and behavior (3)				
Pharmacology and toxicology (1)				
Plant and animal science (3)				
Environmental science (11)	U.S. (2)	Senior (8)	Male (9)	Low (8)
Environment/ecology (6)	EU (8)	Junior (3)	Female (2)	Moderate (2)
Energy engineering (2)	Switzerland (1)			High (1)
Geoscience (3)				
ICT (10)	U.S. (5)	Senior (7)	Male (8)	Low (6)
Computer science, basic (0)	EU (5)	Junior (3)	Female (2)	Moderate (3)
Computer science, applied (4)				High (1)
Electrical and electronics engineering (2)				
Mechanical engineering (1)				
Mathematics (3)				
Nanotechnology and materials science (16)	U.S. (3)	Senior (13)	Male (15)	Low (7)
Chemical, basic (2)	EU (12)	Junior (3)	Female (1)	Moderate (3)
Chemical, applied (2)	Russia (1)			High (6)
Materials science, metals (3)				
Materials science, polymers (1)				
Materials science, ceramics (0)				
Materials science, semiconductors (2)				
Physics, basic (3)				
Physics, applied (3)				

tiple countries. Also, among our respondents, one was originally from Japan. This researcher informed us that he left Japan for graduate education and a career in the United States because he thinks that the United States offers superior education and professional opportunities to those in Japan. These respondents' international mobility reflects the global nature of science.

In terms of the number of respondents for each category, the largest number is in the life sciences, followed by nanotechnology and materials science, environmental science, and ICT. By category, an even number of respondents are based in the United States and Europe in the life sciences and ICT (nine and five, respectively), while the number of European-based respondents significantly outnumbers the U.S.-based ones in the environmental science and materials science categories (nine to two and 13 to three, respectively).

In terms of their career point, 42 senior and 13 junior researchers spoke with us. Among the senior researchers, 14 are in the life sciences, eight in environmental science, seven in ICT, and 13 in nanotechnology and materials science. For the junior researchers, their numbers for these categories are four, three, three, and three, respectively. Further, by career point and location, senior European-based researchers are the largest subgroup, followed by senior U.S.-based researchers (15), junior European-based researchers (nine), and junior U.S.-based researchers (four).

By gender alone, there were 44 male and 11 female respondents. Female researchers made up half of all respondents in the life sciences, but they were in far smaller numbers in the other three categories. Combining gender and career point, senior male researchers lead (37), followed by junior male (seven), junior female (six), and senior female (five) researchers.

As for their level of professional experience in Japan or with Japanese research, 28 respondents were designed as low, 14 as moderate, and 13 as high. The greatest number and share of respondents with high designations are found in the life sciences and nanotechnology and materials science. These designations are based on a combination of respondent self-assessment and the content of their responses.

Among respondents based in the United States, eight have a low level, five have a moderate level, and six have a high level of professional experience in Japan or with Japanese research. Among respondents based in Europe, 21 have a low level, seven have a moderate level, and seven have a high level of professional experience in Japan or with Japanese research.

The designation of low, moderate, or high is based on a combination of respondent self-assessment and the information the RAND research team received from the respondents. This attribute, we believe, informs our interpretation of their responses. We consider as *low* those experts with no current or prior collaborations with Japanese researchers and institutions, few or no visits to Japan, and minimal awareness of Japanese research in their research areas. Those with a *moderate* level might have had prior collaborations with Japanese researchers or institutions, some visits to Japan and interactions with Japanese researchers at professional forums in Japan or elsewhere in the world, and some awareness of Japanese research in their research areas. Those with a *high* level might have current or recent collaborations with Japanese researchers or institutions or multiple visits to Japan; experience teaching, doing research, or participating in advisory panels in Japan; and a high level of awareness of Japanese research in their research areas.

Caveats on Data and Analysis

The information we collected from our respondents is necessarily subjective, as it is based on personal experiences, observations, and impressions about the quality of the scientific research system and research results produced in Japan. This is something RAND and the sponsor recognize from the outset, and, per the objective of this study and intent of our sponsor, this is not considered a problem. Nevertheless, we proffer a few caveats to our readers.

First, the expert input we received typically addressed conditions within the narrower scope of a respondent's specialized research areas rather than for the whole field or the major category to which a field is assigned in this study. When comments address Japanese science education overall, for example, we make that explicit.

Second, comments by our respondents might reflect their experience of a particular time and place. Consequently, two experts in the same research area can have vastly different experiences and opinions. Such differences of opinion are reported without any attempt on our part to query the reasons for their divergence or to reconcile them, as the latter is not the objective of this study or a mandate by our sponsor.

Third, minority viewpoints are treated with the same respect accorded to majority viewpoints in our reporting here. The fact that something was mentioned by a majority of respondents does not necessarily make it more valid than something that was observed by only one or two respondents. Also, our sponsor is interested in the full range of viewpoints and experiences rather than what is the consensus or majority.

Fourth, again, we do not assess the validity of the information provided to us by our respondents. The objective of this research is strictly to collect expert feedback and summarize it in this report. Particular viewpoints, statements, or experiences expressed by our respondents may deserve additional investigation to ascertain their validity and potential ramifications for Japanese government policy. However, the focus and resources for this research do not permit us to undertake such additional investigation.

CHAPTER TWO

Summary of Expert Responses

This chapter summarizes the information we received from the 55 leading scientists we interviewed. There are six sections in this chapter:

- The first reports *sources of information* or ways in which our respondents said they obtain information about quality of research and S&T education in Japan.
- The second summarizes comments from respondents on the *competitiveness* of Japanese research, organized by the four categories (life sciences, environmental science, ICT, and nanotechnology and materials science) and the 25 fields under them.
- The third presents our respondents' opinions on *quality of training, human capital, infrastructure, organization and research management, and national policy* for S&T in Japan.
- The fourth highlights *strengths* that our respondents said could aid efforts to build greater excellence in Japanese research.
- The fifth highlights *weaknesses* that our respondents said could hinder efforts to build greater excellence in Japanese research.
- The sixth reports *our respondents' recommendations* that the Japanese government might consider to improve Japan's S&T performance in particular research fields and areas, as well as Japan's standing in global science.

Sources of Information

Our respondents reported several major sources of information on which they based their opinion on the quality of Japanese research and education.

The most frequently cited was the major scientific journals in their fields and subfields of research. In their view, publication in the top-tier journals of their fields and subfields is a clear reflection of the quality of research and engagement with the international scientific community. Also, we were told that the top-tier journals are typically in English. Thus, publication in these journals, in their view, is one indication of English proficiency among researchers in a particular country and their ability to engage with the international scientific community.

Professional conferences worldwide and professional visits to Japan also gave many of our respondents the opportunity for firsthand interaction with their Japanese peers and to directly observe the quality of Japanese research, facilities, and equipment. In fact, several respondents noted Japan's active involvement in organizing and hosting many international scientific conferences in recent years, and they credited such expanded involvement for their visits to Japan.

A third source for our respondents is their past or current collaborations with Japanese researchers. Six reported having held research fellowships or faculty positions in Japan or having served as advisers and reviewers on scientific boards and panels in Japan. However, none reported active collaboration with Japanese researchers at the time of our interviews, and a small handful explicitly stated no desire to conduct research in Japan. For those who have no active collaboration, most reported not having found the right Japanese researchers with whom to work. Others attributed their choice of not working with Japanese researchers or in Japan to personal preferences in locations for employment and living, as well as (real or perceived) barriers in language and cross-cultural communication, differences in institutional setups and social norms, and challenges securing funding for international research collaborations and travel expenses.

Finally, more than a fifth of our respondents have had Japanese researchers, postdoctoral research fellows, and students visit their laboratories or work with them. Through firsthand experiences with these Japanese scientists and students, respondents reported that they gained insights into the state of the art in their areas of research in Japan and how well the Japanese system educates its scientific talent and functions to support S&T education and R&D activities.

Competitiveness of Japanese Research

Our first major question in our interviews was to learn, from our respondents' perspective or experience, how the quality of Japanese research compares with the best in the world within their fields, where they have seen improvements in the quality of Japanese research in recent years, and in what other countries they might have seen significant improvement. Again, we urge readers to be mindful of the caveats stated in the preceding chapter in their review of the information reported here. Also, more-detailed summaries for each of the 55 interviews conducted can be found in Appendix B.

Overall, 22 of our 55 respondents reported that Japan is at the forefront, is among the top five leaders, or has demonstrated significant improvement in their research areas. Another dozen reported that Japan is doing very well, produces high-quality research, or is among the top ten leaders in the world. This compares well with the responses received in our 2004 study. Similarly, though, respondents frequently qualified their assessments that Japan's excellence is in technology development, applied research, or areas in which expensive equipment is required rather than in theoretical or fundamental research.

Life Sciences

Overall, our 18 respondents regarded Japan as among the world's leaders in the many fields and research areas in which they work. However, Japan's achievement was frequently described as largely technical—that is, developing or refining existing ideas—rather than conceptual—producing innovative research that reaches beyond existing knowledge boundaries. Also, several respondents observed China and India as growing in their research capacity, although none of the respondents speculated on when these two countries might catch up with or surpass Japan. Among the top institutions in Japan named were Fukuoka University, the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Kyoto University, Kyushu University, RIKEN, Nagoya University, Okayama University, and the University of Tokyo.

RIKEN, in particular, stood out for the many times our respondents named it for producing high-quality research and for providing a more open and creative research environment for young researchers.

Agricultural Sciences. Comments from three respondents focused on the quality of Japanese research in biogenetics, soil chemistry, marine biology, and agricultural sciences overall. In biogenetics, Japan was seen as lagging behind the world's leaders. While Japan produces good materials (e.g., ionic membranes), it was perceived to lack the ability to define the "big questions" in research and to largely follow the leadership of other countries. In soil chemistry, Japan was seen as a world leader, but the respondent said that there has been no major breakthrough research from Japan in recent decades. As for agricultural sciences, Japan was observed to have produced some good but not world-class research.

Overall, in the life sciences, the United States was ranked as the world's leader, and China, India, Brazil, Spain, and several other countries were observed to be rapidly improving and expected to become leaders if they continue to improve. Their improvement was attributed to their effort to open up their education and research systems (e.g., sending more students and researchers overseas and inviting foreign scientists to join their faculty and research groups) and their emphasis on merit-based research funding and promotions. (See Appendix B, summaries 1–3.)

Biology and Biochemistry. Opinions of our four respondents on the competitiveness of Japanese research in this field ranged from very good to uncertain. Again, Japan was described as not being a source of groundbreaking innovation. Japan's strength, in their view, was in building on existing technology and making it more accessible. They ranked the United States as the global leader and reported significant improvements in Ireland in the past decade as a result of a good diagnosis of its weaknesses and government policies that were appropriately designed to invigorate research. (See Appendix B, summaries 4, 5, 6, and 7.)

Clinical Medicine. Within this field, one respondent spoke specifically on the quality of Japanese research in molecular parasitology. This respondent did not regard Japan as a leader and remarked that Japan's contribution to this research area is a small one. Leaders in this specific area, in this respondent's opinion, are the United States, Britain, and Australia. Ireland, too, was reported to have made significant improvements clinical medicine research in the past decade. This respondent attributes Ireland's success to its policy of attracting top-quality students and scientists domestically and from overseas to come to Ireland, including Irish scientists based overseas. Finally, this respondent credited the Irish success to increase in research funds, improved research environment, and a higher quality of life. (See Appendix B, summary 8.)

Immunology. For this field, our respondent rated Japan as among the top 20th percentile of countries globally in terms of productivity (e.g., number of published papers) and lower on the scale (top 50 percent) in terms of the innovativeness of its work. The best work, in her view, is done in the United States and Britain, followed by Switzerland, France, and Australia. Japan was described as being extremely strong in research efforts that require strength in numbers. She also rated Japanese researchers in this field as efficient but lacking in innovation and creativity. (See Appendix B, summary 9.)

Microbiology. Within this field, our respondent commented specifically on Japanese research in marine biology. Japan was observed to have some world-class researchers and to have invested heavily in equipment, but our respondent described Japanese research in this area as lacking in innovation. This respondent added that, in his view, Japan should produce higher-quality work in this area considering the level of research support available and the fact that Japan is an island country surrounded by the sea. (See Appendix B, summary 10.)

Molecular Biology and Genetics. Our respondent spoke on his views about Japanese research in this field. Japan was viewed as able to produce high-quality research but as lagging far behind the United States and Britain, which he identified as the leaders in this field. In genomics, in particular, he noted Japan's contribution to developing extensive expressed sequence tag sequencing. While Japan does well in this field, this respondent observed that China is rapidly rising as a result of increased funding for research and infrastructure and overseas training for Chinese scientists. In addition, Chinese researchers were described as having an aggressive and independent spirit. This, the respondent said, can aid them to produce more-creative research. (See Appendix B, summary 11.)

Neuroscience and Behavior. Our three respondents differed considerably in their opinions about the quality of Japanese research in this field. Two commented on Japanese research in neuroscience. One described Japan as "a serious player," "really brilliant," and at the forefront of the field, while the other did not consider Japanese research in this area as highly competitive by world standards. The third respondent commented on the quality of Japanese research in psychology. The best Japanese researchers, we were told, had left Japan. In his view, the United States is the leader in psychology research, while Hong Kong, China, India, France, and Poland were observed to have made significant improvement in this area as a result of increased international research exchanges with the United States. (See Appendix B, summaries 12, 13, and 14.)

Pharmacology and Toxicology. One respondent spoke on Japan's performance in these areas. Japan was rated as being among the top five in the world, with the United States and Britain being the world's leaders in pharmacology research. He credited the Japanese government's investment in pharmacology research and related areas as critical to Japan's success. However, Japan's scientific achievements in drug development were characterized as largely technical and not highly innovative. By comparison, this respondent said that China and India's capacity in pharmacology research is increasing, and he credits this improvement to an emphasis on merit-based funding, professional mobility, and incentives for achievements. (See Appendix B, summary 15.)

Plant and Animal Science. Three respondents commented on Japan's performance and rated Japan as a top leader in this field overall. Japan was described as having high-quality researchers, strong funding, and good infrastructure. In addition, our respondents credited Japan's high-quality graduate programs and saw increased international exchanges for Japanese students and scientists as contributing factors to Japan's success. China, too, was observed as improving the quality of its research in this field as a result of heavy Chinese research investment and overseas education and experience for Chinese scientists. (See Appendix B, summaries 16, 17, and 18.)

Environmental Science

Feedback from our 11 respondents points to a shared view that Japan's achievements in these fields stem from strong funding and good facilities and equipment available to Japanese researchers, as well as the diligence of Japanese researchers. While Japan ranked high overall, there was a view shared by our respondents that Japan's performance should be stronger given the resources available. Among the top institutions named were the Earthquake Research

Institute, the National Institute of Polar Research, Kyoto University, the Tokyo Institute of Technology, and the University of Tokyo.

Environment/Ecology. Japan overall was rated as doing well but not a world leader in the subfields addressed by our respondents. In earth-science research, Japan was regarded as competitive. In geochemicals, Japan was said to produce good technical work. In biodiversity, bioecology, biodiversity restoration, zoological ecology, evolutionary ecology, and entomology, Japan was rated as doing well or fairly well. Respondents all took the view that Japan should be performing better than it is considering the resources, infrastructure, and human talent available. (See Appendix B, summaries 19–24.)

Energy Engineering. Our two respondents ranked Japan as a very advanced or leading country in this field. They attributed a major part of Japan's success to strong funding and high-quality facilities. One respondent observed that top-flight industry research laboratories (e.g., Toshiba) produce higher-quality work than universities in Japan. He was optimistic that new ties between academia and industry in Japan could bring more research money to and improve the quality of research at university laboratories. (See Appendix B, summaries 25 and 26.)

Geoscience. Our three respondents rated Japan as belonging to the middle tier, alongside China, in global rankings for geoscience. Again, Japan was viewed as doing better in research that requires expensive equipment for data collection or measurement than in theoretical research. For example, one respondent rated Japan as doing respectable to very good work in ocean drilling where technology development is concerned but noted that Japan would not be a world leader in this area because it biases against theoretical research. In this regard, our respondents expected China and India, which were seen to give more emphasis to theoretical research, to continue their rise and perhaps surpass Japan one day. (See Appendix B, summaries 27, 28, and 29.)

Information and Communication Technology

Overall, our 10 respondents rated Japan as producing good to top-quality work, but not cutting-edge research. Japanese excellence was seen largely in its technical work, rather than in fundamental research. In their view, the United States is by far the world's leader. The top institutions named included the Japan Advanced Institute of Science and Technology (JAIST), Keio University, the Nagoya Institute of Technology, the National Institute of Advanced Industrial Science and Technology (AIST), the National Institute for Materials Science (NIMS), Nippon Telegraph and Telephone (NTT), Sony, the Tokyo Institute of Technology, and the University of Tokyo.

Computer Science, Applied. Within this field, four respondents rated Japan as doing high-quality work that is technically strong and fundamentally innovative. However, Japanese research was not seen as on par with research in leading countries, such as Britain and Germany. Our respondents cited current research on next-generation Internet as a particularly noteworthy undertaking. The Advanced Telecommunications Research Institute International (ATR) was commended for its efforts to expand international research collaborations. (See Appendix B, summaries 30–33.)

Electrical and Electronics Engineering. Our two respondents' ratings of Japanese research in this field were largely positive. Japan was seen as a leader behind the United States and EU, which were described as producing superior research results and technologies. Japan's work on carbon nanotubes was especially noted. (See Appendix B, summaries 34 and 35.)

Mechanical Engineering. One respondent provided input for this field. Although he could not name them individually, he commented that Japan has some good research institutes and some of the world's leading experts in this field. (See Appendix B, summary 36.)

Mathematics. For the field as a whole, our three respondents took the view that Japan produces good but not cutting-edge research. In the subfield of computational logic, Japan was described as producing high-quality research and active in international collaborations. The country was ranked third after the United States and Germany, with the University of Tokyo and Kyoto University named as the top institutions in Japan. In bioinformatics, Japan was rated highly for its technical work but was said to be less proficient in mathematical development. (See Appendix B, summaries 37, 38, and 39.)

Nanotechnology and Materials Science

Our 16 respondents had varying opinions on Japan's performance in the fields and subfields in this category. Their assessments of Japanese research ranged from "respectable" to "top quality" to being on par with the world's best. Although Japan's competitiveness was seen primarily to be on the technical side, Japan was also praised for producing important original and innovative ideas. Having a high level of research funding and good infrastructure are essential, according to our respondents. They also credit Japan's active participation in large international research programs and increased openness (e.g., international exchanges and publication in international journals) for helping to improve Japan's overall performance in the fields and subfields in this category. The top institutions named were AIST, Kyoto University, Meijo University, NIMS, Osaka University, RIKEN, the University of Tsukuba, the Toyota Technological Institute, and the University of Tokyo.

Chemical, Basic. For this field, overall, Japan was commended for having made significant improvements in the past two decades, including increased publication in the top journals. Japan's efforts to send more students and researchers abroad and expansion in collaborative research with Europe and the United States were also cited as important to this outcome. Rankings for Japan ranged from being in the middle range among the world's top ten to being second after the United States and ahead of Germany. (See Appendix B, summaries 40 and 41.)

Chemical, Applied. Two respondents provided feedback to us; each commented on different subfields. In the areas of photovoltaics and microelectronics, Japan was ranked a world leader. In organic chemistry, by contrast, our respondent did not think that Japan was a leader. In his opinion, Ireland, Finland, and Denmark are producing more high-quality work and catching up with the United States, Britain, Germany, and France, which, he remarked, are the leaders in this area. (See Appendix B, summaries 42 and 43.)

Materials Science, Metals. Overall, our three respondents rated Japanese research in this field as competitive, high-quality, and groundbreaking in some instances (e.g., battery research, building the Earth Simulators). The best Japanese researchers were reported to be internationally renowned. They also observed that Japan's hosting of international conferences has improved exposure of Japanese researchers to the latest research. (See Appendix B, summaries 44–46.)

Materials Science, Polymers. One respondent from this field provided input and rated Japanese research as "absolutely competitive." Japan was commended, in particular, for producing detailed and difficult work when the highest technical capability is required. (See Appendix B, summary 47.)

Materials Science, Semiconductors. Our two respondents from this field rated Japan as a world leader and expect it to stay a world leader well into the future. They highlighted, in particular, Japan's contributions to photovoltaic research on lithium-ion batteries and the use of titanium-dioxide as a photo catalyst. Japan's research on amorphous crystalline silicon cells and injection cells were also described as innovative. Finally, they praised Japan's ability to turn ideas into commercial products. (See Appendix B, summaries 48 and 49.)

Physics, Basic. Three respondents provided input on Japanese research in this field. In the area of theoretical physics, one respondent said that Japan is very strong and has demonstrated visible improvements in recent years. Further, Japan was rated as on par with other leading nations and expected to remain a leader in the coming years. In the areas of astrophysics and gravitational wave physics, a rapid growth in Japanese research capacity was also observed by our respondents. For the latter, Japan was reported to have moved from a position of "significant weakness" to being at the forefront of research. By comparison, in high-energy physics, Japan was not expected to do better because of the absence of critical research infrastructure. (See Appendix B, summaries 50–52.)

Physics, Applied. Our three respondents in general concurred that Japan's strength in this field is primarily in doing technical work (e.g., computer programming) rather than in producing theoretical, groundbreaking research. Thus, while they considered Japan to be doing well, they did not see Japan rivaling the United States or Germany, which they regard as the leaders in this field. (See Appendix B, summaries 53–55.)

Quality of Human Capital and Training, Research Organization and Management, Infrastructure, and National Policy

Our interviews with the 55 leading scientists asked them to comment on the quality of training (from high school through Ph.D. level in science), human capital (primarily scientists), infrastructure (facilities, equipment), organization and research management, and national policy (including funding and other policies to promote S&T capacity). Respondents could address conditions within their own field or subfields (most did) and for Japan as a whole. If they did not have any knowledge about conditions in Japan, they were asked to comment on what qualities in all these areas would be required for a country to establish excellence. Responses for the latter are incorporated into the section of this report that presents recommendations from the respondents. Observations offered by our respondents are consistent with those we received from experts interviewed for our 2004 study. The perception that Japan has potentially good talent but that independent and creative thinking is constrained by social and institutional forces continues to be a major theme in their comments.

Human Capital and Training

Respondents in most cases reported that there are good researchers in Japan in their field, some even outstanding or world-class. (See, for example, Appendix B, summaries 1 and 43.) A few respondents, however, considered Japanese researchers or postdoctoral fellows they know to be low in quality, at least relative to those from countries regarded as leaders in their fields. (See, for example, Appendix B, summaries 14 and 35.) The majority of the respondents professed inadequate in-depth knowledge about the Japanese education system at the undergraduate and graduate levels to comment on how well they educate scientists. On the whole, there was a view that the Japanese education system does adequately well, but it was not perceived to do a good job in teaching students how to think independently. (See, for example, Appendix B, summaries 4, 29, and 42.) Further, more than half of our respondents highlighted their perception that individuals would not be inclined to challenge conventional thinking or authority within the rigid social hierarchical structure in Japan. More than half of our respondents commented that hierarchical structures permeate Japanese society, including its research community. Such hierarchical structures, in their view, are not conducive to enabling independent thinking, creative research, or innovative ideas. (See, for example, Appendix B, summaries 6, 15, 27, and 44.)

Organization and Research Management

The single most common point of criticism voiced by our respondents is the lack of openness in the Japanese system to foreign persons and ideas. A few respondents said that Japan is becoming more open (e.g., the Japan Society for the Promotion of Science [JSPS] and RIKEN provide more opportunities for non-Japanese researchers to work with them). (See Appendix B, summaries 24, 35, and 43.) However, the vast majority of our respondents perceived the Japanese system as closed to non-Japanese (e.g., that it is rare for non-Japanese researchers to obtain permanent positions in Japan). (See, for example, Appendix B, summaries 19, 29, 36, 45, and 48.)

In terms of research management, criticism again focused on respondents' perceptions of a rigid hierarchical structure in Japan. Top researchers or laboratory leaders were seen to have dominant control over the resources for a research group or even a field in Japan. This control would allow them to decide the research topics and how to approach them, to the point of stifling creativity and productivity. (See, for example, Appendix B, summaries 7, 15, 44, and 48). In their view, having the freedom to explore ideas—backed with resources to do it—is what engenders creative and high-quality work. Further, independent research suffers, especially for young scientists who are not in a position to negotiate with their supervisors. Respondents also noted how such hierarchies dissuade non-Japanese scientists and Japanese scientists overseas from choosing to work in Japan. (See, for example, Appendix B, summaries 7, 8, 13, 48, and 52.)

There is broad concurrence among our respondents that this strict hierarchical structure in research management is deleterious to Japanese research. At the same time, our respondents recognize that culture and mindsets are difficult to change, especially when this strict hierarchy in the Japanese scientific community is a reflection of Japanese society itself. (See, for example, Appendix B, summaries 7, 9, 12–15, 18, 21, 27, 29, 30, 35–37, 44, 52, and 53.)

Research Infrastructure

Overall, Japan's research infrastructure was viewed by our respondents as good to world-class and even the best in the world. (See, for example, Appendix B, summaries 5, 10, 15, 35, 38, 40, and 54.) A respondent in the electrical and electronics engineering field described Japan as having more-sophisticated infrastructure than any other country; another—in the polymers field—also described Japan's infrastructure as "top end." Several respondents reported improvement in Japan's research infrastructure (e.g., in applied computing and mechanical engineering). (See Appendix B, summaries 32 and 36.) Indeed, only in a few instances was Japanese research infrastructure described as lagging compared with the leading countries (in environment/ecology) or missing (in basic physics). (See Appendix B, summaries 21 and 51.)

Having good research infrastructure—though necessary—is not sufficient to excellence in research. Several respondents noted the issue of access to research facilities. (See Appendix B, summaries 6, 9, and 18.) At issue is whether individual researchers, especially younger ones, could access facilities and equipment to conduct their research when a senior laboratory leader may not allow it. Respondents also raised this in terms of access by research groups outside of one's own team or institution (e.g., industry research using facilities and equipment managed by universities). Several respondents raised this issue in light of their understanding about how research is organized and managed in Japan. Without access to facilities and equipment, they explained, individual researchers would not be able to conduct experiments to test their ideas and advance their own independent research agendas. If access problems exist, it would be all the more burdensome for young scientists who are working to launch their careers and establish their credentials. One respondent added that difficulties in access could also stifle enthusiasm in scientific research—something that is critical to producing innovative research.

National Policy to Promote Science and Technology

Most respondents did not consider themselves sufficiently informed about this topic to comment on it. Some respondents said that they were glad to see the Japanese government funding more international activities (e.g., fellowships, exchanges, and conferences). Others cautioned against excessive government control of the national research agenda—stifling bottom-up initiation of research ideas and the possibility of "betting on the wrong horse." (See, for example, Appendix B, summaries 29, 30, and 55.) In general, respondents complimented Japan for providing a good level of financial support of research and purchase of equipment. They faulted the Japanese government instead on the concentration of resources among a small number of top scientists and institutions.

Major Strengths in Japanese Research

There was fairly broad consensus among the respondents that there are clear strengths in the Japanese research. Among the most frequently mentioned were strong funding, good research infrastructure, hardworking and meticulous researchers, and proficiency in technical work. These observations, too, are consistent with responses received from experts for our 2004 study.

Top Scientists Are Well Funded

With rare exceptions, Japanese researchers and their research programs were seen by our respondents as well funded. There is a strong perception among our respondents that the Japanese government provides good research support to the scientific community in general and its top scientists and research institutions in particular. Also, there is a broadly shared view among our respondents that research support in Japan is more stable because of clear government-driven research priorities and the centralized allocation of public research funds. This allows research groups in Japan to work without worrying too much about losing support in subsequent funding cycles. Instead of expending endless hours writing grant proposals, Japanese researchers can actually focus on their research. (See, for example, Appendix B, summaries 1, 6, 14, 21, 35, 37, and 38.)

Japan Has Good Research Infrastructure

As described in the previous section, most respondents reported experiencing or having the impression that Japan has good research infrastructure. In their view, this allows universities and other public research institutions in Japan to invest in state-of-the-art research facilities and equipment. A few of our respondents commented that having sophisticated equipment can give a research team the competitive advantage (e.g., in geoscience and energy engineering research). (See, for example, Appendix B, summaries 9, 20, 25, 28, and 55.)

Japanese Researchers Are Hardworking and Meticulous

Although it was a point that was more often implied than explicitly stated, our respondents shared the view that Japanese researchers (including graduate students) are hardworking and meticulous. (See, for example, Appendix B, summaries 8, 21, 31, 42, and 54.) A few respondents, in particular, highlighted the willingness of Japanese researchers to put in long hours to conduct and repeat experiments to obtain clear results, and the care they take to review data earned compliments. Further, a few respondents also praised the strong sense of team spirit and individual commitment that they observed among scientists in Japan.

Japan Excels in Developing Technologies and Equipment-Driven Research

Japan's prowess in developing technologies and putting ideas into products was widely shared by our respondents. In microscopy technology, for example, Japan was credited with having made critical contributions to its development. Another respondent who is a leading scientist in polymer research said that Japan is especially good at doing work that requires high technical capability. (See, for example, Appendix B, summaries 6, 31, 47, and 53.) Overall, our respondents perceived an emphasis on technology development over fundamental research in Japan. (See, for example, Appendix B, summaries 29, 31, 35, and 47.)

Major Hindrances to Greater Excellence

Given Japan's strengths described in the previous section, many respondents said that they would have expected Japan to produce higher-quality and more-creative research. (See, for example Appendix B, summaries 34, 39, 43, and 47.) We asked our respondents to offer their thoughts on what might be holding them back. Their responses largely converged on the points presented in this section, according to how frequently they were cited by our respondents, and they, too, are consistent with expert responses in our 2004 study.

Low Proficiency in English

Feedback from our respondents showed clear consensus on one point: Low proficiency in English among Japanese researchers and students hinders communication with the international scientific community. English, in our respondents' view, is the de facto lingua franca of the international scientific community, so that limited proficiency in English becomes a handicap. Several respondents attributed low proficiency in English as a hindrance to the publication of Japanese research in international scientific journals. In their view, when Japanese research is not visible to the international scientific community, researchers outside Japan have limited awareness of what is being done in Japan and the quality of that work, and therefore are less motivated to seek collaboration with Japanese researchers. For example, one European-based respondent cited the language barrier as one reason for choosing the United States over Japan for an overseas research experience. Several respondents also thought that low proficiency in English was a barrier to more-effective interaction between Japanese researchers and their international peers at conferences, on the Internet, and in formal and informal discussions. (See, for example, Appendix B, summaries 2, 6, 13, 14, 18, 21, 22, 24, 25, 39, 31, 33, 34, 36, 42, 46, and 48.)

Cultural Barriers and Rigid Hierarchical Structure

Respondents also expressed concern about the ability or willingness of Japanese researchers to communicate. Low proficiency in English could hinder Japanese researchers from effectively communicating their work in print and in oral communication. However, proficiency in English does not guarantee effective communication. Cultural norms reinforced by the strict hierarchical structure in Japanese society were expressed explicitly by more than one-fifth of our respondents as hindering Japanese researchers from freely expressing themselves or questioning authority. Such inhibitions, in the view of our respondents, hinder Japanese researchers from exploring the big questions in scientific research. They added that a self-restraining mentality and a constrictive cultural environment could be especially harmful to young researchers who should be seeking and testing new ideas. Our respondents underscored that such an environment would make Japan unattractive to both talented and ambitious Japanese and non-Japanese researchers alike. (See, for example, Appendix B, summaries 6, 7, 9, and 29.)

Also, a system that is ruled by hierarchy rather than merit would not allow young scientists or brilliant researchers to rise or to freely pursue their research. When the leader of a laboratory is the only one permitted to make creative decisions, intellectual freedom and creativity are stifled and ambitious young scientists may become apathetic. Enthusiasm, our respondents underscored, is critical to excellence in research. Also, some of our respondents opined that Japanese culture discourages risk-taking and acceptance of failure, both of which are essential for creative ideas to emerge and be tested. (See, for example, Appendix B, summaries 3 and 11.)

A strict hierarchical structure could also make it much more time-consuming to get things done (e.g., going through each layer to obtain a decision from the top leader). For non-Japanese scientists, especially from North America (and, increasingly, Europe, where hierarchies are being dismantled), our respondents stressed that such a rigid hierarchical environment would make Japan an unattractive place to work for any talented researcher. (See, for example, Appendix B, summaries 4, 6, 8, 12, 27, 35–37, 44, 48, 49, and 52.)

Low Value Given to Fundamental Research

Feedback from our respondents indicates that excellence in technology development is not a solid foundation for innovative or groundbreaking research. Consequently, few of our respondents rated Japan as a leader in their field or subfield when they observed that strength in Japanese research lies primarily in technology development rather than fundamental research. Their comments indicate their perception that research funding in Japan is strongly biased against fundamental research because policymakers favor technology development for its visibility and commercial profit potential. (See, for example, Appendix B, summaries 21, 23, 29, 31, 39, 53, and 55.)

Absence of Women in Research

The virtual absence of female researchers in Japan was raised broadly by our respondents regardless of their career status, gender, location, or field. In their view, not opening research careers to women diminished Japan's labor pool by half. This was all the more problematic considering that Japanese society is rapidly aging. Respondents reported that Japanese women in science rarely assume leadership positions and are forced to leave their positions if they marry or have children. Even those who choose to pursue careers in science are more likely employed as laboratory technicians than as researchers. Female workers in Japan were also seen as victims of male discrimination, with behaviors that one respondent said would be considered sexual harassment in the United States. Both male and female respondents who commented on this point said that discrimination against women makes Japan a less attractive place for foreign students and researchers—male and female alike—as well as Japanese women who want to pursue scientific careers. A few respondents remarked that Japanese women may be better off pursuing their scientific careers outside Japan than within it. (See Appendix B, summaries 4, 6, 8, 9, 11, 21, 22, 32, 41, and 46.)

Japan Is Invisible and Insular

Nearly one-fifth of our respondents expressed the view that Japanese research lacks visibility internationally. For example, they commented that Japanese research is not prominent in the major scientific journals in their fields and that Japanese researchers are not actively engaged in Internet blogs for scientific discussions. In their view, research not seen is not known, and this limits opportunities for exchanges and collaborations. The situation was reported to be improving at some institutions (e.g., scientists were required to publish their research in English), and strong Japanese government support to organize and host major conferences and seminars in Japan also helps to expose Japanese institutions and researchers international audiences. (See, for example, Appendix B, summaries 2, 20–22, 24, 30, 31, and 34.)

In this connection, nearly one-fifth of our respondents also criticized Japan for being too insular. There were observations that Japanese research published in Japanese-language journals limits access to Japanese researchers. A few respondents reported seeing changes at RIKEN and via JSPS scholarships to bring more foreign scientific talent into Japan for short-term exchanges. Our respondents said that these actions are good starts but counseled that much more needs to be done. (See, for example, Appendix B, summaries 16, 24, 25, and 48.)

Another dimension of insularity pertains to our respondents' perception that too few Japanese students are studying overseas and too few young Japanese scientists are experiencing research overseas. (See, for example, Appendix B, summaries 22, 48, and 54.) The Chinese experience was cited by more than one-fifth of our respondents to demonstrate the positive impact that international education and research experience can have on improving national S&T capacity. Several respondents explicitly compared their Chinese and Japanese experiences. For example, Chinese researchers and students were characterized as more open to learning new ideas, trying them out, and considering alternative viewpoints, as well as more active in publishing in leading international journals than their Japanese peers. Such attitudes, combined with significant Chinese investment in S&T, were noted by our respondents as the basis for their optimism about China's future in their scientific fields. (See, for example, Appendix B, summaries 6, 7, 11, 17, 18, 27, 31, 47, 48, and 53.)

Recommendations from the Experts

We asked respondents to recommend ways to mitigate weaknesses they observed and to increase excellence in Japanese S&T. As described earlier, if a respondent had little or no familiarity with Japan, he or she was requested to share with us what they thought were factors essential to excellence in S&T and to name models, experiences, or institutions that they considered to be exemplary. Thus, this section is a summary of recommendations from our respondents per agreement with our research sponsor. It is not within the scope of this research to assess the validity of the viewpoints expressed by our respondents or the appropriateness of recommendations they provide. These recommendations are presented in order of the frequency for which they were mentioned and not in order of sequence or hierarchy.

Increase Proficiency in English

Improving proficiency in both oral and written English was underscored as a fundamental requirement. Our respondents said that, without a high level of English language capacity, Japanese scientists cannot be effective participants in science at a global scale, since they cannot engage in exchanges with their peers worldwide via publications or the Internet or in person in formal or informal forums. (See, for example, Appendix B, summaries 2, 4, 6, 8, 14, 19, 21, 30, 33, 42, and 48.)

Many other respondents also recommended this implicitly in their recommendations that more Japanese students should go overseas for education and more Japanese scientists and faculty should gain research and teaching experience outside Japan. There was also a suggestion to require Japanese researchers to write proposals in English as a way to improve their English capacity. One respondent in Germany underscored the importance of English by informing us that he requires his research team members to work only in English as a way to increase their capacity to engage with the global science community, and he reported that this has helped his students to more effectively participate in international research activities. (See Appendix B, summaries 33 and 42.)

Recruiting more international students and faculty and increasing international R&D collaborations were also suggested as ways to improve English capacity for Japanese students and researchers. (See, for example, Appendix B, summaries 1, 3, 19–21, 23, 25, 27, 29, 30, 33–35, 37, 43–45, 47, 48, 51, 54, and 55.)

Since increasing English language capacity among Japanese students and researchers can take time, there was a suggestion to provide "special funds for professional translation" to help Japanese students and researchers to prepare grant proposals and papers for submission to international journals and conferences. In this respondent's view, even Japanese students and researchers with a high level of proficiency in English could benefit from such professional assistance and improve their visibility and engagement with the global scientific community. He reported that he has seen this approach work well in China, helping to raise the international profile of Chinese research. (See, for example, Appendix B, summaries 2, 6, 13, 14, 18, 21, 22, 24, 25, 31, 33, 34, 36, 42, 46, and 48.)

Emphasize Merit Above All Else

A number of recommendations were tied to cultural barriers in Japan. Our respondents stressed that the rigid hierarchical structure and deference to seniority and authority (the two go hand in hand) must be dismantled and replaced by a merit-based system to allow talent to rise, whatever the age, race, or gender of the researcher might be.

Merit, in the view of our respondents, should be the central criterion for research grants, hiring, promotion, and all else. In particular, to break the restrictive hierarchy and mindset, research grants should emphasize bottom-up research proposals and support high-risk research. Also, considering the weak position that women and junior researchers occupy in Japan, special grant programs that target them could give them a much-needed boost.

Our respondents stressed that, until Japanese students and researchers can think freely and until their creativity is valued, Japan will continue to do good work, but it will not be doing cutting-edge research and be a global leader in science. One senior researcher with a high level of knowledge about Japanese S&T remarked that, when original work is produced in Japan, it is the result of persistence by creative scientists rather than generous funding or equipment. This is not to dismiss that funding and equipment are important, but these inputs alone do not produce creative research. (See, for example, Appendix B, summaries 4, 7, 18, 27, 37, 44, and 46.)

Further Open Japan to the International Scientific Community

There was broad consensus among our respondents that Japan should further open itself to the entry of foreign students, faculty, and researchers into the Japanese education and research systems for short-term stays and long-term appointments. One proposal is that adding scholarships and fellowships that target high-caliber international students and researchers would be helpful.

Our respondents commented that having more foreign students, faculty, and researchers present in the Japanese education and research systems might help to improve English language proficiency among their Japanese peers, expose them to different ideas and ways of thinking, and foster a culture that values creativity and rewards risk-taking and excellence rather than rank and seniority. (See, for example, Appendix B, summaries 3, 9, and 13–15.)

Increase Outflow of Japanese Students and Researchers

Japan should send more students and researchers overseas for education, exposure, and experience. Respondents said that the case for doing so might not be clear cut, because good graduate programs are available in Japan. However, they underscored that overseas experience could not only increase knowledge or skills in scientific research, but also help to improve intercultural communication skills and expand professional networks—both of which are essential to improve excellence in S&T. In their estimation, it may take some time—perhaps five, ten, or more years—to produce a significant impact, but such efforts are much needed and should begin immediately. (See, for example, Appendix B, summaries 1, 4, and 8.)

Emphasize Critical and Independent Thinking in Japan's Secondary and Tertiary Education Systems

Respondents spoke of a need for Japan's education system to change. Respondents widely shared the view that the current system in Japan—at all levels—does not teach students to think critically. In their view, the emphasis on learning "what" over questioning "why" is counter to the culture of science. Further, while Japan may do well in international rankings of science and math test scores, the current system produces good researchers but not outstanding ones because they are unable to challenge the state of the art to forge new ground.

Respondents' recommendations ranged from changes beginning at the kindergarten level to making the undergraduate and graduate programs more open and rigorous. Nevertheless, most agreed that changes at the secondary level are important to prepare young people to become more independent and creative thinkers at the college level and in their professional careers.

Our respondents broadly saw the university system in the United States as the best in the world. They praised its openness to all ideas and people from around the world, as well as its ability to prepare students to become good teachers and researchers. Ireland, Portugal, Germany, Britain, and several other countries were named for successful reforms to make their university more competitive in the global market for talented students and researchers. In many cases, our respondents said they borrowed elements from the U.S. system in their own work and institutions.

Finally, according to our respondents, students beginning at the undergraduate level should learn how to read research papers and write grant proposals and research papers in English and be involved in hands-on research activities, including international collaborations. (See, for example, Appendix B, summaries 3, 15, 20, and 53.)

Continue to Fund Research, Including More Support for International R&D, and to Improve Research Facilities and Workplace Quality

Overall, respondents emphasized that money should be allocated on the basis of merit, whether it is for research or facilities. Where research funding is concerned, they counseled a careful balance between applied and fundamental research.

They also recommended targeted funding to incentivize and support more Japanese and non-Japanese researchers to work together. One option might be special funds to pay for travel associated with international exchanges or, as described earlier, for professional services to assist Japanese researchers in preparing articles for international publication.

International collaboration might also be made a requirement for research grants for students and young researchers. Our respondents repeatedly pointed to the EU experience (the Erasmus and Marie Curie programs, in particular) as very effective in fostering research cooperation and graduate-student mobility across EU member countries. In addition, our respondents suggested that grants could be used to encourage innovative, higher-risk research to motivate researchers to think creatively or as seed money to help young researchers to set up their own research laboratories (as is done in the United States and increasingly in other places). Funds might also be used to leverage industry investment in the national research enterprise and promote university-industry research linkages. (See, for example, Appendix B, summaries 10, 11, 16, 20, 35, 48, and 53.)

Aside from funding research, respondents familiar with institutions in Japan also recommended funding to improve facilities and the workplace environment. While our respondents remarked that Japanese laboratories are generally well equipped and frequently have world-class equipment, the buildings that host the equipment and provide work and social space are not always world-class. A quality workplace, in the view of our respondents, can make Japan more attractive to international students and researchers and provide settings that can better stimulate social and professional interaction. (See, for example, Appendix B, summaries 8, 17, 20, 24, 27, 29, 30, 33, 36, 37, 43, and 45.)

CHAPTER THREE

Conclusions

While scientific research occurs in laboratories situated within national boundaries, the enterprise is increasingly globalized as individuals cross boundaries, physically and virtually, for education and work. Many scientific endeavors also require more resources than any single nation can provide, and scientific queries, too, are increasingly multinational in nature (e.g., climate change and marine science).

The feedback we received from our 55 respondents provides a view of the current state of S&T in Japan. Their individual impressions and experiences may be highly subjective and anecdotal, but there appear to be broadly shared views on major strengths and hindrances in the Japanese S&T system and where changes are most needed to improve excellence in Japanese S&T.

Building excellence is not something that can happen overnight. Financial resource input must be accompanied by determined leadership and a clear vision. Risks must be taken, and the battle against established ways and norms could be long and difficult. Japan's vision and actions via its basic S&T plans began more than a decade ago. Some changes are yielding good results and becoming visible to the international scientific community, as evidence by the data we collected. At the same time, judging by the feedback we received, much more needs to be done to make Japan more competitive, produce high-impact research, and be visible in the global science community.

The recommendations we received from our 55 respondents closely echo what we learned from the 52 scientists we interviewed for the 2004 study (Wong et al., 2004). For example, both groups commented on a perceived bias toward application-oriented research in Japan, that Japan generally excels in technology development, and that Japanese scientists are generally good (and some outstanding) and meticulous in their work.

Similar, too, are their criticisms:

- Japanese research lacks creativity and innovation.
- Japanese research is largely invisible in the global S&T community.
- Japanese students and researchers are not inclined to challenge orthodoxy.
- Young Japanese researchers enjoy little freedom and independence in Japan's hierarchical social and research management structures.
- Japan is not sufficiently attractive to foreign researchers.
- Lack of proficiency in English among Japanese students and researchers is a major barrier to international exchange and collaboration.

Differences in the observations of the experts we interviewed in the 2004 and 2008 studies lie mainly in the quality of specific observations (e.g., more respondents in this study reported seeing some positive changes in Japan in terms of more opportunities available for non-Japanese researchers to conduct research in Japan, a more visible effort by a few Japanese institutions to push their researchers to publish in international journals, and how the virtual absence of female researchers in Japan makes Japan a less attractive place to its own and foreign talent at a time when Japan's population is declining and the competition for scientific talent is a global phenomenon).

One item that stands out in this effort is how much more the respondents said about the rise of China (and, to a lesser degree, India) in S&T. Many respondents made explicit comparisons, such as how they have seen many Chinese students and researchers going to study or gain experience in research in the United States and Europe versus the small number who apparently come out of Japan. Our respondents also appeared to be much more aware of the significant investments the Chinese government is making to promote research and innovation activities in China, including its effort to recruit foreign-trained Chinese scientists to work in China.

In this connection, we also heard more from our respondents on their observations that India, Ireland, Portugal, the Netherlands, Spain, Sweden, and other countries have made notable improvements in specific research areas or on a nationwide scale in recent years. Their rise was not generally seen a threat to Japan or any other leading scientific countries. Rather, our respondents cited these examples to demonstrate what determined efforts and enlightened policies can accomplish within a matter of two to three decades and how capacity growth in these countries expands sources for ideas and collaborators beyond the global leaders in science, such as the United States, Britain, and Germany. Nevertheless, given the pace of change in the global scientific community, input from our respondents suggests that the pace of change in Japan, too, needs to hasten and that more deliberate and dramatic actions are important for Japan to remain an important player in the international scientific enterprise.

Finally, this research provides a view of some major issues in S&T from the perspective of a small number of leading scientists. While there is strong concurrence between our research results in the 2004 study and this one, an in-depth investigation of their observations would be needed to establish the validity of what was described to us and to properly characterize them. Similarly, the recommendations provided by our experts would benefit from additional research and analysis to explore whether they are appropriate and how they might be implemented to improve Japanese S&T performance.

Questionnaire for Interviews with Experts

1. ***What is the respondent's career, and what is his or her professional relationship with Japan?***
   a. Please provide a brief history of your career. What criteria guided your choice (your discipline, specific focus of research, institutions for which you work)?
   b. Have you ever considered working in a Japanese research institute, or have you worked in one?
      - If yes, why, and describe that experience (e.g., a six-month research fellowship or a three-year contract)? Were there any major problems or issues? Would you choose to work again with Japanese collaborators and institutions? Why or why not?
      - If no, why not (e.g., what kept you from choosing to work in Japan? Was it salary, budget, family reasons, visa issues, etc.)?
   c. What should be changed in Japan to encourage international R&D collaborations (e.g., from having international scientists and researchers working in Japan to joint R&D activities between individuals/institutions inside and outside of Japan)?
      - What should be the near-term priorities?
      - What should be the long-term goals?
2. ***What is the competitiveness of Japanese institutions in their own disciplines and research areas vis-à-vis other scientifically advanced nations?***
   a. From your perspective, which are the top institutions in Japan, and who are the top scientists or researchers in their disciplines? (Name them.) If you are not familiar with Japan, then which are the most improved institutions or countries in your field in the world in the past five years? Why?
   b. Where do you see changes in Japan—at the institutional and individual levels—in the past five years? Are they good or bad, and why?
   c. Where do you think that improvements should be made or had you expected them, and why?
   d. What are the indicators you used for your evaluation (e.g., direct experience working in a Japanese laboratory or reading results of Japanese research in major scientific publications)?
   e. Do you expect Japan to reach or stay in the forefront of your discipline or specific areas of research in the next five years? Why or why not?
3. ***How does the respondent think Japanese S&T capability compares with other scientifically advanced nations, especially at public research institutions and universities,***

with a focus on the items below? *(If respondent does not know about Japan, ask which countries or institutions are the best in the world or most improved in the past five years.)*

a. in infrastructure, e.g., quality and access
b. in human capital, especially in the quantity and quality of young researchers, scientists, and technical experts
c. in the management of organization, e.g., level of centralization
d. in the management of research, e.g., adequacy of personnel in numbers and quality
e. in national policy, e.g., on R&D funding
f. in producing groundbreaking research and commercializing research results.

4. ***What important or interesting accomplishments of Japanese scientific institutions—government, academic, industry—has the respondent observed in his or her own disciplines or research areas?*** *(If respondent does not know about Japan, then ask which countries or institutions are the most important or accomplished in the world in the past five years.)*
   a. What are they, and what makes them important or interesting (e.g., fundamentally changing basic assumptions or a groundbreaking innovation)?
   b. On what might this accomplishment be built—long-standing capacity or fairly new capacity built in the past five years?
   c. Is this accomplishment above or below what you would expect from Japan?
5. ***How does the quality of education in science and engineering at tertiary institutions in Japan compare with other scientifically advanced nations (such as the United States and the United Kingdom) and scientifically proficient nations (such as China and India)?*** *(If respondent does not know about Japan, ask what characterizes high-quality education in science and mathematics in the best-performing countries/institutions in the world in his or her fields, which countries or institutions have improved most in this regard in the past five years, and what might be near- and long-term priorities for a country to achieve excellence in this regard?)*
   a. What do you think are the strengths and weaknesses of instruction or training in your discipline and S&T in general in Japan (to go beyond curriculum to include culture and incentive structures)?
   b. Have you seen changes for the better or worse within the past five years?
   c. What do you think should be done to improve that quality?
      - near-term priorities?
      - long-term goals?

APPENDIX B

Summaries of Individual Interviews

The 55 summaries of individual interviews in this appendix provide a view of the responses we received from these experts. In the interest of confidentiality, we removed their names and other personally identifiable information. Nevertheless, we provide information on their category/field, where they are based professionally, their career point, gender, whether they are originally from Japan (that is, born, raised, or educated in Japan), and their level of professional experience in Japan or with Japanese research to provide a context in which to interpret the information we received from them.

Summary 1

Field and Subfield(s):	Life sciences; Agricultural science (1)
Location:	EU
Status:	Established
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	Low

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

Japan was rated as very competitive in biogenetics research. Japanese researchers were reported to be simultaneously using their strengths and growing expertise in areas in which they are weak. Japanese researchers were said to be particularly good in using informatics in production processes. However, in the subarea within biogenetics in which the respondent specializes, Japan was seen as lagging behind the world leaders despite producing some necessary materials, and he thought that Japan does an especially good job with ionic membranes. No individual top Japanese researchers were named, while Okayama University was cited as a leading world center in his specialized area of research.

France was regarded a leader in some areas of research in biogenetics. The respondent reported that his research group has been very satisfied with its partnerships with Japanese researchers, whom the group members considered to be extremely hardworking. After a decade of collaboration, the two sides agreed to have Japanese researchers visit his laboratory in France (though not the other way around).

Partnerships between academia and industry in Japan were seen as a particular strength for Japan. Such ties were reported to be much closer in Japan than in France, most of the rest of Europe, and the United States. Japanese researchers, we were told, also benefit from strong funding and a good level of administrative support.

On Japan's graduate education institutions, in the absence of concrete knowledge about it, the respondent thought they did a good job based on the high quality of Japanese scientists with whom he has worked.

Japan was expected to stay at the forefront in his specialization, but he thought that Japan needed to do better in biogenetics.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

Japan was not regarded as strong in establishing the leading topics or issues in an area of research. Rather, we were told, Japanese researchers tend to follow the leadership of other countries.

What are your recommendations for Japan?

The respondent urged Japan to send even more Japanese researchers overseas to gain new research experience.

Summary 2

Field and Subfield(s):	Life sciences; Agricultural science (2)
Location:	EU
Status:	Established
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	Low

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

In soil chemistry, Japan was ranked as a leading country, with the United States at the top of the list. Yet, he said that he had not seen any major research accomplishment in Japan in the past two decades.

The respondent expected U.S. leadership to become even stronger under the new U.S. administration. Strong institutions outside the United States, in his opinion, include the Technical University of Munich and Kiev University. In Japan, he said that there is a very good researcher at Nagoya University. He said that he knows Japanese peers via the International Union of Pure and Applied Chemistry (IUPAC). Having adequate research funding, in his opinion, is the most critical requirement for leadership in soil chemistry. U.S. researchers, said the respondent, have much better funding, and the United States has many more well-established institutions. He said that funding in Spain has improved significantly and that India is getting stronger, too. France, too, has strong funding, but it has fallen in the past decade. Germany has an excellent funding system, but funds are limited. For Italy, absence of a strong research policy has hindered its performance.

China, he thought, has strong potential to advance in soil chemistry research. Among others, China was said to have many more scientists working in soil chemistry than other countries. The next generation of Chinese research leaders in this field will have had graduate education and research experience in the United States and the EU. While current Chinese research funding is relatively low and the infrastructure remains basic, the respondent said that the launch of new research initiatives, the establishment of centers of excellence, and the diligence of Chinese researchers are all positive signs. He believed that China would become the world leader in soil chemistry in another two decades.

He thought that U.S. leadership in soil chemistry might not be sustainable, since nearly half of all Ph.D. students in the United States are not U.S. citizens and U.S. faculties are not growing. What he thought was keeping the United States a leader in soil chemistry is its infrastructure for research and the substantial funding available.

No comments were made on the quality of Japan's education system. In terms of the U.S. system, he did not think that U.S. schools did a very good job in teaching fundamental science, as students can narrow their focus to specific subjects early in their training. In his view, the first years of a student's education should be much broader. Also, he believed that the environment in the United States is so competitive that Ph.D. students frequently have no interests other than their studies and have no time for social activities or communication with others. The environment in Europe, we were told, is much more open and collaborative.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

Lack of proficiency in English among Japanese researchers was cited as the main problem. Although the respondent has seen improvement in the past 20 years, he believed that there remains room for improvement. Lack of proficiency in English among Japanese researchers was one of his reasons for choosing to visit the United States over Japan (another being Japan's distance from Europe).

What are your recommendations for Japan?

The main recommendation was for Japan to become more open. Our respondent said that Japan should welcome EU, U.S., and Asian scientists to do research in Japan. At the same time, he thought that Japan should become involved in international research programs, exchange of scientific visits, and collaborations. To successfully attract non-Japanese scientists, our respondent said that Japan needs top-quality institutions, excellent professors, and good infrastructure. Further, a first step would be to create a very strong fellowship program and publicize it worldwide to attract the best talent, and the fellowship must have competitive financial and nonfinancial incentives to attract researchers from the United States and EU.

The respondent emphasized that Japanese researchers must improve their proficiency in English and publish more in international journals. Japanese researchers should also be members of international associations and attend those associations' international meetings.

While creating centers of excellence may be useful, the respondent said that Japan should also invest resources in smaller research units that are scattered across the country doing niche research. In his view, centers of excellence have certain limitations: (1) they cannot grow beyond a certain size; (2) they cannot absorb smaller, more-innovative research units.

Summary 3

Field and Subfield(s):	Life sciences; Agricultural science (3)
Location:	U.S.
Status:	Established
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	Low

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

The respondent said that he was not well informed about agricultural science research in Japan so he could not comment on the caliber of research in Japan.

Internationally, findings on genetic traits of corn, soybeans, and cotton, as well as the development of natural insecticides, are significant advances, he said, because of their direct practical implications on how crops are managed.

He ranked the United States at the top of the field of agronomy, followed by Germany, France, and the UK. Australia and New Zealand were also said to be producing good research. He attributes U.S. strength partly to an emphasis on "mission-oriented research," which is intended to have a direct impact on the economy, and not just "research for the sake of research." Also, he said that federal and private funding in the United States has produced substantial advancements in genetics and improved management practices and that all this has contributed to a greater understanding of the roles of nutrients and tillage. He said that the U.S. Department of Agriculture had reorganized its competitive funding to focus on bioenergy crops, an emphasis that is also found in private-sector investment. Thus, in his view, a huge investment in research has propelled the United States to the top of the world. Yet, this leadership is now declining as federal funding falls flat or declines. He added that declining graduate enrollments would mean fewer people working in this field in the future.

In comparison, he said, China and India are emerging powers in agriculture research. In his view, these countries are developing their research programs by investing heavily in infrastructure, R&D, and collaborations with leading international scientists. He specifically noted that China, in particular, is working with experts in the United States and Europe to bring technologies to China for further development. He said that both China and India are producing many young scientists in this field and launching them into careers. China, in particular, he observed, is training many of its people overseas.

Argentina and Brazil were also said to be benefiting from significant private-sector support. These two countries, along with the United States and New Zealand, were said to have done a good job in commercializing their research. New Zealand, he said, has even removed subsidies for agriculture and created a privatized research system with close links to industry. In his view, this approach works work well in New Zealand because it is a small country with a small set of industries that can benefit directly from its scientific endeavors, but the New Zealand approach might not be transferable to other countries.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

He said that the language issue is likely a barrier for most non-Japanese researchers who would consider working in Japan, including himself.

What are your recommendations for Japan?

He said that scientists need, in addition to money, freedom to question and use ways they deem appropriate to their research queries. He said that scientists need to be allowed to fail and learn from their failure. If scientists are risk-averse, he said, they can generate only incremental advances. He believed that only when scientists take risks do they create new ideas and produce "wild ideas that pay." He said he thinks that the United States is moving away from such a system.

Next, he said, money can be used to motivate collaboration because scientists will go where grants are offered. For example, New Zealand's national fellowships pay for sabbaticals overseas. Such schemes, he said, are helpful because most professors cannot afford to pay for sabbaticals abroad. Another example he provided was the U.S. Fulbright Program that sends U.S. faculty overseas and brings foreign experts to the United States.

Finally, he said, students need to have good math and science skills and to be engaged in the process of science from an early age. He said that figuring out how to do this and keep this engaging for youths could be challenging. He saw that the U.S. education system basically "takes something inherently fun and exciting and turns it into something boring." In the early grades, he counseled, instead of learning science from a book with abstract concepts, students should go into nature and count and observe. He said that students should be encouraged to ask questions and look for answers on their own. In addition, he said, students could learn math and science by engaging with the world in which they live (e.g., equations can correspond to practical concepts). The overall effect, he said, is to capture the imagination and develop natural curiosity. He cited the "Planting Science" program of the Botanical Society of America as accomplishing this. He explained that this is an online mentoring program in which scientists work with middle-school students to develop and implement experiments. Further, he said, curriculum at the high-school and college levels could include food and nutrition and provide students opportunities for hands-on use of tools and concepts to get them interested in agricultural science.

Summary 4

Field and Subfield(s):	Life sciences; Biology and biochemistry (1)
Location:	EU
Status:	Established
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	Low

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

The respondent said that he has not noticed any change in the quality of research from Japan in the past five years, although he would be equally unprepared to detail changes in any country within such a time frame.

The only exception, he said, was Ireland, where he had seen significant investment in recent years, but research outcomes will take a few more years to become evident. He noted in particular Ireland's improvement in infrastructure and in recruiting young researchers who have completed their Ph.D. or postdoctoral work in the United States. He said that he does not know details about the Japanese education system. The main impression he had was that it stands out in teaching students to become members of groups rather than individuals. Overall, he said, how students are instructed could differ by institution and discipline. Many Western European countries, he said, appear to be more successful at the undergraduate level, while the U.S. system is stronger at the Ph.D. and postdoc levels.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

The respondent said that Japanese researchers seem to be a bit removed from the rest of the world—that is, there is little interaction between Japanese researchers and their peers outside of Japan. He said that he has had far more interactions with Taiwanese research groups than he has with Japanese ones. He said that there are Japanese colleagues whom he would meet at annual meetings, but he could not specify top scientists or institutions in Japan.

Another weakness, he said, might be the education system in Japan. While the system appears capable of produce top-quality researchers, he said the system produces group thinkers rather than individualists. In his view, this could hinder Japan's success to foster leading scientists who are capable of defining the important questions in the field.

What are your recommendations for Japan?

Overall, he said, having a good S&T policy can make a large difference in research outcomes. A key element of a good S&T policy, in his view, should be the establishment of a Western-style tenure system. He said that, in some places (e.g., the Netherlands), researchers get a permanent position without a "trial" period and might then be tempted not to do any more significant work until retirement. In contrast, in the U.S. system, researchers are first granted a temporary position to test them out. When tenure is not automatic, it gives more opportunities to younger researchers, and that merit-based competition is good for science.

For Japan specifically, he said that expanding exchange programs for Japanese and foreign students and researchers at all levels would be beneficial. He added that such exchange programs should begin as early as possible to improve English language proficiency, which is a bottleneck in international collaborations for many Japanese researchers. He said that programs that support two-year stay abroad for young researchers—with an obligation to return to Japan—would also be desirable, as would increasing attendance of and presentations at international meetings by Japanese scientists.

Finally, he said that Japanese research would benefit from having reduced hierarchies and "affirmative action" programs like those in many European countries, to increase the presence of women in science. In his view, flattening hierarchies and getting more women into science would take time—as the experience in Europe shows—but it would make a positive difference over time.

Summary 5

Field and Subfield(s):	Life sciences; Biology and biochemistry (2)
Location:	EU
Status:	Established
Gender:	Female
Nationality:	Non-Japanese
Professional experience in or with Japan:	Low

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

The respondent considered Japanese institutions to be well positioned in her field. Her opinion was based largely on her observations at the conference of the Society for Free Radical Biology and Medicine, where "there are always plenty of Japanese researchers attending [who] are delivering high-quality research." She was, however, unable to name any institution in Japan or any Japanese researcher that particularly stands out. She did not think that there have been any significant changes in Japan in the past five years. When she visited Japan, the infrastructure and other prerequisites for conducting research seemed to be very good.

Currently, in her opinion, the most successful country in her field is the United States, while Ireland is the country that has most improved in the past five years. Ten years ago, Ireland had poor infrastructure but very good undergraduate training, so people would leave for careers overseas. The Irish government changed the corporation tax to attract pharmaceutical and technology companies, which now employ many scientists. At the same time, Ireland undertook a drive to improve the scientific facilities, building new and very well-equipped institutes, and focused on recruiting researchers from all over the world, but targeting expatriates in particular. Salaries and research funds in Ireland have been very generous ever since. There were some starting difficulties, as the "old" people suddenly received large amounts of money and did not know what to do with it, but these problems were resolved after about two years, when researchers from abroad arrived.

She believes that the quality of education in Ireland is very high. She also mentioned Uruguay, where she believes that the quality of the students and their intellectual maturity surpasses that of the students in the UK. However, she suggested, this may be because students in Uruguay are older than those in the UK (e.g., obtaining Ph.D.'s at the age of 30, rather than 24).

What do you think are the weaknesses or hindrances to greater excellence for Japan?

During her visit, the respondent had one unfavorable impression of Japan. She had made the initial contact with the male Japanese researcher whom she and her male colleague visited in Kyoto. She suspects, at that point, he did not know that she was female. When they visited, he talked directly only to her male colleague and not to her.

What are your recommendations for Japan?

According to the respondent, the quality of people and institutions in Ireland has "incredibly improved" from ten years ago. She believes that Ireland, given the policies enacted by the Irish government, could be "a very good case study for any country that seeks to beef up its science and technology capacity."

Summary 6

Field and Subfield(s):	Life sciences; Biology and biochemistry (3)
Location:	U.S.
Status:	Rising star
Gender:	Female
Nationality:	Non-Japanese
Professional experience in or with Japan:	Moderate

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

The respondent rated Japan's research in biology as not only competitive with the best in the world, but also rapidly improving, with the potential to reach the top. She put Japan currently as fourth in the world in productivity and behind the United States, Britain, and Germany in innovation. However, barring economic collapse, she said, the United States is likely to continue its dominance in the field in the short term. To get to the top, she counseled, resources and innovation are essential.

China was said to be investing heavily in research to create preeminent research, with Chinese resources seeming to be very focused on supporting China's top researchers. Further, to improve its research programs, China is encouraging its people to study and train abroad. In her view, China's massive research investments, in money and people, could move China to the top position in the world.

As for Japan's scientific achievements, she reported that Japan has made key contributions to microscopy technology, particularly in the areas of atomic force microscopy and fluorescent techniques. She noted that these technologies did not originate in Japan. In her view, Japan is not a source of groundbreaking innovation but is good at building on existing technology and making it more accessible.

The respondent said that she would be interested in conducting research or taking a sabbatical in Japan to learn more about these techniques or to obtain technical training. She said that she values the emphasis on technological development in Japan and described Japanese researchers as efficient and eager to embrace technology. She believes that what she could learn in Japan would complement opportunities in the United States.

She said that significant research is being done at Kyoto University and at RIKEN, and she emphasized that RIKEN seems particularly supportive of the work of young scientists by allowing them greater independence in developing their research and in seeking collaborations. Kobe University and Osaka University, too, she reported, have good research programs, and a few particularly strong scientists in her field can be found at the University of Tokyo. In the case of the University of Tokyo, she said that established researchers appear to actively mentor young scientists.

In terms of resources in Japan, she reported her impression that at least some individuals seem to have good funding and access to infrastructure. She believes that existing Japanese programs to encourage international collaborations are having a positive effect and help to send many Japanese postdoctoral researchers abroad.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

In her view, it is a "cultural and not a scientific issue" that creates barriers to collaboration, so that she would hesitate to work for long periods in Japan.

One problem, she said, is the language barrier. She reported that, in her experience, Japanese scientists have good written English skills but are difficult to communicate with orally even if they can speak English. Also, she said that she is wary of how Japanese attitudes toward women might affect her. She said that these attitudes are reflected the relatively small number of leading female scientists in Japan. Also, she said that cultural mores in Japan make it particularly difficult for women to balance family and work.

An "anti-individualist" mindset, in her opinion, is another cultural hindrance in Japan's drive for top-level scientific success. She said that science is driven by individual creativity and that ambition drives scientists toward groundbreaking goals. She added that, when a culture does not reward these characteristics, excellence is elusive.

The Japanese system was described as very hierarchical. The respondent said that, when young scientists are constrained to work under more-established scientists, they may lack access to infrastructure or funding independent of senior researchers and that this might prevent them from pursuing their own research ideas. In a hierarchical culture, she added, any questioning of authority is also discouraged, making it even more difficult to take new directions in research. In sum, she said, the Japanese system "doesn't foster independence and creativity," both of which she believes are key components to scientific breakthroughs.

Japanese power structures and cultural deference to authority may also be deleterious to training young scientists. In her view, currently, most Japanese students do not question their mentors, simply doing as they are told, with the result that they do not acquire independent research skills. Also, students generally have little control over what they work on. She said one of her current students, a Japanese national, decided to go overseas to study because there is little room for creativity in Japan. Nevertheless, in some cases, the respondent said that the Japanese focus on team-driven research might be helpful for collaborative research.

What are your recommendations for Japan?

She said that Japan should take steps to reward innovation, particularly by young researchers. She cited the example of National Institutes of Health (NIH) grant programs that are specifically designed to encourage high-risk, innovative research. She said that, even if funds are limited so that only a small number of researchers receive support, it might still encourage a culture of innovation by showing that creativity is valued and demonstrate that mechanisms for funding higher-risk research do exist.

She said that Japan's research program would be improved if more opportunities were provided for younger scientists to branch out on their own and if funding—the criteria for which was difficult for her to lay out—was specifically provided for creative ideas. She reported that her impression is that most funding for students in Japan seems to be tied to researchers. She said that, if students have their own funding, they would be less beholden to their laboratories and could be more independent.

Collaboration, in her view, might also help to produce more innovative research. She said that broad-based government exchange programs that are well publicized, are inclusive, and have clear criteria for awards would encourage participation.

Overall, she said, she believes that the situation is improving for young Japanese scientists, and she sees them developing independent and successful research programs. To complement their scientific training, Japanese scientists should improve their writing skills, the instruction of which, she said, should be a part of formal training for all scientists in Japan (and other countries).

Summary 7

Field and Subfield(s):	Life sciences; Biology and biochemistry (4)
Location:	U.S.
Status:	Established
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	Low

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

The respondent rated Japan as doing high-quality research in molecular biology and genetics, but the United States and UK were said to be far ahead of the rest in this field. Depending on the subarea, Japan was said to rank third through tenth in the world. The respondent said that he has not noticed changes in Japan's research capacity over the past five years but that he might not know enough about research activities in Japan for changes to be apparent to him. He expected Japan to remain in the top tier of countries but not at the very top. In his opinion, Japanese scientists are "doing decent science."

His choice of the top institutions in Japan includes Kyoto University, Kobe University, and Osaka University. The three universities, he said, are a "research triangle that has been strong for a while." Kyoto University, he noted, is particularly strong in molecular and cellular biology; Kobe University, in developmental biology. He described Japanese research with stem cells as groundbreaking and credited Shinya Yamanaka for bringing Japan to the top of this area. Although not relevant to his field, the respondent identified RIKEN as a world-class institution for neuroscience.

China is moving up, according to the respondent. He said that the Chinese are improving their research capacity by sending many young scientists abroad for training and successfully bringing them back to China. He said that this contrasts sharply with Japan, whose number of Japanese postdoctoral fellows in North America seems to have declined over the past 20 years. The Chinese were also said to be investing substantially in infrastructure and research. Finally, the Chinese researchers were described as generally more aggressive and independent. These qualities, the respondent said, help to produce better research.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

The respondent said that cultural and language differences make it relatively difficult for foreigners to work in Japan. Also, he said that the structure at research institutions in Japan (and Germany) is more hierarchical than in North America. This makes Japan unappealing for young scientists who want to have scientific independence and access to their own resources.

Further, he said, research is "too managed" in the hierarchical system in Japan. The respondent took the view that "scientists are best when left to get on with their own thing." He described the hierarchical system as good for people at the top tier, who would get good access to resources. The downside of such a system, though, is that it could impede the discovery process if researchers are less driven to strike out in their own directions. Even in the case of the genome project, for which a team-centered approach might be expected to work well, he said, Japanese scientists were not particularly effective.

The respondent said that resources for successful research are available in Japan but again that the hierarchical structure makes it difficult for lower-level researchers to access them. He also commented that Japan, like most of the research world, is too concerned with translating research into industrial products. He noted that Americans do this well because they have different people doing their own specialized tasks, with venture capitalists involved in the commercialization processes.

Language is a barrier (perhaps the only one) to collaborations between people inside and outside of Japan. For the Japanese side, having the ability to communicate in English can make a substantial difference in a Japanese researcher's ability to have a presence internationally and allow him or her to engage in international collaborations. Also, he said, much of Japanese research is published only in Japanese, so that non-Japanese speakers are not fully aware of progress in Japan, and that this hinders engagement with Japanese researchers. For the non-Japanese side, language and cultural barriers make it difficult to work in Japan—though he thinks that it is generally difficult to get North Americans to leave for postdoctoral positions overseas in general.

What are your recommendations for Japan?

If Japan's S&T research is to improve, he said, Japanese education, beginning from the primary level, must encourage students to "question and challenge authority and assumptions." The respondent felt that the Japanese are very proficient scientists and well educated, better than Americans in some ways. However, he said, students in the United States are trained to be more independent, which he believes often makes them better scientists.

He commented that the Japanese reluctance to question authority or assumptions is related to the hierarchical structure and respect for authority that is present in Japanese culture. In training scientists, he emphasized that more time should be spent on experiments and less on learning facts. He added that the focus should be on identifying "what we don't know rather than what we do know," because future scientists will need to extend scientific knowledge rather than simply repeat it.

Summary 8

Field and Subfield(s):	Life sciences; Clinical medicine (1)
Location:	EU
Status:	Rising star
Gender:	Female
Nationality:	Non-Japanese
Professional experience in or with Japan:	Low

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

The respondent did not regard Japan as at the forefront of her research in molecular parasitology. She reported the presence of few research groups working on the area in Japan and that only the work by groups at the University of Tokyo deserve any attention. Considering Japan's size, she said, such numbers are far too low. She described researchers in Japan as committed and diligent and recalled her reaction to reading a Japanese research paper as "this [work] would have taken me a whole year!" However, she said that Japanese research lacks creativity.

While that may be the situation inside Japan, the respondent said that she knows of Japanese researchers who are established and doing well in the United States, as well as one who works at the Institut Pasteur in France. She said that this Japanese researcher told her that he left Japan because the hierarchical structure in Japan would keep him from pursuing his own independent research.

She ranked the top countries in her field as the United States, Britain, and Australia. She attributed their success to a combination of quality graduate education, funding, and links with the private sector. In her opinion, the U.S. system excels because it is large and researchers enjoy a high level of freedom and financial support. The European system, by comparison, is more rigid, and younger people usually work on problems identified by their supervisors or tutors and receive less-generous funding and timelines to conduct their work. She cautioned that, while the U.S. system may be seen as a model for emulation, she said that she believes that each country needs to design its own system, one that is sensitive to the financial, cultural, and other constraints that are present.

She highlighted Ireland as having made clear improvements in the past decade, although, she said, she was not well informed about the policies that brought about these changes. She said that the Irish presence in conferences and seminars, the number and quality of their publications, and the amount of money entering Ireland to support research are all impressive. She said that Portugal, to some extent, is following Ireland's example. Like Ireland, it is attracting a critical mass of young researchers from the United States and Britain who are very competitive at the international level. She said that Portugal's membership in the EU has also helped the country to improve domestic conditions to bring back to Portugal a critical mass of young and promising Portuguese scientists who have overseas education and work experience.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

Based on her experience interacting with Japanese researchers, she said, the education system in Japan probably does not foster creativity. For example, she described Japanese researchers with whom she had interacted as usually slow to question ideas and results.

She said that conclusions of a recent conference she attended in France on ways to improve research in Japan highlighted several problems: too many universities, too many universities doing the same things, "jobs for life," and too many organizations supporting science.

Another problem, she said, is the apparent absence of Japanese female researchers in her field. She said that it is very difficult for women in Japan to become researchers. Women, she said, are largely confined to being technicians, only because of concerns that they will leave their careers to become mothers. She said that a female Japanese scientist she knows who has done well in the United States is unlikely to obtain a leadership position in Japan. She added that she is disappointed to see women in Japanese laboratories not complaining about their treatment.

A final weakness she observed is that Japanese Ph.D. program graduates in her field do not seem to pursue overseas postdoctoral research opportunities. She thought that they did not do so because it would not help them to advance their careers in Japan. She said that the Japanese system is so hierarchical that additional experience as postdoctoral researchers probably would not help them to obtain better positions than as assistants under senior researchers.

What are your recommendations for Japan?

Funding is essential, she emphasized, because laboratories and infrastructure play substantive roles in her area of research. However, there is no one right way to fund research, because conditions differ in each country. In the United States, she said, research endowments play a big role; in Britain, charities are a major funding source, and she said that the Irish experience might also be worth examining.

Another priority, in her view, is to aggressively and immediately raise proficiency in English and improve communication skills.

An ideal system, in her opinion, would include (1) student access to scientists and researchers beginning at the undergraduate level; (2) money to attract the right people from all over the world; and (3) collaboration and exchange with the rest of the world so students and researchers could learn about different approaches to and cultures of science. She said that international collaboration and exchange, in particular, would help to foster creativity and a critical view of current ideas. She underscored that Japanese students and researchers should be exposed to different ideas and encouraged to question themselves. She described the European Science Foundation's perspective that science is universal, leading it to strongly support international collaboration. Such perspectives and funding opportunities in Europe, she said, might offer Japanese researchers opportunities for more international exchanges and collaboration.

Summary 9

Field and Subfield(s):	Life sciences; Immunology (1)
Location:	U.S.
Status:	Established
Gender:	Female
Nationality:	Non-Japanese
Professional experience in or with Japan:	High

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

In terms of productivity (number of publications), the respondent placed Japan in the top 20 percent of "research-developed countries." In terms of innovation (quality of research), Japan was rated only as belonging to the top 50 percent.

She said that there are several good universities in Tokyo and Kyoto, with Japanese leaders in the field, including Tasuko Honjo and Tadatsugu Taniguchi. She said that the Japanese leaders in the field of whom she is aware are all close to retirement. She said that she was unsure of the current state of the Japanese research program, partially because of her lessened contact with Japanese researchers over the past decade. In her opinion, the Japanese are less interested in immunology now and more focused on such fields as molecular biology and neuroscience. For instance, she reported seeing fewer Japanese postdoctoral research fellows in North America these days. She said that more students and postdoctoral researchers are coming to the United States from China, India, and Eastern Europe.

On major Japanese scientific achievements, she described Japan as doing high-level work in the cytokine field (e.g., cloning genes for certain cytokines) in the 1990s. She added that some interleukins were discovered in Japan (e.g., interleukin 5) and explained that these successes were often the result of joint work with the United States. She said that the best work in immunology is now done in the United States and Britain, with good work also occurring in such countries as Switzerland, France, and Australia. Countries that have strengthened their programs recently were said to include Switzerland, Italy, and France. The respondent said that she was not aware of the details of how these countries strengthened their programs but that she knows that they are training many people abroad and appear to recognize the need for more effort. She said that the economic downturn is depressing research efforts worldwide, and she expected people to leave the field as funding dries up.

The respondent saw the structure of research in Japan as very different from that in the United States, based on her interactions with Japanese scientists who are heads of laboratories. She described the structure in Japan as having "emperors" run laboratories. In her view, individuals work for little pay under their leaders, merely "do as they're told," and are more eager to please and produce data than to have their own opinion. In such settings, laboratory directors produce almost all the creative ideas. Further, she said, she has not seen leaders helping those beneath them to rise up and expand their skills. Thus, a highly hierarchical system, in her view, is a limitation of the Japanese research program. She said that "fighting about things" (that is, competition of ideas) rather than "respecting the boss" is more conducive to producing creative research.

She described Japan as extremely strong in efforts that require strength in numbers because Japan has many highly efficient workers. Thus, Japan has found research success in molecular biology, genetics, and drug screening. In fact, in her opinion, it is hard to compete with large Japanese groups in manpower-intensive efforts. However, she said, Japan is less successful at projects that require innovation and creativity.

She said that she was unable to comment in detail about the availability of infrastructure in Japan. Although it appeared to her that many researchers have access to high-quality equipment, she was unsure whether these resources are available to all scientists or just to those in the top-tier laboratories. She also professed little knowledge of other elements of the Japanese research system other than knowing that industry research efforts have also produced payoffs. She said that companies in Japan are more willing to set up an institute and let it run independently than is the case in the United States and that academic and industry research ties in Japan help the commercialization process. She said that U.S. firms tend to keep their research efforts in-house and that some policies of the U.S. Food and Drug Administration can hinder commercialization. Fewer regulations in Japan, in her view, present less of a bottleneck in commercializing research results.

In general, the respondent believed, the major Japanese contributions were achieved through great force of effort rather than through establishing a new way of doing or looking at things.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

In her view, language and culture—specifically, biases against women—are the largest barriers to increased collaboration. She reported experiencing language and communication problems with Japanese researchers, whom she viewed as often less eager to share research details than Western scientists. She said that young Japanese researchers would benefit from spending time overseas to improve their English language and communication skills. During her visits to Japan and in her interaction with Japanese researchers in conferences and NIH panels, she also said that women were treated very differently than men and often excluded from activities. In her own experience, she was not invited to some social events, but her male peers were. Since it is extremely difficult to change culture, she believes that younger Japanese researchers should be encouraged to work in foreign laboratories to push them to think creatively rather than just doing the work.

Also, she said, the competitive and male-driven culture in Japan makes it extremely difficult for women to become researchers. She said that she does not know of any female scientists in her field in Japan and that Japanese female postdoctoral researchers she knows do not seem to stay in the field because women are often "not allowed" at the top levels. She said that discrimination against women, in her view, means that Japan is not using half of its creative workforce in science.

Given these problems or issues, the respondent said that she would hesitate to work in Japan, even for a sabbatical position.

The hierarchical research structure in Japan was also described as a barrier. Thus, she did not believe that she would be able to undertake independent research if she were in Japan. The emphasis on respect for authority, in her view, does not encourage creative alternatives in problem solving or thinking about new problems. She said that it is difficult to teach people how to be creative and challenge authority. Even in the United States, it has taken some time. In U.S. universities, she said, junior faculty doing creative work can inspire and be role models to students. She believes that, in Japan, persons in positions of authority feel less comfortable asking junior people to challenge current thinking. She said that this is less the case in the United States.

What are your recommendations for Japan?

To inspire more innovation, she said, young Japanese scientists need to be educated differently. Since culture changes slowly, having more Japanese scientists train abroad—even if it is only a part of their Ph.D. program—would help to introduce to Japan a new culture of creativity. If this process is allowed to thrive, she said, it might spur a greater emphasis on innovation and encourage more Japanese researchers to do more creative projects.

Summary 10

Field and Subfield(s):	Life sciences; Microbiology (1)
Location:	U.S.
Status:	Established
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	Moderate

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

The respondent thought that Japan's research in marine biology was good but not top tier in quality. Notable research was said to occur at JAMSTEC, and Ken Takai was named a young and up-and-coming scientist.

Japan, surrounded by the sea, was said to have a long tradition of studying marine biology and investing in infrastructure (e.g., recently, in a deep-sea drilling vessel). The "stereotype" of Japanese technical expertise rung true to him (i.e., Japanese researchers "pick up technology and run with it" but are weaker in innovation). He found Japan stronger in implementation and development of existing ideas.

The United States, Britain, and Germany were identified as the leaders in his field. U.S. leadership, he said, had resulted from strong funding, but support has been falling and the old infrastructure is deteriorating. Bottlenecks in data storage and analysis also demand a new computational infrastructure. Further, the United States suffers from gender inequality in his field and underperforms in some subareas (e.g., environmental research and blocking research into stem cells). Finally, he thought, the big U.S. laboratories (e.g., those run by the U.S. Department of Energy [DOE]), can be extremely effective in their focus on big questions, but they can be beset with problems in management, personnel, and quality control, so that sustaining excellence is never guaranteed.

Notable improvement was observed in research programs in Chile, Brazil, and Mexico, among others. Their improvement, the respondent said, resulted from their deliberate import of knowledge by inviting experts from abroad to teach summer courses and sending their students overseas for education. These countries may not enjoy the same financial support and infrastructure as the top countries, but, he said, they are doing a great job at achieving targeted goals. Their emphasis on applied S&T, in this case, supports their development goals (e.g., genomics for agriculture and oceanography for managing fisheries).

He also said that the United States does well in commercializing research in established areas (e.g., engineering). In other areas, the United States still has to determine how to commercialize research without allowing "silly patents," such as for each and every gene in molecular biology, pharmacology, and other growth areas. Another challenge, in his view, is in identifying real innovation, and trying to commercialize everything could bog down the system and generate little profit for investors and the scientific enterprise as a whole.

Therefore, he said, the U.S. government must be careful to make sure innovation serves practical purposes (e.g., funding for human health research via the NIH). Funding for basic science, in his view, is also important because it is often difficult to predict where the next major innovations will come from, adding that many high-impact applications do not come from applied science. Thus, President George W. Bush's efforts to bolster basic science through programs of the National Science Foundation (NSF) and DOE were beneficial.

In his opinion, much of the innovative and top-tier research in the United States comes out of academia, so that the U.S. university system is the dominant player in research activities. Although the system is competitive and professors get a lot out of their students, he was uncertain how elements of the U.S. system (e.g., national laboratories) might transfer or translate to another system. He said that another model that seems to work well is the one used by the Max Planck Institute in Germany, which focuses on specific topics, provides strong funding, and uses the best people to manage projects to produce high-quality work in the targeted areas. In his view, the Max Planck Institute is more flexible in how it approaches research problems than the national laboratories under DOE.

He said that he would consider a short-term sabbatical in Japan because he believes that Japanese researchers are doing some very interesting work and that Japan has, in particular, innovative programs in deep-sea biology. Further, he said, he values the potential access to useful technology (e.g., oceanographic platforms) in Japan. Outside of research, he said that he is also interested in firsthand exposure to Japanese culture.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

In his view, Japan's research is not as strong in terms of innovation. He said that private research laboratories that are run like industrial organizations have the advantage that the director can steer the ship. However, he said, this setup is good for strategic targeting but not necessarily for innovation, and added that engineering responds better to a top-down approach than science, which needs more "wiggle room" for innovation. Thus, he said, giving researchers funds and freedom to conduct independent research is a better model for innovation.

What are your recommendations for Japan?

The respondent had several thoughts.

First, he said, having mixed approaches can be helpful in promoting S&T—specifically, attack important, difficult problems with a top-down approach, and simultaneously allow independence in research (bottom up) to create innovation.

Second, he said, research programs need to recognize that many important questions extend beyond traditional disciplinary boundaries. While the United States has done well in developing research and education side by side, and universities have done so within disciplines, he said, they have not done a good job at expanding boundaries with interdisciplinary programs. He gave the example of climate issues, which, he said, need to be dealt with from the perspective of many disciplines, such as computer science, planetary science, geology and oceanography, and others. Further, both research and education need to cross disciplines. He said that one way to accomplish this would be more flexibility in evaluating young faculty for tenure beyond the traditional boundaries of disciplines.

In this connection, he said, collaborative research might help to foster interdisciplinary research. In his view, top-down programs could work in some instances (e.g., a program in Singapore that targets researchers at top institutions worldwide and invites them to spend six months to a year in Singapore). However, such programs can create problems for the sending institution when researchers on leave might need backfill to teach their classes or assume other responsibilities. On the positive side, participants in such a program, he said, could learn from the experience of working with other participants and produce work together.

Nevertheless, he said that collaborations are often best when they originate from the bottom up—that is, when individual researchers find useful partnerships on their own. In his view, bottom-up collaborative processes often create the most-complementary collaborations. He added that incentives for bottom-up collaboration could help (e.g., a program in Spain makes international collaboration a requirement for research grants and researchers identify their own collaborative partners). Collaborative elements might also include partners visiting each other's laboratories and sending their students to train in a partner's laboratory. He said that there are mechanisms in the EU that encourage collaboration between laboratories in member countries that are more advanced scientifically with those that are less advanced scientifically. He added that such types of multi-institution collaborations can be exciting and fun.

However, communication across institutions can be difficult, even with virtual meeting technology. He said that improving how information technology is used to support collaboration would be helpful. In his experience, today's approaches are not good enough, so researchers must physically travel to effectively communicate in person. If virtual collaboration could be more easily facilitated, research, industry, and education would all benefit by allowing people to share ideas, have more-fruitful interactions, and doing it in a less costly way than traveling.

Summary 11

Field and Subfield(s):	Life sciences; Molecular biology and genetics (1)
Location:	U.S.
Status:	Rising star
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	Moderate

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

The respondent rated Japan as excellent in genomics (e.g., its contributions to extensive expressed sequence tag sequencing). Another noteworthy Japanese achievement, he said, is the development of the silk moth as a model organism. In many cases, he said, Japan's achievements in genomics resulted from Japanese scientists holding to their original plans despite skepticism. In the United States, he said, choosing to use alternative approaches might not have secured funding from agencies.

The respondent named RIKEN and the University of Tokyo as the top institutions producing high-quality work—for the former, despite its small size. He said that Japanese universities are generally producing good work but that the top-quality work in the biomolecular sciences is found in the United States and is substantially better. In the biomolecular sciences, he ranked the United States at the top, followed by the UK and Germany, then Japan in the fourth position. In Europe, he singled out the European Molecular Biology Laboratory (EMBL) as a top institution.

He said that each top country has its own strength and that, for the United States, it is its infrastructure and its ability to attract high-quality young scientists from across the world. Nevertheless, he said, researchers outside the United States have superior quantitative skills.

China was seen as rising in the next 20 years. He said that methods by which China is developing its research capability include training people in the United States and successfully recruiting them back to China by giving them more money than U.S. institutions can afford. Also, he said, labor costs are cheaper in China, so research money goes further there. In interactions with young Chinese scientists, he sensed, they have a greater irreverence to authority than their Japanese peers. He hypothesized that China's one-child policy produces the same kind of "spoiled child" that American wealth does. These individuals, in his view, might be driven to succeed to gain the attention of their mentors or to prove their own ideas correct.

He also saw Singapore as an emerging research power, especially relative to its small size. Singapore, he said, is finding success by "throwing a large amount of resources at the problem," importing the best scientists by providing them with tremendous amounts of funding along with good infrastructure.

He said that he would consider spending a sabbatical year in Japan but that such a decision would be driven more by his interest in Japan and its culture than the appeal of doing science in Japan.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

The respondent said that he believes that Japan's research program is at a decision point at which quality could either improve or get stuck at its current level. He said that there are two large problems that Japan must overcome.

The first major problem is the old-fashioned European system that Japan adopted. In this system, he said junior people are "subjugated" to senior researchers. When junior scientists are not fully independent, they are unlikely to be as creative as they could be. In Japan, he said, junior researchers are never fully rewarded for their creativity, because senior researchers always take some of the credit. In addition, there is a disincentive to take risks—or for the senior researcher to allow it—because, if the experiment does not succeed, the senior researcher's reputation suffers as well.

The second major problem, in his view, is Japan's failure to treat female scientists as equals. He said that, when he visited Japan, several female scientists told him about their poor treatment. In his opinion, how females are treated in Japan would be considered sexual harassment by American standards. This discrimination of women, in his view, diminishes Japan's talent pool by half.

Other than these two problems, he said, the traditional Japanese social structure restricts maximum creativity from its graduate students. The system, in his view, promotes higher levels of respect for the professors than they deserve. He said that he encourages his own graduate students to "seek out opportunities to prove" him wrong. This openness to challenges and new ideas, he said, is a strength of American laboratories. He added that such openness is essential to good research because progress results from researchers who dare to "push on ideas to see if they will stand up to additional testing" and to synthesize components into more-comprehensive ideas and better explanations. "A good scientist is a skeptic," he said.

What are your recommendations for Japan?

He underscored that high-quality research programs must have a peer-reviewed grant process in which funding is controlled by scientists and determined by scientific merit rather than a government mandate to do certain types of work. When government mandates research agendas, there is a great deal of waste when researchers sacrifice their research focus in the pursuit of funding. Europe, he said, does well in its grant process, citing that European funding agencies do not generally place onerous emphasis on preliminary data, something required by many U.S. grant programs.

Collaboration, he said, is important both with internal and external partners. He said that he chose to work at his current institution because of its highly collaborative and collegial environment, in which people like each other and learn from each other. (He said that he was also offered start-up funds for his research and that he has good access to equipment.) He added that there are many opportunities for collaborations, to the extent that he rarely collaborates outside of the institution. He said that having collaborators located nearby has contributed to successful projects. He said that his institution also allows researchers complete academic freedom. Further, like most other research programs in the United States, people are hired because they are bright and are good scientists, not because they fill a preordained niche. This, in his opinion, allows creative exploration and the ability to change fields, as he did.

He said that structured grants should be created to foster international collaborations. The respondent suggested that money should be made available to all parties, contingent on an international collaboration. Travel funds should also be included. A good model, in his view, is the Keck Futures Initiative of the National Academies in the United States, in which funds are available to both collaborators as long as they are from different disciplines.

There should also be a willingness to invest in long-term projects. The respondent said that Japan should further invest in infrastructure. For example, the University of Tokyo has the right equipment but is visibly underfunded for general maintenance, which he summarized thusly: "The labs were nice but the hallways were not." In the United States, he said, the best institutions know that good aesthetics can be a powerful recruiting tool.

Academic positions should be dictated by scientific merit. Japan should, he said, make assistant professors independent in the U.S. style, giving young faculty their own laboratories and research funding and thus having them take their own risks and rewards. This setup of the U.S. system, in his view, is a major contributor to the success of the U.S. research program.

Independent research opportunities, he added, are also important as part of undergraduate education to give students a sense of what science looks like, especially with respect to the social environment of research and what research demands in terms of lifestyle compromises. These experiences allow undergraduates to get used to being with people who are intense and discussing science all the time. Students, he said, would also begin to feel like they are members of the scientific community, which can motivate them to work hard to produce good research.

Teaching could also be improved by emphasizing history in addition to quantitative skills. Scientists, in his view, should learn more about the historic work in their discipline. Knowing about the hard work and success of others can provide the courage to perform long, difficult experiments. Students need to recognize and be able to deal with the fact that most experiments fail. This kind of education, he said, can "create a scientist by teaching them not to give up, and then give them skills to make the odds of success a little better." As for quantitative skills, he remarked that even observational science is quantitative, so knowledge of statistics is crucial.

Summary 12

Field and Subfield(s):	Life sciences; Neuroscience and behavior (1)
Location:	EU
Status:	Established
Gender:	Female
Nationality:	Non-Japanese
Professional experience in or with Japan:	Moderate

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

According to the respondent, Japan is "a serious player" and "really brilliant" in neuroscience. In her view, Japan recognizes the field's importance and funds it well. Japan, she said, is likely to remain at the forefront of the field. She said that the top people in Japan include Msaso Ito, Tetsuro Matsuzawa, and Susumu Tonegawa—the latter she described as "very imaginative." She said that she knows of many Japanese neuroscientists, whom she met in the United States, at RIKEN, or at neuroscience conferences. She noted a recent experience at a conference in which a University of Tokyo researcher approached her and asked a "brilliant" question. She said that she was impressed by his forthrightness and appreciated his lack of reserve and that this inspired her to explore the possibility of collaborating on a shared interest.

She said that she has seen Japan reaching out to bring in researchers from other countries in the past five to ten years, rather than hiring only Japanese nationals for scientific and academic positions. This mix of international people, in her opinion, is absolutely important because people teach one another things and learn by "having tea, rubbing [elbows], sharing offices, [all of which] is tremendously broadening."

Discussing the field's innovation in general, she said, she has seen "progress around the fringes" but no answers on central issues, such as central nervous system organization. Further, research is generally funded for minutiae but not the big questions, which, she said, is a problem for an emerging science like neuroscience. For instance, she said, the big questions cannot be answered without studying monkey physiology, which people have done since the 1950s, although techniques are constantly improving.

Canada, in her view, is "doing pretty well, smart enough not to go to war so they have more money to put into science." Italian researchers have also shown signs of improvement. In these cases, researchers are not under as much pressure as they are elsewhere to write grants and publish, so they have time to think, converse, and "chew on ideas with you." As for the UK, she said, the country has "put in a huge effort" in improving its infrastructure.

As for the United States, she said, the NIH has become sensitive to the need to do more for young scientists. She said she could see senior scientists in the United States undermining the entire system if things did not change. She described the NIH granting system as notoriously conservative and unwilling to fund innovative projects. She said that she does not know whether the situation is similar in Japan but said that she would be "surprised if Japan doesn't fall victim to similar habits."

What do you think are the weaknesses or hindrances to greater excellence for Japan?

When the respondent visited institutions in Japan to give talks and attend summer events, she said, she found it "always very difficult to interact in such a short time." She surmised, "[T]his may have been misperception on my part." At her own institution, she said, people "wander in to tea and have interesting discussions—things are a hive of activity even at 10 p.m.," whereas she did not have that feeling in Japan, where people are very proper and reserved.

She said that some of these difficulties may be cultural (e.g., professors hold chairs for life so that younger professors do not have much chance for promotion until the old professors die). As result, she said, young professors "kowtow to the [old] professor and follow in his footsteps, read what he writes, do what he does." Such, she said, is the situation in Germany; as a result, little good work is done in Germany. She said that this very rigid hierarchical structure needs to change and that one option may be to identify people who can bridge areas of research and have a vision of what the big questions are. She said that she is not aware "if anyone in Japan fills that role" at present.

What are your recommendations for Japan?

The respondent said the most productive research environment is one that is "open, where you can talk to anybody and there is no sense that one is famous or just a graduate student." In her view, this type of environment stimulates productivity and provides innovation, and partnerships form when people realize they have similar ideas and can do new and interesting things together.

Summary 13

Field and Subfield(s):	Life sciences; Neuroscience and behavior (2)
Location:	U.S.
Status:	Rising star
Gender:	Female
Nationality:	Non-Japanese
Professional experience in or with Japan:	High

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

The respondent did not think that Japan was doing well in psychology research and said that no Japanese institution stands out. She said that she thinks that Japan is more innovative in such areas as physics, math, and engineering.

She said that all the notable Japanese researchers in psychology of whom she knows have left Japan, mostly moving to the United States for higher pay, for better research opportunities, and to escape the hierarchical system in Japan. She cited the example of a U.S.-trained Japanese scientist who pioneered the subarea of cultural psychology in Japan. Yet, today, she said, most work in this area occurs at the University of Hong Kong, the Hong Kong University of Science and Technology, and Peking University.

She ranked the United States as the leader in psychology research. The top research institutions include Harvard University; Columbia University; New York University; Cornell University; Stanford University; Yale University; the University of California, Los Angeles; the University of Illinois; and the University of California, Berkeley. After the United States, the other leaders are Hong Kong, China, and India. In these parts of Asia, she said, work at the Chinese University of Hong Kong stands out. She added that the UK, Poland, and France also produce high-quality work. She said that she expects European countries—France in particular—to improve greatly. One reason for her thinking is the expanded research and exchange relations these countries have with the United States. As a caveat, she noted that research at the top institutions is constantly improving, so she could not comment on which is improving the most. As for education in the field of psychology, she said that the Max Planck Institute in Germany has made the greatest improvement in the past five years.

She said that she does not expect Japan to reach the forefront of the field in the next five years because, in her view, Japan does not value psychology or the social sciences in general. She cited as evidence that the best research is published in U.S. journals, which require proficiency in English to write papers for submission—a weakness among Japanese researchers.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

She said that, when university admission rather than performance in a university program is the key determinant for graduation, the system will not produce high-quality students or researchers.

What are your recommendations for Japan?

Near-term priorities, in her view, should be faculty exchange programs between U.S. and Japanese academic faculty. Alternatively, institutions in Japan could try to attract foreign researchers to come to Japan, but, she said, this may be more costly. Also, she commented that most foreigners are "taken aback by Japanese culture." Therefore, in her view, Japan needs to identify those who will take time to understand the Japanese way and not try to impose their way on the Japanese system. Building strong working relationships, she said, takes time and having open-minded people on both sides willing to learn cultural differences.

Education is also important, and academic faculty must be well trained. Japan, she said, could send students abroad and recruit them back to teach. In her view, Singapore, for example, does a good job in sponsoring its citizens to go abroad in exchange for agreeing to teach in Singapore. Also, university students should not just be taught to perform rote memorization. With the proper training, faculty can teach students in more-creative ways. For example, allowing students more "structured freedom" and giving them permission to be creative will ease their fears of negative repercussions from trying out new ideas.

The respondent also urged for changes to Japan's research funding mechanisms. From what she saw in the 1990s, she said, the mindset could be summed up as "give it to your buddies and people who are old." She emphasized that Japan needs to reward young researchers, as is done in United States, India, and the EU.

Finally, in terms of producing groundbreaking research, in her view, the Japanese are more inclined to think more about improving things, like making them more efficient and cheaper, than about coming up with brand-new ideas. Such a mindset, she said, is not conducive to doing innovative research.

Summary 14

Field and Subfield(s):	Life sciences; Neuroscience and behavior (3)
Location:	U.S.
Status:	Established
Gender:	Male
Nationality:	Japanese
Professional experience in or with Japan:	Moderate

What is the overall competitiveness of Japan in your area(s) of research and, in general, what are Japan's strengths in research?

The respondent rated Japan as not highly competitive in his field. He said that, on average, Japanese university departments in his field are low in quality but that there are a few good researchers in Japan.

He said that training in the hard sciences is one of Japan's strengths. Japanese universities are very selective, and the sense of discipline that permeates among students in Japan prepares them for training to do sophisticated work in science.

The respondent named RIKEN as the "only attractive place" in Japan for research in his field and where he would consider working, because it is well funded by the Japanese government and supports research in a broad range of areas. This, in his view, allows researchers more freedom to pursue their research interests. He added that senior researchers who desire prestige as a "professor" may not choose to work at RIKEN because this title is not given (nor is it at Max Planck Institute in Germany).

What do you think are the weaknesses or hindrances to greater excellence for Japan?

Lack of proficiency in English, in his view, is the biggest barrier, and cultural barriers also hinder international collaborations. Japan, he speculated, seems to have a weakness for foreigners and a cultural desire to maintain peaceful personal relationships (*ninjo*, in Japanese). For example, in his opinion, foreign researchers are almost always treated as guests and are never integrated. He said that this mentality and a refusal to integrate non-Japanese discourage foreign researchers from seeking careers in Japan.

Also, he said, he found that foreign researchers who are mediocre performers are allowed to stay on their jobs in Japan because Japan does not want to discourage them from coming to Japan. Japanese researchers who are mediocre performers, too, are rarely dismissed.

At an institutional level, the respondent said, there is a lack of support for young researchers. This undermines their independence to pursue research that interests them. A hierarchical social structure in scientific research, in his view, does not allow Japan to fully benefit from the quality of science education training in the country.

Finally, regarding training, the respondent said, graduate studies in Japanese universities are not as well organized as in U.S. universities, with their requirements of qualifying exams, required courses, and the like. (Ph.D. students in the United States typically must take these exams to demonstrate mastery of a subfield or subject before they are allowed to enter the dissertation stage of a Ph.D. program.)

What are your recommendations for Japan?

The single most important thing, he said, is to improve proficiency in English among Japanese researchers. Having more native English speakers teaching in Japan, mostly at the high-school and college levels, is helpful. Another recommendation is that Japan must integrate non-Japanese researchers into the Japanese system. Non-Japanese researchers, he said, cannot be seen only as short-term fellows or visitors. Also, longer-term exchanges between researchers and institutions might help to lessen cultural barriers to foreign collaboration. Finally, he underscored that funding, promotion, and tenure decisions should be based on merit rather than relying on personal relationships. In his view, the Japanese bureaucracy currently has too much power in determining the distribution of research funds, and the personal relationship carries too much weight (e.g., professors can personally negotiate for research money with government officials). Using merit as the central criterion for funding decisions would force mediocre researchers to move aside and allow good young researchers to move up. In this connection, fair and high standards for tenure appointments, which, he emphasized, are currently "not rational," should be implemented.

Summary 15

Field and Subfield(s):	Life sciences; Pharmacology and toxicology (1)
Location:	U.S.
Status:	Established
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	High

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

The respondent placed Japan among the top five in research in pharmacology, describing its research as "very good." He ranked the United States, the UK, China, Japan, and Singapore at the top, with China, India, and Thailand on the rise. Political decisions to invest heavily in pharmacology and related areas, he said, are rapidly developing research programs in these countries. He added that China is starting to achieve higher quality by emphasizing merit-based performance, professional mobility, and reward for achievements and that India, using a similar approach, is also producing good results.

The competitiveness of Japan's research program, in his view, has remained fairly constant. He said that Japan has produced outstanding accomplishments in molecular cloning, transgenics, and drug development. In general, he said, Japanese advances tend to be technical in nature and not particularly innovative. Also, infrastructure in Japan is quite good overall, but the quality of its human capital is more variable. The top institutions in Japan he named include the University of Tokyo, Kyoto University, and Fukuoka University, and a notable high-achieving scientist is Gozoh Tsujimoto of Kyoto University.

The respondent said that he has a few long-term collaborators in Japan and consulted for a Japanese company, which has allowed him to travel extensively in Japan. He said that he collaborates with his Japanese peers because of the quality of their work and that their work complements his own.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

Research management, in his view, is a major problem for Japan. Like the rest of its society, Japan's research structure is very rigid. Although he believes that it is improving, he says that Japan needs more flexibility in its research structure. Currently, those in high positions cannot be removed, and everyone below these individuals is subordinate to them. He said that the U.S. approach is better for research development and noted that Europe has some problems similar to those in Japan.

Similarly, he said, the highly homogeneous and hierarchical nature of the Japan's educational system makes it difficult for students to think outside the box.

Finally, he said, there are cultural barriers for foreigners interested in working in Japan. He said that he would not consider a long-term stay in Japan because of cultural differences. He explained that he does not feel comfortable in Japan partially because he finds Japanese body language difficult to read and because Japanese people are so polite that it is difficult to know what they are honestly thinking.

What are your recommendations for Japan?

Good science needs competition, he said, and he added that "you want the best people to go up and others to go down." He said that it might help to limit tenure for senior positions and make merit the central criterion. Less productive researchers can then make way for more-productive younger people. In his view, Japan needs to "rebalance" with "people who are currently productive over people who used to be."

Japan could also foster more creativity by encouraging more individual interactions with outside cultures. He picked the United States as a successful model of education, one that gives students more independence, supporting their "crazy ideas" and letting them fail as a part of the learning experience. In Japan, he said, students are considered successful if they do what they are told, but "this does not make good scientists."

He said that the rigidity of Japan's education system might also be reduced by having non-Japanese enter the education system. The infusion of outside attitudes might help to break down existing norms in Japanese culture and society. To do this, he said, Japan would need to hire more foreigners and participate in more exchange programs, and he added that exchange programs in which Japanese students work abroad and foreigners come to work in Japan might also be a useful approach to developing research programs.

Foreign collaboration and exchanges would benefit Japanese research, too. Science, he emphasized, is best done collaboratively. Since Japan is a small country, opportunities for domestic collaboration are limited. Japanese institutions should therefore "strengthen their outward ties." In expanding recruiting for non-Japanese researchers and faculty, he said, their lengths of stay in Japan should be extended. In his view, for researchers to do any significant work, their lengths of stay should preferably be at least one to two years.

Summary 16

Field and Subfield(s):	Life sciences; Plant and animal science (1)
Location:	EU
Status:	Established
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	High

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

The respondent ranked Japan as among the top five countries in the world in his subfield, with the other leading countries being the United States, the UK, Germany, and Sweden or France. He said that he has worked at RIKEN and at other Japanese institutions. These collaborations, he explained, were motivated partly by his interest in the work of some Japanese researchers whom he regards to be very competitive on a global scale. At these institutes, he said, he found the facilities and the levels of funding to be good. He described the researchers as very well prepared and said that they publish regularly in the field's top journal. The top Japanese institutions also have high-quality graduate programs, where classes are taught in English and high-quality students go to foreign institutions for training and experience. His own university, he said, is in the process of hiring five or six Japanese Ph.D.'s in his department, all of whom are very well trained and knowledgeable.

He said that he does not see any compelling improvements in other countries in the past five to ten years that deserve to be mentioned and said that he expects Japan to stay at the forefront of the field in the coming decades.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

The respondent highlighted several points.

First, he said, international collaborations have been a consistent weakness of Japan in recent decades. Despite advances in communications and the Internet, collaboration between Japan and the rest of the world has not dramatically grown, as he would have expected. Part of the problem, in his view, lies in the absence of specific policies at the national or institutional level to foster collaboration. International collaboration endeavors are instead driven by personal initiative—that is, by researchers who are interested working with specific Japanese institutions or researchers. Of course, funding is needed, and it has been consistently scarce.

Second, language is another problem hindering international collaborations. The experience of other non-Japanese researchers informed him that one needs to speak Japanese to have in-depth interaction, and, in his view, Japanese is a very difficult language to learn. Most students in Japanese institutions are Japanese, and non-Japanese students are rare.

Third, Japan is not doing well in commercializing research results. Commercialization of research results in his area (e.g., selling patents) could be a good source of revenue to fund research.

What are your recommendations for Japan?

He said that Sweden does a good job in commercialization and might be a model worth examining. Researchers own the intellectual property rights for their work—not the university or Sweden. This kind of arrangement incentivizes researchers to pursue research, and it has helped Sweden to become competitive in the field. In Sweden, private or enterprise funding can also be important to support research. He was not clear whether Japan had something similar in place. Finally, he said, Japan needs to invest in developing its researchers.

Summary 17

Field and Subfield(s):	Life sciences; Plant and animal science (2)
Location:	EU
Status:	Established
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	Moderate

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

Japan was said to be in a very good position at the international level since the 1970s. The quality of Japanese research was described as comparable to that in the United States and Europe. The respondent said that Kyoto University and the Tokyo Institute of Technology are among the top institutions in Japan. Japanese researchers were described as outstanding, original, and grounded and as enjoying a high level of administrative and technological support. He credited much of Japan's improvements to improved teaching at the graduate level in Japan.

More Japanese, we were told, are being sent overseas for training and to attend conferences and seminars. Overall, the respondent said, he is seeing more students from Asia coming to Europe.

He ranked the United States as the world leader in his field and said that Germany, Sweden, and, lately, Spain are doing a very good job. Russia, in particular, was identified as a leader in forest ecology. He said he has seen Spain improve greatly in the past five to ten years, especially in ecophysiology. Other countries improving at a faster rate than the rest are China and Brazil. China, he said, sends a lot of students to the United States, while Brazil puts large investments in science.

He said that the United States has the ideal system for S&T research. He stressed that the presence of enormous financial resources, strong competition between institutions and researchers, openness in the system, and a free flow of ideas all help to foster creativity.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

Despite improvements, graduate education was described as weak in Japan (and Italy), and the respondent put the blame on cultural issues (e.g., a society that is less open to non-Japanese).

What are your recommendations for Japan?

The first thing Japan should do, he said, is to open up as much as possible by sending students abroad and by bringing in non-Japanese graduate students and researchers. The government should also promote cooperation with researchers or institution outside of Japan. In today's research environment, it is "very difficult to stay at the forefront in isolation." As globalization increases in research, students and researchers need to increase their exposure to others' ideas and learn how the way they express their ideas. The EU experience should be studied and adapted to Japan's needs. The EU, for instance, offers experience and has learned its lessons on what to do and what not to do to foster collaboration.

In this connection, he said, collaboration should involve researchers in the United States and Europe. Japan, he explained, tends to look more to the United States and less to Europe.

Finally, collaborations need to be more systematic and should involve graduate students. He cited the Erasmus/Socrates programs in the EU, as well as the European Science Foundation and the European Research Council (ERC) as providing good examples for funding collaborative research.

Summary 18

Field and Subfield(s):	Life sciences; Plant and animal science (3)
Location:	U.S.
Status:	Established
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	High

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

The respondent said that Japan is not very strong in animal science but still placed Japan among the top ten countries worldwide. Some laboratories, he said, hold potential to do better because they produce some good research. Then, in a few areas, such as cloning, Japan has done very well. In molecular biology and developmental biology, he ranked Japan among the top five countries in the world. In developmental biology, he placed the United States at the top position, followed by the UK, Switzerland, Germany, France, Japan, and China.

Overall, he said, the quality of research in Japan in his field can vary considerably, and Japan does not appear to be improving. Weaker laboratories, in his experience, suffer from a lack of rigor and enthusiasm among their workers. Also, some laboratories have high-quality equipment, but access seems to be a problem, and some researchers are hindered by insufficient resources.

Recently, he said he has seen more high-quality scientists appointed to important positions. Also, he added that many of these talented researchers are more outward-looking and are more inclined to interact with the international scientific community. If promotions continue to evolve in this direction, he said, Japan's S&T should improve.

He singled out China as having made substantial improvement in its research program recently. The Chinese government, in his view, appears determined to improve the quality of science and is investing heavily in science. He reported that more Chinese educated overseas are also returning to China to help build the research program. This contrasts sharply with a Japanese postdoctoral researcher he has working with him who is not enthusiastic about going back to Japan. The main reason given was that returnees can face many difficulties accessing opportunities when they lack the connections that may be necessary in the more hierarchical Japanese research structure. In his experience, he said, researchers in China have consistently better access to resources than in Japan. Finally, he said, China's success is also due to its careful selection of areas to focus its resources and talent.

The respondent said that he would not consider spending prolonged periods working in Japan—even on the scale of a short sabbatical—primarily because of cultural and language difficulties. He said that his wife would not accompany him because of the "foreignness of Japan" and it would be difficult for her to find something meaningful to do. Further, he said, there does not appear to be many funding opportunities for prolonged visits to Japan. He said the lack of financial support—or awareness of them—may obstruct Japanese efforts to recruit visiting researchers.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

He emphasized that the social network's importance to success in Japan may hinder Japanese living overseas from returning to Japan.

Also, the hierarchical structure in Japan gives individuals at the top of the research structures enormous power, even if they are not particularly good scientists. Inside research laboratories, he said, such hierarchical structures may diminish the productivity of individual workers, especially in the weaker research groups. In his limited experience, he reported seeing low-level researchers working long hours without a focus on getting things done. He said this "lack of a sense of action" could be remedied by bringing in enthusiastic individuals.

What are your recommendations for Japan?

The respondent said that recruiting based on more impartial measures of ability would help to attract more people, including Japanese overseas, to work in Japan.

He said that he believes that political leaders in Japan know that the rigid scientific structure is a problem and that they are trying to improve it. He said that whether a new culture of science will emerge and take hold in Japan depends on the flexibility the head of a unit has to allocate resources even if it would upset the hierarchy. Also, research programs are most effective when there is less control from the top. In the United States, he explained, there is a long tradition of giving people freedom, and the UK has been evolving in this direction.

It is important to choose the right areas to fund for long-term success, including commercialization. He said that developing countries often want to fund research that is related to commercial ends but that this may not necessarily produce the best research in the long term.

A rigorous university education is important to develop researchers. He underscored that it must be intellectually demanding and allow people to develop their own ideas. In his view, Japan places tremendous pressure on students through the high-school level, but, once they are admitted into college, this pressure is excessively relaxed. He continued that the result is an educational experience that is insufficiently rigorous. In the United States, he said, universities make up for inadequacy and inconsistency in high-school education. The U.S. system, he added, is more flexible and allows people to play catch-up if they are willing to put in the effort but penalizes them if they do not meet certain standards. Further, students in U.S. schools who take initiative have access to a wide variety of opportunities to develop their skills (e.g., working in laboratories or via internships).

To encourage foreign collaborations, he said, Japan's researchers need better speaking skills in English. In his experience, he found Japanese scientists to be very self-conscious about speaking, so they do not practice enough. Even those who had received a good part of their education in English would benefit from more emphasis on speaking practice. He said that it might also be useful for Japanese hosts to be more sensitive to the specific cultural ways or needs of their international visitors (e.g., allowing foreign visitors more time to themselves).

Summary 19

Field and Subfield(s):	Environmental science; Environment/ecology (1)
Location:	EU
Status:	Established
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	Low

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

Europe, the respondent said, leads the world in his area of earth science research, and Japan and the United States may be characterized as competitive vis-à-vis individual European countries. He credited collaboration between European countries for making Europe the leader as a whole and said that the strongest institutions in his area of research include the British Antarctic Survey, the University of Bergen, the University of Bern, and Grenoble University. As for Japan, he said, the National Institute of Polar Research seems well organized and very efficient.

Although there has not been much change in the field in the past five years, he said, Europe is leading because the EU funding motivates collaborations between member-state institutions.

In his field, the respondent said, innovations are driven by stepwise improvements in technology, analysis of ice cores, and the like. Success in reaching the bedrock, for instance, has been driven by technologies that allow faster drilling. The first advancements occurred in

Denmark, then Germany, Italy, France, Japan, and others followed. In short, technologies are shared among researchers across national borders, and accomplishments in the field are built on sustained joint research and networks created by collaboration. Thus, in his view, any single country—whether it is the United States or Japan—cannot compete with the collaborative efforts of ten or more countries as in Europe.

He said that half of all research funds in Europe are coming from the EU and require joint work from institutions across EU member states. This, in his opinion, has strongly motivated collaboration on all levels, from sharing infrastructure to exchanging personnel.

As for the education system, he said, British and French institutions provide the best education in his field. While they have good funding, he attributed it more to their long history of research in his field and having good strategies in picking research questions and pursuing them.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

He said that Japan has increased its openness over the past five years but that it is still far from matching Europe in research collaboration.

What are your recommendations for Japan?

Japan, we were told, needs to become more open and collaborative. He said that the EU research funding strategy to promote joint projects across Europe provides a model for consideration because the initial funding incentive has generated strong and continuous collaboration. The respondent added that Japan is perhaps less open because of its geography and culture.

He said that increasing the share of teaching by non-Japanese faculty might help to improve the quality of Japanese education. He said that he thinks that the proportion of international experts teaching at universities is far greater in the UK and France than in Japan.

Summary 20

Field and Subfield(s):	Environmental science; Environment/ecology (2)
Location:	EU
Status:	Rising star
Gender:	Female
Nationality:	Non-Japanese
Professional experience in or with Japan:	Low

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

The respondent said that Japan is not leading in geochemicals, her area of research. She said that no single country could be regarded as the leader in her area because it is a very broad one and leaders are to be found at different institutions and countries across the world. In her opinion, Yale University has a very good group, and so do the Laboratoire de Géophysique Interne et Tectonophysique (LGIT) and Grenoble University in France. She stressed that, in her area of research, good facilities are critical (e.g., the synchrotron high-energy beam lines at Stanford University and the University of California, Berkeley).

As for the marine sciences, she said, the research group under Hiroshi Kitazato of JAMSTEC is a leading research group. She described this group as focusing on small organisms living on the sea bottom and said that it has done well in visualizing biomineralization processes in organisms. In her view, the main reason for this success is the very strong financial and technical support the group receives. She also noted that a Japanese researcher with whom she had worked has done groundbreaking work on iron sulfide.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

She said that her perception is that Japan is doing well technically but that its scientific output may not be visible enough in terms of publications and participation in conferences. Based on her observation, she said, Japan is internationally underrepresented relative to the level of funding available to Japanese researchers.

She said that another weakness might be the very bureaucratic environment in Japan, based on what her colleague had told her about his experience working in Japan. This colleague was very enthusiastic about the research opportunities in Japan but said that the environment is highly bureaucratic.

What are your recommendations for Japan?

Visibility is very important in science, she said, and the United States is very visible. Consequently, she suggested that more efforts should be put into motivating Japanese researchers to actively participate more in international conferences and to publish more in international journals.

For any institution that aims to achieve excellence, she said, there must be competitive funding for individual researchers, excellent technical facilities, and well-trained staff. She added that having a long history in a field might also help to attract young researchers but is not an absolute requirement. More important, in her view, is to bring together young researchers, match students with the appropriate professor to help them to learn and develop their research, and provide adequate funding for their work.

She said that it is difficult to say what could make Japan more attractive to young non-Japanese researchers because so much depends on what an individual is looking for. For her, Japan feels too far away, so she said would never consider working in Japan. Further, for most researchers at a postdoctoral level or higher, any location must also offer employment opportunities for their spouses or partners.

As good practice, she stressed that funding for short-term collaboration as well as continued collaboration is important; this should also include travel funds for researchers who already have basic funding for their research. She suggested that incentives might also be structured to motivate international collaboration (e.g., giving additional points to grant proposals that involve international collaboration, as the Dutch grant system does).

Funding at the individual level, she said, is important to giving researchers the opportunity to set up their own line of research. She noted that, in the Netherlands, postdoctoral fellows can apply for competitive three-year postdoctoral research funding to pursue their own research ideas, and high-risk research is permitted. Competitive funding involving larger grant amounts also occurs at the professor level.

As for improving the educational system to produce research scientists, she said, students should be educated in English and they should be familiar with reading scientific papers. They should also learn how to present ideas, form their own opinions, and design research and follow it through. Good language, presentation, and writing skills, she underscored, are important to a successful career. In this regard, she said the undergraduate- and master-level systems in the Netherlands work very well. Students in the Netherlands, she explained, are all trained in basic science to give them a strong foundation before they are allowed to specialize.

Summary 21

Field and Subfield(s):	Environmental science; Environment/ecology (3)
Location:	EU
Status:	Rising star
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	High

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

The respondent rated Japan as doing "fairly well" in research on biodiversity and bio-ecology. The top institution in Japan was said to be the Center for Ecological Research at Kyoto University. The respondent said that the entire group is doing good work. Yet, he said, Japan is not among the best in the world, even though the country has an enormous richness to be studied, including natural areas, species, and ecological situations, good funding, and some good people. The more advanced countries include Australia, New Zealand, Sweden, Germany, and the United States. He said that he was somewhat reluctant to compare the United States with the rest because the United States is so much bigger than the others.

Japan, in his view, seems to have adequate funding for research in his field. His impression is that universities in Japan are well funded and that researchers can seek centralized funding. In his experience, block grants at his university gave him the resources he needed for his research. In other subfields within ecology, he said, additional funding or infrastructure might be needed. He said that Japan is catching up in terms of infrastructure but still lags well behind the advanced countries. Also, in his view, an extremely positive change was introduced at the institutional level in 2004 when the legal status of Japanese universities changed from being government entities to becoming independent entities. This change, he said, has allowed them to independently raise funds in order to improve the physical infrastructure and create new salary structures.

The respondent had worked a total of four years in Japan, first on a fellowship and later as a professor. His said that his impression was that academic jobs in Japan are obtained by personal recommendation, recalling his own hesitation to travel so far to Japan for an interview. The Japanese professor who recommended him for the position informed him that there would be no interview, that he was offered the position. He said that the salary offered was good, considering that the cost of living is higher in Japan than in Europe. Although he was the only non-Japanese researcher in the university, he said, he did not feel it was a problem except for some colleagues who seemed displeased that an "outsider" was hired. He said that, had he stayed in Japan, he likely would have gained promotion. Being Japanese or not made no difference because the career path is mostly defined by seniority. In other words, "unless you do something obviously wrong, you will keep your job."

He commented that there seem to be no female researchers and recalled having read that the percentage of women in science is ridiculously low in Japan (around 2 percent). He said that women are generally underrepresented in science (e.g., gender distribution in the sciences at the graduate level is quite even in Europe and women, too, are in the minority at the Ph.D. level and beyond).

The respondent added that he had also spent three months in China 12 years ago. That experience, he said, was quite difficult compared with his experience in Japan. He said things might have changed since that time, but he found China "uncongenial" and one of the "hardest environments to work in." He also described the Chinese people as closed off and as viewing foreigners only as a source of money. For example, he said, he had to pay higher prices for the same things because he is not Chinese.

On research management and human capital in Japan, the respondent did not comment on the quantity and quality of Japanese researchers but said that cultural barriers might make it easier to know older researchers than newer ones. On clerical staff, he found their numbers excessive in Japan and commented that there is too much bureaucracy in government-sponsored research organizations. For example, he said, his current institute has 15 clerical staff supporting 255 researchers, versus his university in Japan, which had 17 clerical staff supporting 50 researchers. Many procedures, in his view, were created simply to give the clerical staff something to do, which, of course, results in additional time and effort to deal with all kinds of requirements. For example, he had to ask permission to go on his first field trip, a requirement that he had not encountered in any of other seven countries in which he had worked.

He noted that Japan's research collaboration has improved in recent years but that, given the amount of incentives available, it is difficult to gauge how this is affecting the quality of Japanese research. Due to the prestige associated with bringing in international scientists and that additional funding (or point value) is allocated to institutions that bring in international faculty, he said, people might be invited to Japan with little attention to their quality or how their visit supports institutional objectives. He said that he has seen such practices during his time in Japan.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

He said that international collaboration is very much needed in Japan but that centralized management and language present challenges. Although Japan's system has been decentralizing since 2004, in his view, it is still too "top-headed," and further decentralization is necessary. Also, although language was not a barrier in his professional life, it was for him and his family in their daily lives. For non-Japanese researchers in Japan, learning Japanese is essential, and it could take several years to command some level of proficiency.

He said that, although many more Japanese researchers are publishing in both English- and Japanese-language journals, English might still be a problem for many others. He said that the requirement that persons seeking entry into Ph.D. programs must possess a certain level of proficiency in English (passing an English exam) is a good thing but cautioned that it can be imposed blindly. In one instance, he said, his intervention made it possible for two highly motivated youths who had failed to pass the English language exam to gain admission to the Ph.D. program at his university in Japan.

As for Japanese graduate students, he said, they are hardworking but are too attached to techniques. In his view, they do not challenge ideas (e.g., repeatedly doing the same experiments without critically questioning why they are doing the experiments or whether the experiments are necessary). He cited one instance, in particular, when a Japanese researcher on insect development repeated an experiment for thousands of times and his Japanese students, too, "did things that needed to be done a hundred times [or] a thousand times." Thus, such constraints in the Japanese education system hinder the production of groundbreaking research in Japan.

Finally, he said, Japan has been involved in the field for only the past 150 years. A century and a half, in his opinion, is a relatively short period in maturing basic research, which Europe had conducted back in the 17th to 19th centuries and the United States worked on in the 19th and 20th centuries. Also, Japan's choice to move rapidly to the more glamorous side of the field (e.g., in deoxyribonucleic acid, or DNA, analysis) rather than to build a critical mass of experts on the basics reduces Japan's visibility in the field. He said that, although compiling the distribution of species is much less glamorous than DNA study, the latter produces work that is more easily publishable and can increase a researcher's visibility and reputation.

What are your recommendations for Japan?

He said that the best overall way to improve S&T research is to increase collaboration between individual researchers or through bilateral agreements between institutions. In this connection, Japan has to abandon its prejudice against people who have spent time overseas.

English language capabilities among Japanese researchers must also improve. One option, he said, might be to create something similar to China's "translation funds," which he believes are very good. In this program, he explained, researchers can write first in Chinese, and their work is then turned into English by highly qualified translators.

He emphasized that changes to Japanese education are also needed and should begin at the high-school level. At present, he explained, students who question their teachers or are critical of their ideas get "crushed." He said that Japan does well in repetitive tasks, as shown by results for the Programme for International Student Assessment (PISA) of the Organisation for Economic Co-Operation and Development (OECD) and the Third International Mathematics and Science Study—Repeat (TIMSS-R), but lags behind the United States and Europe in creativity and problem solving. He said that this high-school mindset of "unwillingness to challenge ideas" persists at the undergraduate and graduate levels in a culture that does not criticize seniors or professors.

Further, students in Ph.D. programs, we were told, are treated more like adjuncts to professors than like independent researchers. As the only non-Japanese member of the faculty when he was employed at a Japanese university, he said, he would ask graduate students why they were doing something, and their response was, "I don't know. Professor X told me to do so."

On near-term priorities to improve Japan's education, he said, one option would be to recruit more non-Japanese faculty to work in Japan. Another that he favors is to have more collaboration with institutions outside Japan to expose Japanese faculty to other teaching methods. But when this problem is deeply rooted in the culture—and culture is difficult to change—real change will take time, and this is why he counseled beginning at the secondary education level to challenge current views and foster innovation.

Summary 22

Field and Subfield(s):	Environmental science; Environment/ecology (4)
Location:	EU
Status:	Established
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	Moderate

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

In the respondent's field, there is "a large diversity in terms of quality of research" within Japan. He cited Kyushu University as among the top institutions and said that it is very well known and prestigious. For this reason, he expected Kyushu University to maintain its position. However, he said that other Japanese institutions need to improve—e.g., Hiroshima University and Tsukuba University, which he thought were better positioned six years ago. He said that, although they are doing good work, improvements at these institutions have been slow. He said that interesting work is being done by research groups in Canada, Germany, the Netherlands, and the United States.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

He said that language remains a barrier and that he has not seen adequate improvement in the past six years. He thinks that JSPS is doing a good job in encouraging higher proficiency in English but that teaching faculty in Japan generally have not progressed enough and graduate students still struggle with English. The rote-learning approach to teaching English is, he believed, a hindrance to greater improvement.

He said that there are also cultural barriers. Although he described his experiences in Japan as "wonderful," he did not believe that he would be able to find a position in Japan, because he is not Japanese. He added that it was odd to find women absent in various social contexts in Japan because Japanese cultural norms frown on their inclusion.

He considered the lack of statistical skills among biologists in Japan a significant weakness. He said that Japanese universities do not teach statistics, believing that biologists do not need to learn these methods. The respondent professed "teaching [colleagues] how to do basic crosstabs and reading very simple tables." This weakness, he said, affects not only the empirical work done by Japanese scientists but also "the theoretical foundations" of their work. In his view, the whole approach needs to be changed. He said that he would collaborate more with Japanese researchers if he would not have to be responsible for doing the "basic analysis."

What are your recommendations for Japan?

He said that Japan must improve its capacity in English, foster exchange, attract more visiting researchers, and push for collaboration with the rest of the world. He added that more money is not the solution because his field does not require large input in resources to produce good work. Rather, the problem lies with Japan's educational system, which should strengthen its instruction in statistical analysis in its undergraduate and graduate programs.

On research management, he said, no single system necessarily works better or worse. He explained that, in France, the system is entirely government-run and that it works relatively well within budgetary constraints, while the U.S. system also works well but requires very a large financial input that would be impossible for other countries to match.

He said that more international exchange and exposure are critical. So far, in his view, most exchanges involve foreigners going to Japan. He said that Japan should push its people to study abroad, which few do right now. Pushing Japanese researchers to publish outside Japan would also expand their international exposure. He said that most Japanese research is published only in Japanese. He commented that the research group at Kyushu University publishes in Japanese journals and international ones as well. He counseled that, to be successful in publishing in international journals, Japan needs to identify the "sexy topics" in the discipline and emphasize research and writing on those topics, and added that the task of identifying topics and writing in English would become easier as exposure to international peers grows.

Summary 23

Field and Subfield(s):	Environmental science; Environment/ecology (5)
Location:	EU
Status:	Rising star
Gender:	Female
Nationality:	Non-Japanese
Professional experience in or with Japan:	Low

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

The respondent said that she does not consider Japan a leading country in her area of research on biodiversity and restoration, in which the United States and Britain are the world's leaders. She said that she could not name any notable Japanese researchers in the area but said that, in other subareas, such as zoological ecology, "there are good names and institutions." In her area, she said, the United States has "too many places to mention." Among them are Stanford University, Princeton University, and the University of California, Davis. Other top institutions are the University of Edinburgh, St. Peter's College, the University of York, and the University of Sheffield in the UK and the Max Planck Institute in Germany.

She noted Germany as one of the countries making progress toward reaching the top in the past 15 years. She said that Germany embraced internationalization by teaching and publishing in English. Young researchers, she explained, are also given many more opportunities in an effort to disrupt the hierarchical structure. Further, there are new lines of support for female researchers.

Another way to improve, in her view, is to ensure that research stems not only from universities but also from other institutions, such as research centers, that receive private-sector funding. Universities are public entities, so their access to funding is restricted by government rules and bureaucratic procedures. She noted that Australia, a country with some tradition in her area, is doing well using this type of approach.

Spain, the Netherlands, and the Czech Republic—countries with less tradition in her area—were also said to have greatly improved recently. She highlighted the Czech Republic as having "recovered its good, detailed teaching tradition." In each case, she credited internationalization as having helped to bring about improvements. "People go out, communicate what they are doing, ask leading researchers, [and] try to get answers," she said. Russia, too, was noted as making gradual improvements.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

The respondent gave no answer to this question.

What are your recommendations for Japan?

In her view, Japan, or almost any other country, can rise to the forefront of the field as long as it has adequate levels of infrastructure and human capital. She said that it is possible to catch up to the leaders quickly by identifying role models and leaders to guide the process and invest the necessary resources.

The leading countries, she said, are doing well because they ask the large, fundamental questions. They do not waste time on insignificant issues. They also allow researchers—both young and old—to use their creativity to find answers. This freedom in their work, she emphasized, exposes the researchers to "all kind of ideas and innovation." Freedom of expression also increases faculty and researcher motivation.

She stressed graduate education as one fundamental area that must be addressed. Leaders, enthusiastic faculty, and students must be identified and recruited from wherever they are. The United States is a good example of this approach to attract people from all over the world. Further, as part of their training, she said, researchers need to learn how to interact with peers and communicate their work. In her opinion, the United States does the best job in doing this. Beginning at the high-school level, students in the United States learn how to exchange ideas and continue to do this all through graduate school. Instruction, she said, could be accomplished using a variety of methods, ranging from email exchanges to attending conferences and seminars.

Finally, she underscored the importance of collaboration to help expose researchers to other people's ideas and other ways of expressing ideas across cultures and languages.

Summary 24

Field and Subfield(s):	Environmental science; Environment/ecology (6)
Location:	Switzerland
Status:	Established
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	Low

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

The respondent said that Japan is doing well in his field of evolutionary ecology. However, he does not consider Japan to be at the forefront and does not regard any Japanese institution as being among the leaders in his field. In his opinion, the United States, Canada, Finland, Norway, and Sweden are at the top of this field, as indicated by publications in major scientific journals. Generally, in his view, the countries that do well in ecology are those that have vast land areas and have a more "natural" approach (i.e., not trying to control it or make it adapt to human needs) to understanding ecology. Entomology is one area in which the respondent believes Japan is doing well and has developed expertise because it needs to control plagues.

While the United States is not the best in all areas, its overall advantages are its size and approach to graduate education. In his view, the approach to graduate education in the United States and Canada stands out. In places like Japan, the system produces generalists by trying to cover all areas in breadth but not in depth. In the UK, too, a large number of universities study diverse fields, but none was thought to be the best in the world. The respondent explained that the United States, with its size and a critical mass of universities, could do more specialized work, which could help to foster innovation and creativity. However, he cautioned that the U.S. approach might not be good at the undergraduate level, where students need exposure to a diversity of ideas. Also, he said, U.S. universities are very good at screening and recruiting, which helps the United States to attract qualified and enthusiastic people from all around the world.

The respondent said that he recently began interacting with Japanese researchers, whom he hopes will give him more insights into their work and approaches.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

He said that Japan's approach to ecology, like Germany's, is too technocratic, trying to control nature rather than understanding its behavior. For this reason, he has not considered working in Japan or Germany, his native country.

What are your recommendations for Japan?

In his estimation, he said that it will take more than ten years (using quantity and quality of Japanese publications in major scientific journals as an indicator) for Japan to catch up to the leading countries. In addition to money, he said, other changes are needed. First, Japan must abandon the "control of nature" approach and move toward an "understand nature" approach. Japan could adopt policies similar to those in the leading countries (e.g., the United States) and look at the experience of others that are already emulating the leading countries (e.g., France and Spain). In France, for example, protectionist regulations were removed to make science more open. Immigrant workers used to have to go through a "slow and bureaucratic process"—registering, obtaining a work permit, and so on—before they were offered a position at a university. In many cases, job applications were not even considered because people were unaware of hidden rules. These barriers have been either removed or bypassed to allow France to bring in international researchers. This, according to him, is significantly changing the composition of faculty at French universities and opening up good career opportunities for international researchers in France. He said that Spain, too, has been implementing similar changes. Italy, however, has not, and it does not look like Japan has either. He said that culture might have a role in shaping perspectives—and policies—in Japan and Italy. In the respondent's opinion, the scientific world is "a mirror of society." In other words, Japanese society is relatively closed, and so is its scientific community. He added that overcoming such cultural constraints might be particularly difficult for countries of a certain size, such as France, Germany, Italy, and Japan. For some others, that decision to open up may be more deliberate, and the process of it happening might be easier (e.g., for Switzerland and Ireland). Smaller countries know they need to open up to and collaborate with the rest of the world.

He compared Germany and Switzerland, which, 25 years ago, were in similar positions in his field. He explained that the arrival of one American professor to Basel and his leadership completely changed things in Switzerland. He said that this professor introduced a more open, American-style approach to ecology research, shifting Switzerland from the "mechanical" approach that it had shared with Germany. He also introduced an aggressive policy to screen and recruit the best people from all over the world when interest in ecology among Swiss students at the time was low or even nonexistent. This first generation of "foreigner" ecologists in Switzerland generated sufficient enthusiasm that spilled over into the rest of Swiss academia and society and stimulated Swiss interest in ecology study, enough to eventually result in a critical mass of Swiss students.

He said that he has a sense that Japan is attempting to open up. JSPS, for example, has been doing a great job in the past five to seven years in leading this process by pushing scientists to publish in English. Internationalization, is his view, is critical to improving the quality of research in Japan. To begin with, classes must be taught in English at undergraduate and graduate levels in order to attract people from the rest of the world and to force Japanese students to become acquainted with the language. Both Switzerland and Germany, he noted, have moved in this direction over the past ten to 15 years. It is important to attract students internationally in order to bring in the right people to produce rigorous research. The countries at the forefront of the field all attract the best people from around the world. He emphasized that such a strategy could be especially important if there are few people entering the field domestically, and added that "diversity always helps."

When recruiting students into graduate programs, he underscored, "enthusiasm is decisive" because researchers must feel emotionally connected to the field. Nevertheless, "selecting the right people" can be extremely difficult.

Overall, he said, he has seen more progress in places where private universities play a substantial role in S&T education. Private U.S. universities can be productive because they enjoy funds from their large endowments and from alumni giving, the latter of which is very important to fundraising. In his view, countries that rely solely on public universities in S&T education can face more problems. For example, in central European countries, the public would not feel a need to support the research enterprise or science education when they see their role only as taxpayers and deferring to the state for action. Compare this, he said, with the situation in the United States, where an alumnus would be motivated to make financial support to his or her private university alma mater and assist the institution in identifying suitable graduate students.

The respondent said that separating applied research from the basic research in the educational system might also be beneficial. For example, in Germany and Switzerland, applied research is done at the polytechnic universities, while basic research is done at the universities. The former would produce workers and research that could meet the expectations of the private sector, while the latter would produce workers and research that could advance fundamental science.

Finally, he stressed that partnerships with the industrial sector are important and should be increased. He cited the examples of oil companies hiring paleontologists and farmers working with researchers to find ways to control plagues. For these partnerships, applied research was said to have a particular value.

Summary 25

Field and Subfield(s):	Environmental science; Energy engineering (1)
Location:	EU
Status:	Established
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	Low

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

The respondent said that his experience with Japanese researchers has been limited to attending scientific conferences in Japan. He said that he would have liked to conduct research in Japan but has not found the right opportunity.

Japan, in his assessment, is very advanced and produces a great deal of research in his areas of research, earthquake engineering and wind engineering. He said that Japan has made some significant advances, such as in design and applied research. He said that he is not aware of any major research breakthroughs in his area of research in Japan, adding that other countries, too, have not produced major research breakthroughs in the past decade.

Given the effects of globalization on research, the respondent did not believe that there is still a "prevailing" (leading) country but that, if he had to rank them, the top countries would be the United States followed by Japan. The leading individual institutions would be found in the United States (e.g., the Massachusetts Institute of Technology and the University of California, Berkeley), but unfamiliarity with Japanese research institutions did not allow him to name any in particular. In his field, he said, the largest institutions conduct the best research because they have the requisite heavy and expensive equipment (e.g., wind tunnels and shaking tables) and the highest-quality equipment is in the United States and Japan. The respondent said that Japan might even have the better equipment of the two countries.

In Europe, he said, he has seen some collaboration between individuals in European universities, but they are ultimately driven by relationships between individual researchers.

He attributed the primacy of the United States and Japan in his field to the availability of strong research funding support. In his view, funding institutions in these countries understood earlier than those in other countries the importance of investing in applied research. He suggested that having superior funding for salary and high-quality facilities might have been crucial for the United States to attract the best people from across the world.

On the S&T competitiveness of other countries, the respondent reported that few foreign researchers work in Italy—at least in the technical fields—and that more Italians go abroad than build their careers in Italy. According to the respondent, Germany possesses more-advanced funding mechanisms than other European countries, but they are highly dependent on the political leadership. As for the United States, he said, a great deal of time is spent on writing applications and bureaucratic activities rather than doing real research. In Europe, this "imbalance" between time spent on nonresearch and research activities is even more extreme. China, in his view, is making tremendous progress in his field and has a large number of researchers, but whether quantity translates into quality is still to be determined.

As for the Japanese educational system, unfamiliarity with the system did not permit the respondent to say much about it. In an age of increasing globalization, the respondent said, hybrid models in educational systems are emerging in Europe and the United States. Specifically, the U.S. system has moved closer to the European one and vice versa.

Most important, though, he said, is that an ideal education system is one that "adapt[s] to the students." The old model of teaching theory followed by practice may be the best if university students are individually selected and trained. In today's age of mass education, which gives superior access to education and is important to building knowledge societies, he asserted that it would be beneficial to use a "hybrid" model that sandwiches theory between first exposure and use of practical knowledge and results.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

For Japan to attract foreign collaboration, "it would have to overcome the language barrier, as English has become the common scientific language." Another obstacle, the respondent suggested, might be the Japanese culture and way of life, which are quite different from those in the West. They might not be problematic for a short research stay but could be for a longer stay in Japan.

What are your recommendations for Japan?

In his view, it is generally good for research to have "a good mix of everything." For example, providing funding for risky projects would encourage creativity, while funding for large collaborative projects (e.g., the EU Framework Programmes) helps to further develop established ideas.

His key recommendations were to provide more funding and freedom to young researchers and allow them to grow rather than keeping them on the sidelines. When "old people" occupy available positions, he said, younger scientists are deprived of adequate funding and growth.

He added that anyone who wants to grow his or her career should move around and go abroad to see how other people work. He noted that top institutions exist all over the world and that the specific location is less important than obtaining a broader viewpoint of different ways of conducting research. Also, there should be a mix of theory and laboratory work, with theoretical studies supported by practical application.

Fostering individual mobility would also improve research collaboration. Ideally, he said, this would begin at a student level and continue throughout an individual's research career. To do so, it is necessary to create opportunities as well as funding and to facilitate frequent moves and various lengths of stay. In this connection, immigration policies need to be conducive to such movements into and out of Japan. Finally, Japanese researchers need to improve their skills in English.

Summary 26

Field and Subfield(s):	Environmental science; Energy engineering (2)
Location:	U.S.
Status:	Established
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	Low

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

Japan, the respondent said, will remain at the top of his field for the next five years and "possibly for centuries." He does not see Japan's standing declining in the world, except perhaps relative to China's rise in number of publications. But, where the quality of research is concerned, he would still rate Japan as number one in the world. The top Japanese university in this field was said to be the University of Tokyo, followed by such institutions as Kyoto University and the Tokyo Institute of Technology.

However, he stressed that the best work in his field in Japan occurs in industry rather than universities. He said that while Japan's industry "kowtows to professors at universities, they don't think much of university research." Japanese companies were said to be very secretive and to shield their best research from the outside world because "the university system just doesn't mesh with industry's profit motivations." Thus, outsiders can typically visit industry laboratories, but it would not be possible for them to work there. Among energy firms in Japan, he identified Toshiba as one of the best. He added that there are cooperative ventures involving private firms that are partly funded by government to pool their knowledge and talent (e.g., a fuel-cell laboratory in Osaka). In other industries, such as automobile manufacturing, audio and sound equipment, and biotechnology, he also rated Japan as being the best in the world.

The situation in Japan was said to be improving. "They [the Japanese government] say they want the imperial universities to be more self-supporting; that is, to work more with industry." For example, at any top-flight laboratory with a cutting-edge professor, there are three or four faculty members working for him and as many as 50 people working in the laboratory. Among them would be several from industry and one non-Japanese researcher. He said that he sees advantages and disadvantages to such arrangements. On one hand, it brings together a critical mass for collaboration, something rare in the United States. On the other, there is little collaboration outside a single company or network, even within groups of companies, and no information is shared with those outside.

He described the situation in Japan as being very cutthroat. Professors work very long hours, and the top 15 percent do all the work. Every night, they have business dinners, although, he said, "they might take time off on the weekend because wives have become a little more assertive."

Comparing Japan with the United States, the respondent said, "There's something about Japan's system that is more successful in putting out better work." Even though U.S. universities' research is not particularly respected by industry, their research is cooperative. In rating institutions by the quality of their work, he would put Japanese firms first, followed by Japanese universities, then institutions in the United States. He said that the situation in Britain is "really terrible—they have no facilities at all. They are really poorly equipped."

Nevertheless, close ties between industry and universities do not always help with commercializing research results. He explained that there remains hesitation in Japan to allow industry into the university system even as things have been changing in the past five years. Universities, in his opinion, are more able to promote industrial research and use university students as researchers. In the United States, he does not see such change happening. The United States, he said, "likes to think there's a line between basic and industrial research that should not be crossed, but in Japan that line is being blurred." The United States, he added, has research parks, for instance, but there are no instances of industry using campus laboratories. The respondent said that he would support more usage of universities as locations for industrial research.

When asked whether he had ever worked in or considered working in Japan, the respondent replied emphatically, saying, "Never! I would never consider working in Japan." Although the respondent is ethnic Japanese, he does not speak Japanese and said that he would not fit because he would be considered a "second class citizen in Japan," adding that "there's a trusting relationship in Japan; Americans will never get that trust." He said that there is a rigid social structure in Japan, and especially in research. He said that he has close friends with whom he would go out to dinner and spend recreational time but that these friendships would never rise to a professional level, because "it's a matter of where you stand [that determines] what kind of respect you can get." In some ways, the respondent said, he is well respected in Japan from when he used to work there, but this is not extended to professional respect in research.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

In his view, the Japanese "educational system is junk"—from kindergarten to university. In Japan, he said "if you get a B.S. [bachelor of science degree] and can find a professor who likes you, you write three papers with him as a coauthor, you go through an oral exam headed by that professor and three of his friends, and that's it! It's almost a joke!" Japan was said to have people in industry writing Ph.D.'s in absentia and later making large donations to the universities. This, the respondent said, is "almost like bribery."

Education in the United States, in his view, is far superior. The respondent pointed out that the U.S. system might be flawed because education is not politically important enough. This flawed educational system is tolerated because, about 40 years ago, the United States decided to have the best universities in the world. It now spends far more on higher education than any other country. The respondent estimated that the United States contains maybe 15 of the 20 top universities in the world. Furthermore, if one subscribes to the theory that the top 5 percent of the population does all the work, those top universities produce and host the majority of the top researchers.

Although Japan's academic education system is poor, it may not be worth changing because the best students will go to college and the best of those will run the country. In his view, Japan would need a complete overhaul of its education system only if it wants to achieve equality or parity in education.

What are your recommendations for Japan?

The respondent said that money is the best tool Japan's government can use to encourage international research collaborations. He felt that Japan should take after the Singaporean model but cautioned that Singapore is worse than Japan in terms of viewing outsiders as second-class citizens. In the respondent's view, Singapore is so focused on success that it has lost its human values. Japan is also focused on success but has not yet lost those values.

In the short term, what Japan is doing right now is fine. Japanese people are proud to have foreigners there. There are good links for the future and future research opportunities. In the end, he believes, the "second class citizen problem" is not that important and can be overcome if the incentives are great enough.

In terms of a long-term strategy, the respondent said, it would be best to encourage foreign collaborations at the most basic level by bringing in international students—starting from kindergarten. If foreigners are to feel comfortable in Japan, they must feel as though they are a part of the cultural system, or at least have some familiarity with it or understand it. This, clearly, would be a long-term strategy. Japanese researchers themselves also need to develop more openness, allowing, over time, different researchers to work more with each other.

Summary 27

Field and Subfield(s):	Environmental science; Geoscience (1)
Location:	EU
Status:	Established
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	Low

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

The United States, Australia, Germany, and the UK were ranked as the top countries in his field. Japan and China were said to be among the countries in the "middle." China, our respondent noted, is growing rapidly in the field because of large research funding. Given China's size and funding, he said, China has "great prospects" to be very competitive in a short time. Chinese researchers were observed to be more open, more eager to open up, and more willing to hear other peoples' opinions than Japanese researchers.

Japan was rated as doing very well in ocean drilling research. The respondent said that he knows of at least five very good Japanese universities joining the Integrated Ocean Drilling Program (IOPD) and that a leader in Japan is the Ocean Research Institute of the University of Tokyo.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

Lack of international exchanges and collaborations were said to limit Japan's exposure to the state of the art and how others work in the field. Weakness in infrastructure, in his view, could also hinder Japan's advancement in the field.

What are your recommendations for Japan?

First, the respondent said, Japan needs better infrastructure that is competitive with that of the U.S. National Aeronautics and Space Administration (NASA) or the European Space Agency (ESA). Much of the future research in geology will require resources from space, so infrastructure that can obtain these resources is required to remain at the forefront of the field. Japan, in his view, does not currently have facilities of this type, which demand long periods of investments. It is also short on human capital.

Japan should also change its approach to education, beginning in high school. Students should be inculcated with "the willingness to succeed by yourself." The hierarchical system in Japanese society must also change. No incentives, we were told, can motivate creativity or excellence as long as the rigid hierarchy and career path persists (e.g., one cannot advance until those at the top leave). In Japan, researchers, including senior researchers, have employment for life unless they do something very wrong.

Changing the lifetime-employment system will take time. To begin with, Japan needs policies or instruments to offer better career prospects to young researchers. Right now, challenges in finding good positions in Japan might force students to forgo graduate school or leave Japan for careers overseas. Finding attractive career opportunities is difficult anywhere in the world, but the hierarchical research structure in Japan aggravates the situation. The respondent underscored that "this circle needs to be broken."

One way to accomplish this is to expose faculty to different ways of teaching. Faculty members need to travel overseas to see how colleagues in other parts of the world organize and teach the same topics. Japan should also invest in bringing faculty from advanced countries in the field, send Japanese graduate students to these leading countries for education and exchanges, and offer continuing education support (e.g., postdoctoral fellowships).

Summary 28

Field and Subfield(s):	Environmental science; Geoscience (2)
Location:	EU
Status:	Established
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	Moderate

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

In the geosciences, the respondent said, most of the work is done in Europe, the United States, and Australia, although there are "a lot of very good Japanese researchers." Those of whom he knows travel internationally, and he thinks they are very good. He said that Japan does well in areas that require expensive equipment and that Japanese researchers make very good use of it. He added that many Japanese laboratories have the best equipment and that this gives Japan a competitive advantage. For instance, he said, a top institution in Japan is the Earthquake Research Institute in Tokyo, which has a lot of equipment that almost nobody else has.

Top institutions in Europe include the University of Toulouse; universities in Liverpool, Tubingen, and Stockholm; and the Swiss Federal Institute of Technology Zürich (or Eidgenössische Technische Hochschule Zürich). In the United States, the State University of New York at Stony Brook and Brown University were cited as two of the top institutions. The respondent said that European programs are doing well and should maintain their position in the future. They have the necessary educational infrastructure, and European countries work well together. Also, large research budgets in China and India, in his view, would make them seriously competitive as well. India, he said, has especially strong potential because it does a good job in teaching theory.

Research-funding policies in France were described as polar opposites of those in Australia and the United States. In France, all funding is for collaborative research among multiple laboratories and targeting specific topics. Funding in Australia and the United States comes out of national funding bodies (e.g., the NSF in the United States) for individual research and does not target specific topics. The United States, in his opinion, does a better job in promoting groundbreaking research, but the more structured approach in France may be better for training. Recently, he said, he has observed that the United States is moving toward creating collaborative networks, while France is moving toward funding individual research in addition to collaborative arrangements.

One advantage of the French system is that all the different research organizations are in one building, making collaboration more natural. At the same time, this runs the risk of inefficiency, given that decisionmaking may be more cumbersome with all the different interests under one roof.

As for the attractiveness of Japan to non-Japanese researchers, the respondent said, Japan is an attractive place to live, and several researchers in his laboratory have visited Japan. One was said to want to stay in Japan permanently.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

Lack of funding for collaborative research may be the biggest problem. In Japan, as in other countries, researchers may have an easier time securing funds for travel than obtaining funds for collaborative research.

What are your recommendations for Japan?

The respondent said that it is important to have a variety of funding mechanisms to attract different kinds of projects. Funding structures, such as the EU Framework Programmes, focus on fostering collaboration, and it would be beneficial to Japan to put in matching funds and join the program. In contrast, the ERC sponsors more individual projects. Both types of funding structures, in his view, are necessary.

Not only is funding critical, but money must also go to the appropriate funding mechanisms, including seed money, to drive different types of research projects. Seed money, he remarked, is often lacking. Small seed grants, he said, can be more expensive to manage because they are small sums. So coming up with a system that could efficiently allocate small seed grants "would be great."

The ideal university administration is one that has a high degree of flexibility in supporting researchers. Less centralized systems that focus on building networks would be good. Research structures should allow individuals to be more creative and innovative. There should be administrative balance between targeted research on what the government perceives as priority areas and open research that is driven by researchers' individual curiosity. Researchers should not set aside curiosity. Science education can foster this sense of curiosity by giving students a good theoretical base and freedom to choose between theoretical and applied fields when developing their research careers.

Summary 29

Field and Subfield(s):	Environmental science; Geoscience (3)
Location:	U.S.
Status:	Established
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	Low

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

The respondent said that the best oceanographic and climate-science work from Japan could be considered respectable in quality. He said that some classical papers came out of Japan in the 1930s and 1940s, when the field was still very small. Japan recently began investing significant amounts in physical oceanography, but, considering how much it spent and the country's natural resources, he expressed surprise that Japan is not a leader in the field. In his opinion, Japanese researchers would not be "the go-to people to ask 'where do we go from here?'"

The best country in physical oceanography is Germany, followed by the United States, France, and Britain. Russia, he said, is no longer a leader in this area of research. He said that Japan is competitive with Western European countries in physical-oceanography research but that it is not as good as Germany in general or the top people in the UK. In his view, the best Japanese scientists in basic science all work in the United States.

Technology development, the respondent stressed, is different from scientific development, and, the respondent said, "Japan seems primarily interested in the former, not the latter." It was unclear to him Japan's motivation for pursuing particular technologies when Japan seems to lack basic scientists who could use these technologies. Scientists, he said, should drive the demand for particular technologies, and not the other way around.

Japanese academic and basic science structure also do not seem entirely suitable for nurturing state-of-the-art science leaders. "In order for a collaboration to work, you'd need some basic science colleagues who are in Japan [who] are capable of the daily interactions and are on the same wavelength as their American counterparts."

On the quality of undergraduate education in Japan, the respondent said that it is "good in a formal sense." However, Japanese students who come to study in the United States "are not used to the give and take of scientific argument" or challenging conventional wisdom, probably because the Japanese system is hierarchical and they are too polite. Thus, he said, if a professor says to set up an experiment a certain way, the students will do so without questioning or thinking. This restricts independence and creativity, and most Japanese students have a hard time unlearning such behavior.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

In his view, the Japanese are very good at engineering, but not basic science. Japan has not often come up with innovative ideas on which they or others can build. Rather, he said, Japanese researchers have produced the second or third generation of instruments and ideas.

Collaboration with Japan can be difficult, according to the respondent. In one potential collaborative effort, he said, he felt that JAMSTEC was doing things backward. Specifically, he described JAMSTEC as interested in the technology but not the science. He said that he was frustrated by JAMSTEC's approach because many interesting potential experiments were left out of the discussion. "They [the Japanese researchers] were looking for a black box where they could put instruments out there and the data will be so interesting that everyone will want to analyze it."

Another time, the respondent said, his potential colleagues in Japan insisted that he go to Japan to work with them. He added that the Japanese side insisted that the work could not be done remotely, when such work is typically done remotely in the United States. He complained that the Japanese side would expect collaborators to fly all the way to Japan for just a couple of days of work. Several U.S. colleagues have more recently tried to work with these Japanese researchers, and all concluded that "it's a big hassle." When queried why he could not work remotely, the Japanese side indicates only that it is their policy, with no additional details.

Finally, the research hierarchy was said to be a problem. Secondhand information from colleagues, the respondent said, had been that the senior people in Japan control research funding. He said that, if a senior person is open-minded and progressive, then all is fine. However, if the senior person is controlling or overly cautious, problems result. In the United States, he described, funding is more fluid and less centrally controlled.

What are your recommendations for Japan?

In the long term, the respondent said, Japan needs to find a way to render the university-like systems more attractive to the younger, more-iconoclastic Japanese and foreigners. The result should be that the Japanese people who come to the United States are able to engage in more-dynamic basic science research. This should be the highest priority, even if what Japan eventually wants is technological development. One problem in pursuing this, he said, is that "research looks wasteful to bureaucrats. . . . [A] lot of it doesn't amount to anything and you have to deal with a certain amount of messiness." In basic research, even if there are no results, the idea might have been good and the experiment important to try out.

Japan should also try to attract postdoctoral researchers. These young researchers are at a point in their career at which they are the easiest to convince to go abroad. There was a time in the 1920s or 1930s, the respondent recalled, when every "serious scientist" in the United States had to go to Europe for a postdoctoral fellowship. Japan, he counseled, should strive to make itself a desirable destination for postdoctoral researchers.

Finally, if Japan really wants to make a difference in the field, he said, climate-change research would be a good area on which Japan could work, given its centralized structure. Climate change is a long-term problem, and the world needs countries willing to make a commitment to making useful measurements in the coming decades and beyond.

Summary 30

Field and Subfield(s):	ICT; Computer science, applied (1)
Location:	EU
Status:	Established
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	Low

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

The respondent said that Japan performs a great deal of high-quality applied research. Japan was said to be strong technically and innovative, but not at the level of Britain or Germany. He ranked Japan with Switzerland as among a group of leading countries. Top research institutes in his field in Japan include the Tokyo Institute of Technology, the Nagoya Institute of Technology, and the JAIST. Private firms, such as NTT and Sony, were also said to conduct high-quality research.

He said that Japan is gradually improving. ATR, in his view, has done a great job in particular of internationalizing research under national policy mandates.

Many Chinese were said to be going overseas for Ph.D.'s in his field because good Ph.D. programs are absent in China. Japan, he said, receives many foreign students, especially from Asian countries. In his view, China is catching up, making it "only a matter of time" before China becomes internationally competitive.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

He said that he could not accurately evaluate the quality of Japanese research in his area because most Japanese experts publish in Japanese only. Thus, he had nothing to say on this question.

What are your recommendations for Japan?

He said that movements to break hierarchies are good. In his view, hierarchies exist in different ways in Japan and Europe, and, to break them, he said, Japan could learn from the experience in the UK and some central European countries. He said he was aware that Japan has introduced competitive research funding and also implemented a "pay for performance" model. These efforts, he thought, should be used to fund good ideas regardless of age or gender of the researcher.

Japanese universities need to attract international, high-quality faculty and students from overseas. There should also be graduate-level student exchanges. At present, he said, universities are less open in Japan than in Europe and the United States, and Japanese students do not usually go overseas to study because there are high-quality Ph.D. programs in Japan. Thus, Japan must find ways to expand interaction with other cultures and ideas, and the earlier the better. Japan, in his view, could learn from programs in the EU (e.g., the Marie Curie Fellowships) that promote international mobility for young researchers. Overall, collaboration could make Japan less insular.

In this regard, improving proficiency in English would benefit collaboration and get more Japanese researchers to publish in international journals.

Finally, he recommended strengthening links between academia and the private sector to encourage more industry funding for research at universities.

Summary 31

Field and Subfield(s):	ICT; Computer science, applied (2)
Location:	U.S.
Status:	Established
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	Low

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

The respondent recalled that Japan was at the leading edge in work on fuzzy logic in the 1980s but that, over time, Japan has lost this leadership. With its emphasis on application over theoretical research, he said, Japan has produced some very impressive results in terms of putting the technology into products and is very good about designing products that are attractive and meet consumers' needs and expectations. It has, however, not pushed fundamental research further. He said that Japan might have chosen not to engage in more-fundamental work on fuzzy logic because it decided to move on to other topics. Today, Chinese researchers, in his opinion, are doing much more-basic work in this area and publishing far more papers, even if the quality is not necessarily high.

He suggested that perhaps it is Japanese culture or the mindset of Japanese people that makes that them so good at emulating, borrowing, and adapting technology. He described Japan as being very open to learning from others, taking what is good or useful, and making it better and using it. Japanese people were also observed to be very meticulous. All this makes Japan very good in engineering, but not in theoretical research, which compels one to ask why instead of what. So, the respondent said, he was not surprised to see few new technologies in his field coming out of Japan, even though Japan is a major producer of related consumer goods. Japan, in his opinion, is probably the most change-oriented society in the world, but it lacks originality and creativity to produce fundamentally new things.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

The respondent believed that the Japanese might lag behind even further if nothing changes. Technology used to be more about hardware, at which the Japanese can excel, but the current direction is toward advancement in software (information processing), at which the Japanese are not quite as good.

Japan's lack of English proficiency may be another weakness and, in his view, it is exacerbated by the Internet, which is English-dominated. Without proficiency in English, Japanese researchers are not contributing information to the global community of researchers. Already, he said, Japanese researchers do not seem to publish much in the top international journals—which are largely in English—and are not engaging in discussions or collaborations over the Internet. So it is as if Japan is not even on the scene or visible at all these days.

Regarding independence, creativity, and innovation, he said, there is such demand for consensus and uniformity in Japan (noting that research teams in Japan even dress in uniforms) that independence and creativity are compromised. The Chinese, he said, are eagerly learning English, hosting conferences in China in English, publishing in top English-language journals, and going overseas to conduct research and for education. The Chinese, in his opinion, have some way to go to catch up, but they are moving ahead. In Japan, where "the good of the society comes way ahead of what's good for the individual," there is no innovation, and this, he said, is a fundamental value difference that might explain why Japan is not good at innovation.

What are your recommendations for Japan?

The respondent offered no recommendation. Instead, he queried why the Japanese government is seeking to build strength in basic research when Japan's nature might lead it to excel in basic research. Further, he queried why Japan should aim to be like the United States or any other society in what it does in S&T, as well as why Japan does not stick to what it does well—that is, engineering—and aspire to do even better.

Summary 32

Field and Subfield(s):	ICT; Computer science, applied (3)
Location:	U.S.
Status:	Established
Gender:	Female
Nationality:	Non-Japanese
Professional experience in or with Japan:	Low

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

In her field of networking, the respondent highlighted the Akari project, a Japan-wide project supporting the future Internet, as a key research initiative. For this project, Japan was said to be interacting with researchers in Europe and the United States and seeking collaborations with foreign researchers. The project team, we were told, seems to be informed about activities elsewhere in the world and is using this knowledge to determine how it can make unique contributions.

While she was not aware of any specific, recent notable accomplishments in Japan, she commented that the University of Tokyo and Keio University were doing noteworthy work. Top researchers in Japan, in her opinion, include Jun Murai, who is considered the father of the Internet in Japan, and Kenjiro Cho, whom she regards as doing interesting work.

While Japan does interesting work like the Akari project, the top countries in networking are the United States, the UK, France, and Germany. She thinks that a particular strength of

U.S. research is the tight relationships with innovative start-ups and connections with industry. This may be the case because the Internet originated in the United States. In contrast, Europe and Asia may have an advantage in the wireless and cellular network fields. Being smaller countries, expanding cell-phone coverage is easier; thus, cellular phones gained a larger role earlier in these smaller countries.

In the United States, she noted, there is a great deal of support for people building things (e.g., writing code, building equipment). The availability of financial resources required for large projects allow researchers to "try stuff out and let it evolve over time" to see how ideas work in practice and make the necessary alterations. Undergraduate students are also trained to be involved in these building activities.

These types of projects are not necessarily better than other types of projects. Each serves a purpose. For some problems, such an approach is indispensable. For example, with the Internet, one does not know whether something will work until it is put into practice. One needs "to try it out, interact with real users." The respondent cited a U.S. National Research Council study on how to judge research in computer science that states that, in general, the United States highly values work that involves "engineering," building, then testing. The problem with this approach, in her view, is that it takes a long time to build and deploy and that these activities would not happen if incentives were structured solely around numbers of journal publications.

Over the past 15 years, with the rise of these larger projects, she said, there has been an evolution toward accepting a lower paper output as well as toward valuing conference papers. In contrast, in Asia, many researchers are judged only by their journal-publication output, which discourages large projects.

One downside to these large projects is that they can be anti-intellectual. She said that it is important to also examine the research findings using rigorous theory when large projects are good for identifying important problems and seeing how things work in practice.

Germany, she said, is an emerging country in the field. Its approach includes creating focused institutes (e.g., at the Max Planck Institute) and running weeklong computer-science retreats with people from around the world. She added that Germany is building its programs and attracting high-profile people, including German expatriates. The country is able to attract these individuals by making positions highly attractive in terms of resources. For example, in Germany, a position might come with funding for students. Thus, one does not have to spend much time writing research proposals to fund students. In the United States, low grant-funding rates, in her view, compel professors to expend much of their time writing proposals.

She clarified that competition for support is not entirely a bad thing, as long as funding mechanisms can provide sufficient evaluative scrutiny. It is also important that researchers be judged in other ways, such as by peer evaluation. However, junior faculty members need a launchpad at the beginning to get their research going. If their resources are based only on the number of funded grants they have received, launching their research would be more difficult, since there is usually less success in obtaining funding early in a career.

European countries, she reported, consider networking a "hot topic" and are putting resources into it. In the respondent's view, because Europe and Japan feel they are lagging, they are investing more now in research and experimental infrastructure. She said that the United States is putting fewer resources in because it feels more comfortable and less pressed to do better in the field and because of the current financial crisis.

The United States, however, is strong in human capital. Although visa restrictions have made it more difficult to enter the United States, foreign students, in her view, coming to the United States still represent a major talent pool. As other countries are developing better research programs, there is now more competition for students. Many of these potential students now have good opportunities to work in their home countries rather than going to graduate school in the United States. She remarked that American students tend not to go to graduate school in engineering; rather, most pursue careers in which the financial rewards are promising (e.g., industry, finance, and professional schools). Fears of outsourcing also negatively affect the numbers of people entering the discipline.

In American culture, she said, technical graduate degrees are not highly valued. The United States needs to cast technology in a positive social light to help change this. For example, women, who are still underrepresented in computer science, should be shown that technology is a way to connect with people.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

Young faculty in Japan were viewed as having a difficult time getting started and were not as "protected" in research with lighter teaching and committee loads as their peers are in the United States. With fewer professional obligations, young faculty can spend more time on their research, learn how to get funding, and learn how to deal with students. The respondent said that it is critical for young professors to be very productive in the early stages of their career to "get off on a good foot." Quite the contrary, young faculty members in Japan, she said, "have to pay [their] dues," and they receive less mentoring to ease the learning curve. Young faculty members in Europe face similar challenges.

Some minor obstacles to foreign collaboration include the language barrier but also that foreigners are not sure what professional behavior is appropriate. The respondent said that not knowing how to behave might make collaborations difficult.

What are your recommendations for Japan?

The respondent's comments speak to issues in the field at large and in the United States in particular in some instances. Her recommendations might be seen as applicable to any country striving for scientific excellence rather than strictly for Japan only.

Undergraduate students should be encouraged to perform independent science projects. Their excitement for their research may spur them to consider graduate school. Undergraduate research should therefore be encouraged or even be made mandatory. Also, youths might be motivated to pursue research careers if they are aware that they would own the intellectual-property rights for their work (true in the United States) and they could leave academia to pursue start-up innovation enterprises. Such departures from academia, in her view, can be a good thing, as turnovers in academic positions provide opportunities for the next generation of young researchers.

Prerequisite courses for computer-science and engineering degrees should also be made more widely available. Some high schools do not even offer physics, which renders students ineligible for engineering programs. When students do not even know what computer science and engineering are actually about, they are less likely to choose them as academic majors. Making engineers more visible in the popular media (e.g., as characters in television shows in Pakistan) might also help to encourage more youths to take an interest in the profession.

Junior faculty programs could also provide a longer-term initial grant so that individuals are more able to take risks on their first large project. Support for postdoctoral research is declining in the United States. Without the extra training that postdoctoral fellowships provide, young researchers would be less able to conduct ambitious research projects. Postdoctoral experience, she said, also helps young scientists to mature and prepares them for academia.

Finally, in her view, industrial research laboratories are at the very tail end of their "glory days." This means that students will have fewer internship opportunities and researchers will have less industry exposure. Long-term industrial research is especially important and might be encouraged through tax incentives.

Summary 33

Field and Subfield(s):	ICT; Computer science, applied (4)
Location:	U.S.
Status:	Rising star
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	Moderate

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

The respondent said that research in the United States is far superior to that in other countries and that all of the top centers of excellence and training in the field are in the United States. Strength is growing in India and, to a lesser extent, in Brazil and China. In the case of India, he believes that Microsoft's research presence is helping India.

The respondent could not think of any innovative research highlights for Japan. He noted, though, that he was impressed by the sheer size of a large-scale Japanese project in which Japanese researchers and an Internet service provider collaborated to measure how people were using the Internet in their homes.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

In his experience with a Japanese research laboratory, he thought, skills for "problem selection" were lacking. So while the Japanese researchers worked with high proficiency, the problems they picked were uninteresting.

As for mentoring students, the respondent said, it could be challenging for non-Japanese researchers considering the more-formal sense of seniority that prevails in Japan and most other Asian societies.

Finally, language could be an issue. Without a certain level of proficiency in English, it is hard for Japanese students and researchers to work well in international collaborations. Laboratories outside Japan might not find it rewarding to accept Japanese students or collaborate with Japanese researchers when they cannot communicate and contribute to the exchange of ideas and show they are making a fair contribution to the collaboration. Having proficiency in written English is not enough; researchers must be proficient in spoken communication as well, because it is in impromptu discussions that ideas are often generated.

What are your recommendations for Japan?

The top institutions in the world all support a "culture of research." Funding is important, but it will not accomplish anything without the right research culture to think about science. Success, he said, "feeds itself," in that successful faculty members are those who have "absorbed the model" and new entrants learn from them and absorb that culture by being immersed in it.

Productive collaborations and exchanges are essential to improving research programs. To be successful, these exchanges need to be appealing to both visiting and home researchers. The home researcher will perceive a benefit if there is a financial incentive and good research is produced. Countries that want to send their students to visit laboratories overseas need to prepare their students before their departures so that they can make a useful research contribution.

Researchers work together, our respondent said, if they can see potential benefits. For example, a very positive ongoing collaboration for him started when the best student from his collaborator in Germany visited the United States. The German professor took steps to make sure the process was smooth and placed no restrictions on the student's activities while in the United States. The student did good research and, upon his return to Germany, was asked to recommend another student he thought would work out well in the U.S. group. Exchanges have continued, establishing a chain of students visiting the United States and reinforcing the relationship between the two groups.

Exchange programs can be risky, especially if the lengths of stay are long and there is little prior knowledge of the quality of the visiting researcher. It would be better if students could visit a laboratory for a couple of weeks at no cost to the U.S. researcher. The U.S. researcher could evaluate the student and decide whether it would be beneficial for the student to stay longer.

Another way to improve collaborations would be for Japan to convince successful Japanese expatriates to build connections back to Japan. They would not necessarily need to return to Japan, just "build bridges."

Such collaborations and exchanges can be especially helpful to developing the proper approach to scientific thinking, such as for identifying important research questions. To learn to excel at research, he believes, one needs to be around people who know how to choose problems and observe how they do it. Good researchers can pick their problems strategically and articulate what they are trying to achieve and why, setting the research question in a larger context. They can map out the goal posts and the possible routes to get there. Most researchers outside the United States are not as good in thinking critically like this, especially those in Asia. One way to remedy this may be to begin with reading introductions to cutting-edge papers, which explain "not just where the research is going to go but why we should care." In fact, in his graduate classes, he uses this method to teach his students, questioning them why papers are significant in a broader context. Then he follows with direct contact with researchers who are able to look at problems critically; personnel exchanges between laboratories can facilitate this.

At the student level, encouraging open discussions and an open-door policy among faculty might help, and informal mentoring by putting new students in work spaces in closer proximity to more-experienced students may also help. Such informal exchanges would allow immediate feedback from mentors to help students learn how to think critically about research problems.

Then, for those students who are writing proposals or submitting papers, comments from reviewers can also be helpful to sharpening their skills in critical thinking.

Finally, a high level of proficiency in English is essential. This view is shared by this German collaborator, who has gone so far as to make English the language of his research group in Germany.

Summary 34

Field and Subfield(s):	ICT; Electrical and electronics engineering (1)
Location:	EU
Status:	Established
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	Low

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

The respondent did not rank Japan among the top countries in his field, or at least, he said, Japan is not as "visible" as one would expect from a country of its size. Further, Japan is not visible in his subfield. His assessment of Japan's performance was based on the quality of Japanese research papers in major journals of his field (e.g., those published by the Operational Research Society and the Power and Energy Society).

Knowledge of microeconomics, mathematics, operational research, and electrical engineering were said to be essential in his field. Thus, researchers in his field cannot be experts in only one area. Countries doing well in his field are those that emphasize this combination of fields in their graduate programs—for instance, Sweden and Brazil. Germany is making progress, too, but he does not know what policies are responsible for their improvement.

Ultimately, the ideal model for his field, he said, is found in the United States. Students in the United States are free to choose courses to provide them the necessary multidisciplinary background. The European system is rigid and burdensome when students try to take courses outside their own department. Some exceptions to such conditions occur at institutions in Eastern Europe or Russia, but U.S. universities are still more flexible.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

The respondent commented that, even if Japan is doing great research, the rest of the world does not know it, because Japanese researchers do not publish in the leading journals. As an editor for some journals and having organized conferences, he reads a wide range of papers and meets many people. The Japanese research papers he has read are high in technical quality but poor in English and editorial quality. He also has not encountered any Japanese in Ph.D. programs outside Japan at his institution or other places he has visited.

By comparison, Chinese researchers, he said, are much more visible (e.g., researchers from Shanghai University have shown dramatic improvements in their English language proficiency and the technical content of their work in the past two to three years). He also finds Chinese researchers eager to contribute to growth of the field by publishing, attending seminars, and engaging in activities to identify research questions and find answers to them.

What are your recommendations for Japan?

Japan's efforts, in his view, should be focused on human capital. Computers are essential, but they can easily be purchased. Fostering human capital, however, will require Japanese researchers to interact more with the rest of the world. More Japanese should go overseas for their Ph.D. training or to do postdoctoral research. Japan should also bring non-Japanese to Japan to teach and conduct research in Japan. Japanese researchers must learn not only technical skills but also how research activities are organized, how questions are framed, and how interaction between students and faculty is carried out.

Since Japanese research is currently so invisible to the world, the first step would be to open up to rest of the world to show what Japanese researchers are doing and the quality of Japan's graduate programs. Complementing this would be a policy to encourage Japanese researchers to publish in the top journals and attend more conferences and seminars internationally and to expand relationships with individual researchers and countries that are at the frontiers of knowledge in the field.

Summary 35

Field and Subfield(s):	ICT; Electrical and electronics engineering (2)
Location:	EU
Status:	Rising star
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	High

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

The respondent said that Japan is quite strong in his field of carbon nanotubes. A major research group in Japan is led by Summio Iijima, who was said to be the first scientist in the world to observe carbon nanotubes using an electron microscope, in 1991. Iijima, said the respondent, controls significant funding and has additional research teams working under him. Other high-caliber professors leading strong groups are Marinobu Endo, Hisanori Shinohara, and Yoshio Bando. The respondent named Hiromichi Kataura, Dmitri Golberg, Shigeo Maruyama, and Ryuichiro Saito as additional prominent researchers in the field of carbon nanotubes working in Japan.

In fact, the respondent said, the world's leading experts in carbon nanotubes are in the United States, the EU, and Japan. However, the best papers and technologies come from the United States and Europe, even though Japan has very good equipment (e.g., electron microscopes).

The respondent estimated that about 300 people conduct nanotube research in Japan but that only 20 are internationally renowned as leaders. By comparison, he estimated, Europe has about 40 of the world's top nanotube researchers and the United States has 50, including many young faculty members who are also quite well known and with stronger publications than their peers in Japan. In this connection, he observed that the average age of nanotube researchers in the United States is about 40 versus 55–60 in Japan.

Notable institutions in Japan, according to the respondent, include NIMS and AIST, adding the observation that few researchers from Europe and the United States work at these institutes despite their being very well funded.

In his view, Japan is much more efficient in performing research that leads to the development of technology devices. Japanese researchers can obtain significant support and work on ideas that come to them externally, mainly from industry. AIST, for instance, receives considerable industry support from companies, such as Sony and Toshiba. Research projects at AIST usually are funded at levels five to ten times higher than is typical in Europe.

In this connection, it seems researchers Japan are far more focused on applied research—perhaps 90 percent focused on developing devices—versus the United States and Europe, where researchers are more interested in discovering new phenomena.

The respondent sees positive changes in Japan. He cited the Japanese Ministry of Education, Culture, Sports, Science and Technology's (MEXT's) center-of-excellence program, which provides funding to Japanese universities to create centers that (each) pursue a five- to seven-year project with about 20 professorial positions and recruit scientists from Europe and the United States to work at these centers. This reflects an opening of Japan, but these are still projects of short durations, so the majority of foreign scientists will leave Japan when the project is completed.

Research infrastructure in Japan is perhaps more advanced than in other countries due to the availability of public funding and support from industry for research and commercialization of results.

As for the quality of students in Japan, the respondent thinks that their knowledge of theory is quite comparable to their peers in other countries. The quality of education, on the whole, depends on the caliber of the university. Thus, he found students from Tokyo University and Tokyo Institute of Technology to be very strong, and reported that those in the engineering department may be even stronger.

In his view, Japan's higher education system is reasonably good on average. Master's of science programs in Japan may be even better than those in the UK; it takes six years to complete a program in Japan versus four in the UK. These additional years allow students to acquire more practical knowledge. He credits the yearlong assignments to research organizations as particularly helpful to increasing students' practical knowledge. Typically, he explained, in the fifth year of a student's master's program, the student would interview with companies and be offered employment. This leaves students to focus on their research in the sixth (final) year—in particular, to conduct research that relates to their future work and acquire the specific knowledge to prepare them for their new jobs.

The respondent had a positive experience in Japan from the start. He chose to go to Japan because he personally found Japan a very attractive place. Also, he considers the JSPS fellowship he received as one of the best in the world in terms of salary, research and travel support, and the opportunity to attend conferences in Japan. Although funding was more restricted for individual researchers to purchase materials and equipment, his research team as whole was well supported. He also had access to new equipment.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

Japan, on the whole, is not an attractive place for non-Japanese researchers. While Japan may be attractive—both professionally and personally—for a short duration of a few years, establishing a long-term career and life in Japan for non-Japanese is rather challenging. Language is a fundamental problem. It may be possible to learn enough Japanese for communication at a basic level, but attaining proficiency for communication at a professional level and writing academically are very difficult and time-consuming. Another difficulty is the social environment. Knowledge and practice of Japanese customs are important in the work environment, and the work structure is very hierarchical. He explained that solving a problem means going to the supervisor, who then passes you on to the secretary of the head of the group. The secretary then arranges for a meeting, and only then can you put forward your request for help.

Another problem of doing research in Japan is that research groups do not openly communicate with each other. At his institute, for example, each research group receives money from a different set of companies or government sources. Consequently, there was a high level of secrecy about what they were doing and who was paying for the work. As such, he finds the research environment less open to the free flow of ideas and said that research groups are more focused on pursuing money for their own work than on exploring new ideas and collaboration. When comparing funding per paper citation in his area of research, the UK spends ten times less than Japan but has more citations.

In this connection, the respondent believes, there is less creativity in Japan than the United States and the EU. When researchers can more openly communicate with each other and not be given topics on which to work by their superiors or industry funders, they are freer to explore and exchange ideas. At the University of Cambridge, for example, researchers can pick up ideas from a range of open sources, including conferences and journal publications, and take them further.

Also, in his experience, the Japanese research community—like Japanese society—is a "quite closed circle." He cited as an example that Japanese researchers in his field seem to put more weight on their participation in two local symposia in Japan and communicating their research within these forums than within the research communities outside Japan.

Also, researchers in the United States and Europe can generate spin-offs from their research—something Japanese researchers cannot do as easily. In Japan, research results are owned by the research institutions. It is the institution that would transfer patents to industry, which would conduct the final evaluation and production.

As for the education system at the doctoral level, the respondent finds that institutions like his in the UK to do a far better job in recruiting the best students from across the world; they conduct courses and research in a more open environment than in Japan. For an institution like AIST, the absence of a graduate school and having only a few research scientists also mean a less productive environment for the average postdoctoral fellow.

Another problem is the strict hierarchy system in Japan. The dependence young researchers have on their older colleagues and their relative lack of freedom in research negatively affect the quality of their work. Thus, he finds Japanese postdoctoral fellows to be generally inferior in quality to their peers from Europe and the United States.

What are your recommendations for Japan?

At present, some Japanese S&T policies aim to foster international collaboration, using such mechanisms as fellowships. Most non-Japanese researchers stay up to three years because establishing a permanent career and life in Japan is too challenging for a longer period.

Also, there is limited support for international collaborative projects. He knows of only two or three agencies—with JSPS being one of them—actively promoting international collaborations (e.g., making non-Japanese researchers an essential element in their work). This is not enough. Japan needs to become more open and create real opportunities for international projects, such as getting involved in research programs in the United States and the EU.

Finally, overall, he recommends that the Japanese government direct resources to encourage creative, innovative work. This ultimately would benefit the Japanese economy.

Summary 36

Field and Subfield(s):	ICT; Mechanical engineering (1)
Location:	EU
Status:	Established
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	Moderate

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

There are good institutions in Japan, some of the world's leading experts, and some major accomplishments in the area of mechanical engineering. However, the respondent could not cite them off-hand during the interview.

He found that, in the past, under certain circumstances, Japan's ability to determine goals and executing a long-term strategy to achieve them in a ten- to 20-year period has proven to be a strength. Japan appears willing to commit to plans that may take ten or 20 years to execute and achieve a goal, like becoming world leaders in creating electronic compact discs and making "made in Japan" a sign of quality by the 1970s. By comparison, European countries might have plans for the next five years, or the United States for an even shorter period.

The danger of using long-term plans is, however, that these plans could become outdated. Thus, in the United States, plans may last for as little as three months. Since the future is becoming increasingly unpredictable, such short-term plans may be more flexible in responding to anticipated and unanticipated changes.

He also found significant improvement in infrastructure at industrial laboratories in Japan over the past 20 years. He suspects that Japanese government support might have helped to make the difference and that professors, who are required to retire from faculty positions at 65 years old—like in Austrian and German universities—take up positions at private-sector laboratories after their retirement (e.g., a Japanese colleague of his went to work for Hitachi Corporation).

The respondent stated that he does not know enough about the Japanese education system to comment on it, although he has had five or six Japanese graduate students working under him and all were very good. The main problem in working with them is their lack of proficiency in English.

He has seen stronger interaction between Japanese universities and industry in the past ten to 15 years. However, as a non-Japanese working outside Japan, it is hard to know the relationship between universities and industry in Japan. In Munich, he said, a great deal of emphasis is now placed on creating "spin-offs." In the United States, too, professors would leave their university jobs to exploit business ideas.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

When working with Japanese researchers, the language barrier is a prominent issue. The living environment in Japan, too, can be challenging for anyone considering study or research in Japan. The language problem, small living spaces, and other factors make Japan less attractive. A friendlier living environment in the United States motivated him to attend graduate school in the United States and to accept a job from a U.S. university. This may explain, in his opinion, why most European students who come to the United States to study choose to stay for work as well.

Bureaucratic burdens are also greater in Japan (and Europe, too). By comparison, there is less bureaucracy in the United States (and more emphasis on individualism).

Finally, Japanese researchers work long hours but do not seem to be very efficient compared with their peers in the United States, who work fewer hours.

What are your recommendations for Japan?

The respondent emphasized that his recommendations are based only on his experience, and he cautioned against generalizations or jumping to conclusions.

First, giving space to creative research is important, and so is having high-quality researchers and good infrastructure. Good funding is, of course, also critical. For those whose research is closer to industrial research, industry money would be important. For those involved in basic research, public funding is essential.

On research organizations, both networks of small research institutions and larger centers are necessary.

Relaxing the hierarchical culture in Japanese research, in his view, would also be important if it is not serving the country in educating the next generations of scientists or providing services to industry. Universities in the United States have a much more open environment, and professors and students can more freely communicate.

Such a research culture, exacerbated by language problems, in his view, has made it extremely difficult for non-Japanese researchers to fit in. This, in his view, explains why no European or American researcher has managed to build an academic career from the beginning in Japan.

Summary 37

Field and Subfield(s):	ICT; Mathematics (1)
Location:	EU
Status:	Rising star
Gender:	Female
Nationality:	Non-Japanese
Professional experience in or with Japan:	Moderate

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

In her field of computational logic, she said, there are very good people in Japan. Based on her experience, she said, there is good international collaboration with Japanese researchers, with the latter seeming to have adequate travel funds. Her collaboration with Japanese researchers began with email exchanges and mutual visits, and she characterized the collaborations as "very open." Although the respondent believed that the system is very hierarchical in Japan, she did not personally have that impression when visiting and working with her Japanese colleagues.

In addition to having some very good researchers, Japan was also said to be publishing a lot in her area of research. This, she explained, is a good demonstration of the quality of research in Japan when it is the individual researcher rather than institution size or equipment that drives the work in computational logic. Several top people were named, including Gaishi Takeuchi (retired), Hiroakira Ono (at JAIST), and Yuichi Komori (at Chiba University). Younger professors, such as Kazushige Terui (at Kyoto University) and Makoto Tatsuta (at the National Institute of Informatics, or NII), were also mentioned.

The respondent said that several Japanese institutions appear to be well funded and able to fund monthlong visits of European researchers. Nevertheless, there are other institutions, such as the Institute of Mathematics and Its Applications, that are barely able to sustain themselves. Some of the leading Japanese institutions include JAIST, NII, and the Research Institute for Mathematical Sciences at Kyoto University.

In her own country (Austria), the respondent lamented that internal university funding in her field is very limited. In fact, the university has few publicly funded positions. The two key research grant sources are the Austrian Science Fund and the Vienna Science and Technology Fund. These two institutions, she said, do not limit their awards to specific topics. Awards are given to creative proposals, and grant amounts can be between 200,000 and 300,000 euros for up to two years.

Having no in-depth knowledge of Japan's educational system, she did not comment on its competitiveness vis-à-vis other countries. She was aware, however, that Japan has a strong tradition of mathematics. Where the European system is concerned, she rated it as superior to the American one because, in her view, the former emphasizes day-to-day studying while the latter is driven by tests. Thus, the European system produces students with a better mastery of concepts and skills.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

She said that researchers would work where they can find an outstanding level of research, infrastructure and access to equipment, and a nice and friendly environment inside and outside the university. For foreign researchers, both professional and personal lives in Japan could be challenging because they are not Japanese. Such adversity, she said, might explain why a number of her colleagues had spent only short periods in Japan.

What are your recommendations for Japan?

First, support basic research. In economic times like this (global financial crisis), basic research frequently suffers cuts when policymakers choose to emphasize applied research.

Second, help young researchers to launch their careers. Assistance, in her view, includes creating a friendly environment for them and having good mentors to guide them. She stressed that mathematics is not dependent on equipment and is somewhat less competitive than other fields. This makes mathematics a more open community intellectually, and collaborations can more easily occur when researchers do not require expensive equipment or access to facilities.

Summary 38

Field and Subfield(s):	ICT; Mathematics (2)
Location:	EU
Status:	Established
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	Low

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

The respondent named the United States as the best country in his field of mathematics, with Germany (specifically, the Max Planck Institute) and Japan (specifically, the University of Tokyo and perhaps Kyoto University) as being other leading countries. He saw China as likely to build strengths in mathematics but said that it is currently lagging behind the top countries.

He said that Japanese researchers have been working in the field of bioinformatics for the past 15 years. Japan, in his assessment, is very good at this applied side of his area (i.e., applying algorithms to computer science), but it is not as good in new mathematical developments. Japan's other strengths relative to the other top countries include its human capital (e.g., Japan ranks at the top in international high-school science and mathematics tests, such as PISA and TIMSS-R). Japan also has very good funding levels, hardworking people, and a relatively stable economy. The country is also highly ranked in its teaching capacities in terms of infrastructure, funds, and human capital. In comparison, the United States needs to import graduate students, while Europe struggles with funds and Russia with its economy.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

Japan's relative isolation and self-sufficiency might be its greatest challenges, according to the respondent. Even though Japan is very much developed in his field, he has never seen opportunities to collaborate with Japanese researchers. The respondent noted that there is little collaboration between Japan and his country and that there is no tradition of working together in developing Ph.D. programs or research endeavors. "There are no Japanese students in my country, while you see a lot of Chinese people in and out of the campuses."

What are your recommendations for Japan?

It is important to build networks. Japan, the respondent emphasized, needs to build more in this respect even as it has greatly improved in the past decade. An example to follow is the Erasmus student-exchange network that aims to foster graduate students' mobility.

For any country, he said, the key to a successful mathematics and science policy is to encourage scientists to be researchers as well as professors. Professors need to be hands-on researchers and expose their graduate students to research from the very beginning. Exchange initiatives, such as Erasmus, could help to mitigate these difficulties and challenges in collaborations due to differences in cultures and approaches in the same field.

Summary 39

Field and Subfield(s):	ICT; Mathematics (3)
Location:	U.S.
Status:	Established
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	Low

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

The respondent ranked the United States as the top country in mathematics. France would follow (the Centre National de la Recherche Scientifique), then Germany (the Max Planck Institute), and, finally, Russia, even though it has "lost its critical mass due to convoluted politics." He said that he was clear how Japan compares with other countries. In general, he thought, Japan is doing well, though not at the frontier of the field. He thinks of Kyoto University as competitive in the field and as doing good research. Two decades ago, he would have expected Japan to become a leader in the field today. However, in his view, Japan's performance has been disappointing in the past 20 years. In his own experience and those of his colleagues, Japan is a very expensive place to visit and live. Also, English is the "official language" in academic interactions, but Japanese is indispensable for more in-depth interactions.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

Tradition, he stressed, is important in mathematics, and time reinforces the strength of an institution. In his opinion, it is very difficult for any university, institution, or country to gain strength in the field without such a history or tradition in the field. In the case of Japan, such a tradition is lacking, so, he said, he considers it very unlikely that Japan will become a leader in the field.

What are your recommendations for Japan?

There is "no unique solution of how to organize and fund a successful scientific system," he said. Decentralization works well in the United States, while centralization works well in Russia and France. Russia, he noted, has a solid and sustained policy of investment in math- and science-related human capital that has lasted many decades.

Unlike other areas, he said, mathematics does not appear to have useful commercial applications for which synergistic links to industry would be useful. In fact, he said, the financial world can attract qualified people away from research in mathematics. Those left in research in math are people whose ambition is not driven by money. So a good environment that fosters innovation and a reasonable salary may be sufficient to attract math researchers.

His advice to any country wishing to build strength in mathematics would be to pick a subfield and attempt to build a tradition around it. A single country, especially a small country, cannot lead in all subfields. Another approach might be to create a number of institutions with "different levels of sophistication." This, he said, helps to explain America's success. With opportunities to combine academic training and subsequent professional work, people with different skills could find places to stay and grow professionally.

Summary 40

Field and Subfield(s):	Nanotechnology and materials science; Chemical, basic (1)
Location:	EU
Status:	Established
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	Moderate

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

Japan was seen to have improved a great deal in basic chemistry during the past two decades by doing the right things—specifically, sending people abroad and paying them to come back, giving incentives to firms to invest in fundamental research, and encouraging collaboration with European and American researchers. The respondent considered Japan to be second in the world behind the United States, and followed by Germany, with results published in the top five journals of the field. The University of Tokyo, Tsukuba University, RIKEN, and Osaka University were cited as examples of quality research centers in Japan. The respondent was also aware of some Japanese researchers who have won Nobel prizes. He said that he expects Japan to remain near the top of the field.

In his view, funding and connections with industry are definitely strengths of the Japanese system, and far ahead of Europe. He compared these with his experience in European countries, such as in Belgium, where, he said, it took a lot of effort to make connections with firms to get funding for both applied and theoretical research. In Europe, funding arises from individual initiative, with no official policy aimed at encouraging people to do so. In Japan, however, firms invest in theoretical research. He believed that it has been Japanese policy in the past five to seven years to provide public funding to private-sector firms for theoretical research. Although, he said, he is not aware of the specific instruments involved, he knows that firms have to compete for such public research funds. In this connection, he said, Japan is a leader in commercializing research because of strong links between fundamental or theoretical research and firms.

Japan, he said, is also very competitive in terms of infrastructure, administrative support, and travel support, especially when compared with the situation in Europe. He also ranked Japan highly in quality and quantity of human capital. He highlighted improvements in English language proficiency. In the past, he said, Japanese researchers hesitated to speak for fear of embarrassment if they did not reply accurately. With improved proficiency in English, he said, he found that Japanese researchers are more able to communicate.

In his view, he said, the centralization of national policies in Japan has worked well to coordinate different actors on infrastructure and funding and to provide guidelines.

He said that he strongly believed that Japan's strength in S&T is also due to the high regard its society has for scientists, thus making it attractive for people to pursue scientific careers.

As for visits to Japan, he said, he would not be daunted by the higher cost of living in Japan, as he knows that professionals are properly compensated.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

One problem is the aging population. Japanese society has a problem with aging in general, and this will affect its scientific and technological activities. Japan is aware of the problem and, to some extent, has tried to cope by hiring foreigners, even Chinese researchers. However, he said, he does not see too much future in this approach of using Chinese researchers because of historical tensions between the two countries. Specifically, he said, he does not expect Japan to put the development of the fundamental areas in Chinese hands.

The second problem, in his view, is the lack of interest among Japanese youths in the research professions. He said that this is a worldwide phenomenon and not unique to Japan. Young people value "soft professions" that might yield high pay. In the case of Japan, he said, when young researchers generally work under senior researchers as their subordinates rather than pursuing their own research interests, the most-driven ones might choose to go overseas.

Third, he said, "it is very difficult for a European to adapt to such a different society [Japan]." This foreignness of Japan to non-Japanese researchers might prevent them, including the respondent himself, from going to Japan to conduct research.

What are your recommendations for Japan?

In his opinion, both short- and long-term priorities are set in Japan, and they are fine. Japan simply needs to sustain what it has done so far and try to address its weaknesses.

The ideal S&T system, he said, would combine the leadership of the United States and its faith that everything can be solved, the creativity of the European system, and Japan's systematic approach to science and the hard work of Japanese researchers.

Summary 41

Field and Subfield(s):	Nanotechnology and materials science; Chemical, basic (2)
Location:	U.S.
Status:	Established
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	High

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

The respondent said that Japanese researchers do some very high-quality nanotechnology research. However, he regarded it as "not the most earth-shattering research but the next level down." Japan was rated as being in the middle among the top ten nations in nanotechnology, with little change in its competitiveness in the field in the past five years. Although Japan is investing in the field, the respondent noted that other countries, too, are investing. Also, this is a quickly developing field, so others are catching up. The top country, in his view, is the United States, followed by Germany, Switzerland, South Korea, and China.

Much of the top Japanese research in nanotechnology is instrumentation-based. As such, his pick of the top Japanese institutions are NIMS, RIKEN, Kyoto University, Osaka University, and the University of Tokyo. All other Japanese institutions, he said, rank at a substantially lower level. Among the top Japanese scientists in the field, he names Masakazu Aono, Akira Tonomura, and Kunio Takayanagi.

Although Japanese nano-scientists have highly sophisticated equipment, he said, he is uncertain whether the volume or number is adequate. Research groups at universities in Japan do not appear to have much success in commercializing research results. He surmised that this is partially due to a culture that does not incentivize individuals. When an entire department may have to put its resources behind a commercialization effort for the research results of one or a few individuals, the individuals might not have the support of the group. Japanese companies, in contrast, are very aggressive and successful in protecting their intellectual property. This relatively strong division between academic and industry research, according to him, is reminiscent of the old model in the United States.

He said that he is aware that Japan has been trying to improve the quality of its research and collaborations (e.g., at NIMS and the World Premier International Research Center [WPI]), by giving more opportunities to young researchers to think independently and creatively—skills that are essential to research success. Also, he cited Japan's large financial investment in the WPI initiative as an example.

However, he emphasized that breaking out of cultural patterns is not easy, so, in many cases, it is a "lot of talk but not much change." He said that he has great hopes for the center and that it looked like there would be strong potential to work with Japan. However, there has been little collaboration in practice. He attributed this outcome to excessive caution. In contrast, a training program in Denmark took the risk of recreating the system from the ground up, and big changes have helped to make Denmark competitive. He said that the aversion to risk hinders Japan from dramatically increasing its research competitiveness.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

First, he noted that the Japanese are trying to encourage collaborations through WPI and JSPS. However, in practice, these efforts have not always lived up to the aspirations of the planning stage. For example, in discussions with scientists in Japan, he said, he and his colleagues had planned on using English as the default language of collaboration. However, many conversations ended up taking place in Japanese, which meant that scientists lacking fluency in Japanese (such as himself) were left out of the discussion. He also observed that Japanese collaborators often wanted the researchers in his own laboratory participating in the project to be American rather than other nationalities. Such discrimination may also be driving away potential international collaborators.

The culture of Japanese laboratories might also hinder collaboration to some extent. He said that he finds many Japanese researchers lacking enthusiasm in scientific research. He also observed a much stronger division between personal and professional lives in Japan than in North America, which can sometimes feel strange to foreigners. For example, he said he was rarely invited to the homes of co-workers or got to know co-workers as individuals.

The social structure in Japan could also be an impediment to high-quality research. In his experience, he said, there are individuals with power who can do anything they wish. He also observed that students entering a laboratory are guaranteed a job upon exit by their supervisor. Thus, he thought, they have less motivation to perform well at their tasks. If this were changed, he said, students would become more motivated. He said that he also found that students were rarely very enthusiastic about their work and were more focused on getting published in high-visibility journals, such as *Science* and *Nature*, than on doing high-quality research for its own sake. High-impact papers should not be the only indicator for good research. An emphasis on paper-driven research might be an artifact of the reward system as well as pressure from laboratory heads.

Finally, he said, it is substantially more difficult for women to be active in high-level science in Japan. There are few women in positions of power, and they are paid less for performing the same job. In his experience, women were also shut out of some social gatherings. In this manner, Japan is missing the "power" of half its population.

What are your recommendations for Japan?

In the respondent's experience, he said, Japanese students currently do not challenge each other, as students do in the United States. For example, in his research group, students take responsibility for discussing and debating their research and the literature. In Japan, the filter is primarily at the entry point. Once researchers pass this point, they are guaranteed that their supervisor will find jobs for them. Their independence as researchers is also constrained. A diminished feeling of competition results, and they become less motivated to learn and improve. In the United States, there is competition for success at every level. This, the respondent stressed, encourages individuals to improve, which collectively improves the situation for everyone.

Summary 42

Field and Subfield(s):	Nanotechnology and materials science; Chemical, applied (1)
Location:	EU
Status:	Established
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	High

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

The respondent ranked Japan's work in his field as comparable to the best work in Europe, and noted that he has "a very high opinion of Japanese universities and industry." He did not think that the United States was very strong in applied chemistry. He named two companies, Mitsubishi and Hitachi, as leaders in his field and said that there are "excellent universities" in Japan, but he could not name the specific institutions. He explained that research in his field has been moving from basic to applied work and that the best work in Japan occurs in the private sector rather than universities. He ranked Japan a leader in other fields, too, such as photovoltaics and microelectronics.

In his opinion, Japanese researchers are "very quick," filing many patents, even on less innovative things to ensure that they are guarding the space surrounding other inventions, or so that a competitor cannot harm their product. U.S. firms were seen as less inclined to file patents, which would require them to publish their work. With knowledge in the public domain, others can make modifications on their work and file new patents, which might bar the originating company from using its products.

The research infrastructure in Japan was described as "good to excellent." Human capital in Japan, he said, is suffering the same problems as in U.S. universities 20 years ago. Specifically, average student motivation is decreasing (e.g., "nowadays you don't see them working [into] the night as in earlier times"). At least the top students still seem to be driven and committed. But, in general, students are less motivated and are driven to finish up quickly so they can earn more money outside of university. The respondent reported seeing the same tendency in China, noting that, when teaching there a few years ago, over 100 highly motivated students would attend his lectures. More recently, the audience is much smaller. He said that the organizers explained to him that attitudes are changing in China. With improved living conditions, motivation has fallen and interests shifted.

In his view, universities in Japan, the United States, and Europe all face similar bureaucratic problems. He noted that, when he visited the United States to conduct research, the individual research funding he received created a "complicated" immigration and tax situation.

He characterized Japanese industry research firms as well managed and said that there is a strong feeling of "belonging" to the company. This, in his view, benefits the company and should be supported in the workplace. In Japanese universities, too, he described professors as gods, but they were seen to treat their students very well, and everyone is friendly and respectful to each other.

The respondent said that he does not know much about the funding structure in Japan, but he thought that research funding was becoming more political everywhere. For instance, the EU Framework Programme allows the people writing proposal requirements to apply for funds, thus giving "the feeling it is a kind of mafia." Researchers who are awarded support are also not always the best ones. Similar tendencies in program funding was said to be true in other programs in Europe, the United States, and China.

He said that the quality of Japanese education is comparable to that in Europe and the United States and is much better than that in China, Singapore, India, and Indonesia. Among Asian countries, he ranked Japan and South Korea at the top. In his own experience, he said, he has had several Japanese postdoctoral researchers who are "excellent," hardworking, and who "listen to you and try to do the best they can."

What do you think are the weaknesses or hindrances to greater excellence for Japan?

In his view, the Japanese have a closed mentality, which always makes "real collaboration" a problem. Also, the Japanese like to have a strong feeling of "belonging" to something, which can be the family, the company, or the Japanese society as a whole. This may have positive implications, such as that Japanese researchers, after dinner, go back to continue working at their company, but he said that negative implications are also possible. For example, in his experience, a researcher at a company seems far more reluctant to share information than his or her peers in other countries. The politeness of Japanese people, too, can make it difficult to communicate with them.

Finally, in his experience, most Japanese do not have good mastery of English. Japanese people, as with other Asians, face language barriers because "the structure of their language is completely different [from] English or other European languages" so that it is extremely difficult for them to learn good English. Although Japanese scientists now command superior capacity in English, which helps in most communications, high-level information exchanges (e.g., writing for journal articles and presenting at conferences) remain very challenging for Japanese researchers. He said that he observed that researchers belonging to some larger European countries, such as France and Italy, also lack proficiency in English compared with their peers from smaller countries.

What are your recommendations for Japan?

He said that it is critical to promote original research in an unbiased fashion. Proposals are often evaluated by experts who may be too close to the research. For instance, reviewers might be friends and help each other out, or they may be enemies and would attempt to kill the proposal. Switzerland has a good system in this regard that the Japanese should consider adopting. He said that the research proposal must be submitted in English and is sent to at least one outside (non-Swiss) reviewer to make the funding process more independent and unbiased. He said that this might be initially difficult for Japan, because young researchers would have to write their proposals in English. In the long run, he said, requiring them to do it in English will strengthen their English capabilities.

He also recommended a preference in funding for individual research ideas because they can be most innovative. Ideally, the largest funding amounts, he said, should go to fund innovative individual ideas. Right now, in his experience with reviewing proposals, he noticed "a preference for proposals that fit into some framework."

Another way to encourage creativity would to be guard against "inbreeding." Early in their careers, scientists should change locations multiple times. For instance, the Ph.D. program at University of California, Berkeley, gives preference to people entering with master's degrees from other universities and admits only the most-outstanding master's degree graduates from the University of California, Berkeley, into the Ph.D. program. Basic research, he underscored, requires new ideas, which are most easily generated by the "refreshment of your head" that comes from change. The best system is therefore one in which people obtain a master's degree at one university, get a Ph.D. at another, and then go to yet another university for an assistant professorship. In the respondent's ideal career path, one would change locations four or five times before one turns 45 years old and then remain in the same place for the subsequent 20 years.

The question of what would constitute the best education depends on the goals of the system, he said. Some countries might choose to produce a smaller number of top researchers, while others might prefer to produce a larger number of graduates able to work in industry. To do both, universities need to provide mass education as well as Ph.D.-level education. To train outstanding people, he said, there needs to be "special treatment for top individuals who have a creative idea." The best universities also have the most critical evaluation system for appointing professors. While not all professors can be excellent at any given university, it is the top performers who make the difference. These individuals set the standards for teaching and research and produce thoughtful students.

Summary 43

Field and Subfield(s):	Nanotechnology and materials science; Chemical, applied (2)
Location:	EU
Status:	Established
Gender:	Female
Nationality:	Non-Japanese
Professional experience in or with Japan:	Low

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

In organic chemistry, the respondent named the top countries as the United States, the UK, Germany, and France. Japan, she said, is in a good position, but "one might have expected something better." She noted that Japan is very competitive in catalysis and perhaps at the forefront in this specific area.

She said that these countries stand out not only because of sufficient funding levels but also how they allocate funds to spur high-quality research and support physical infrastructure. She emphasized the necessity of pushing scientists and researchers to be competitive and to publish in the main journals in the field. For instance, she mentioned that the United States is uniquely competitive with its combination of an openness to discuss ideas, its graduate education system, and its large size.

The respondent named Ireland, Finland, and Denmark as doing well and catching up to those at the forefront. Ireland is promising, she said, having progressed a great deal since the 1970s and particularly in the past decade or so, due to the leading role played by government. She commented on its varied public policies, which range from strong human and infrastructure investments to the introduction of tax incentives for the private sector. Collaboration was said to be aggressively promoted between researchers inside and outside of Ireland and with researchers in private-sector firms (mainly pharmaceutical companies).

She stressed, however, that Ireland, Finland, and Denmark are small countries whose policies could not necessarily be extrapolated to Japan. The respondent did not know Finland's policies in detail, but, with respect to Denmark, she insisted that money played a role but that tremendous efforts also went to improving its Ph.D. program and the quality of its faculty.

One of Japan's strengths, in the respondent's view, is its graduate education. She commended Japan for its investment in human capital, increasing the quality of its Ph.D. programs, and fostering collaboration with institutions and researchers in other countries at the undergraduate, graduate, and postdoctorate levels.

While the respondent did not single out any specific institutions or researchers in Japan, she remarked several times on the high quality of Japanese Ph.D. graduates. Japanese postdoctoral researchers are also very well trained and "very detailed" in their work.

Finally, she said, she is seeing Japan opening up, as reflected by the increased number of Japanese students going to the UK for postdoctoral work, and she cited agreements between Japanese firms and research centers in Ireland.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

Based on her experience collaborating with Japanese students and researchers, she said, the main weakness in Japanese research is its overemphasis on applied research.

What are your recommendations for Japan?

Any country that wishes to be at the forefront of the discipline must first invest in physical infrastructure. She added that the quality of education at all levels must also be improved, both by bringing in high-quality faculty and by "raising the bar for students and researchers." Increased investments in ICT and promoting collaborations, through guidelines and funding, with leading countries or the private sector would also be helpful. Such actions in the EU exposed a large number of students and researchers to new ideas. Finally, quality must be emphasized over quantity. She counseled a "focus on excellence [and] to invest in the best science and in the brightest people."

Summary 44

Field and Subfield(s):	Nanotechnology and materials science; Materials science, metals (1)
Location:	EU
Status:	Rising star
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	Low

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

The respondent said that the field of materials science is too broad to say that there is national leadership in the entire field. Within specific areas, there are researchers in Japan doing high-quality work (e.g., in battery research, along with Korea, which is ahead of Europe and the United States). So, in his view, there are some renowned Japanese experts with international visibility, and he thought that Japan was well represented at conferences, especially relative to its population size.

In terms of Japan's research capabilities, he said, Japan is competitive in the quality of equipment and amount of research support. The respondent said that he thinks that Japanese researchers are paid good salaries, which, from a financial perspective, can make Japan a more attractive location for a postdoctoral fellow than going to, say, the United States. In his view, researchers in Japan have access to excellent equipment, more so than their peers in Germany or maybe even the United States. However, for foreign researchers working in Japan, life may not be the same as for Japanese researchers. The respondent opined that there appear to be two systems for researchers in Japan: one for Japanese and one for foreigners, with the latter generally excluded or left out on their own.

On improving the quality of education in Japan, from his perspective as a professor, he said, he would focus on cultivating academic excellence, even if it means having a smaller group of highly motivated students. Such students would ideally begin laboratory work as soon as possible to integrate them into creative scientific work.

Looking at the U.S. experience, the respondent said, U.S. professors are generally excellent, but the U.S. system does not necessarily produce exceptional students. In his research area (materials science), he said, his students in Germany are better trained than their peers in the United States. He attributed this to a better and broader education system in Europe that takes in a large number of students but weeds half of them out, leaving only the best to complete their studies. By comparison, he said that the U.S. education system is more tailored to the individual student's interests and does not impose on them a broader educational experience. Further, he said, U.S. students are less "internationally mobile" than their peers in Europe. For example, the respondent reported that a significant number of students at his university in Germany go to France, the Scandinavian countries, the United States, and even China for part of their academic training. This is something rarely seen among U.S. students.

The respondent said that he has the impression that, in the past few years, Japan has been putting a great deal of resources into establishing elite, internationally known institutions in the materials science field that would be attractive to international experts. However, when it fails to attract the world's leading experts to come to work in Japan, the country invites them to sit on expert advisory boards.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

The respondent said that, in spite of its financial resources and excellent laboratory equipment, Japan does not have enough qualified staff (both technicians and students) to maintain and handle equipment and that it is generally difficult for young researchers to build a career.

Also, he said that the pattern in Japan's research emphasizes "quantity" rather than "quality." Japanese research groups were said to be highly hierarchical, sometimes with some 50 to 60 people working under one professor. The respondent took the view that it is not possible for a single professor to maintain adequate scientific oversight for such large groups. Also, ultimately, a strong hierarchical structure is counterproductive for creativity.

What are your recommendations for Japan?

The respondent stressed that Japan must increase its human capital and dismantle the "counterproductive" hierarchical structure that discourages creativity. One option might be to increase the number of international research collaborations to reduce the "island existence" for Japanese researchers. Such collaborations would target researchers and students and would include travel support.

He noted that Japan already seems active with programs and activities designed to attract international experts to Japan. He said that there are several similar programs in Germany and the United States. For example, the German Academic Exchange Service (Deutscher Akademischer Austausch Dienst) has signed bilateral agreements with a number of countries. Another example is the Materials World Network of NSF in the United States, which provides money for common research projects between U.S. and international materials-science researchers. In this network, each participating country agency is responsible for funding its own researchers.

Such schemes may be superior, he said, because they nurture relationships to produce excellence in research. Creativity, too, must be nurtured, and creativity is about allowing individual ideas to come forth and be tested—which, in the case of Japan, may be hard to achieve because Japanese society values the group over the individual. Japan, he emphasized, should consider how to support people who think "outside the box." Such nonconformist thinkers or "freaks" can be especially important in the basic sciences because they dare to do things no one else believes in.

Depending on its focus, he said, centrally planned research is neither always possible nor fruitful. The respondent commented that the prevailing trend in the United States, and more recently in Germany, is to support large, interdisciplinary projects with research questions established by policymakers and often large and international research teams. As an example, he noted that, in the United States, funding mechanisms provided by NSF generally support large collaborative projects, while funding for individuals is practically nonexistent. In his opinion, these projects generally do not show a large return on investment in the form of scientifically exceptional results. Also, their huge structures are not manageable, which means lower productivity. The respondent suggested that it would be much better to have smaller teams of people who choose to work together because of a shared research interest.

Therefore, the respondent said that a key question for S&T policy is how to support independent researchers with creative ideas. He pointed to a new European initiative, the ERC, which funds unconventional ideas from researchers who have already proven their competence and expertise, as well as to a Deutsche Forschungsgemeinschaft (DFG) program for research ideas outside predetermined research topics. He highlighted that these funding approaches that respect and promote intellectual freedom are much more promising than having policymakers establish research priorities (as it was with nanotechnology and now energy). The respondent also cautioned that topic-driven funding should not be completely abandoned but that, especially in basic research, there must be room for individual creative thinking.

He underscored that it is generally important for researchers to conduct research based on their own ideas and on the approach they perceive as most promising, even if they fall outside program-oriented funding structures. Productivity and creativity need to be promoted, and scientists should have the freedom to establish their own framework. In this vein, the respondent stressed the importance of recruiting young rising stars and promoting international mobility for students and researchers.

Summary 45

Field and Subfield(s):	Nanotechnology and materials science; Materials science, metals (2)
Location:	EU
Status:	Rising star
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	Low

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

Japan is definitely competitive in his area of research, especially in some specific subfields, said our respondent. He described recent advances in his field as fairly evolutionary, such as advances in multiscale modeling, the possibility to treat longer scales in the case of bigger systems, and continuous improvement of computer codes and algorithms. The respondent said that the only recent project from Japan that attracted his interest is OpenMX. Looking further than five years back, the respondent mentioned the Earth Simulator in Japan as having significant impact and that Japan's contribution is mainly experimental, such as making electrons visible at the end of the 1990s. The respondent said that there are a few very good people in Japan, although a highly qualified wider research pool is lacking in his specific field of expertise. Nevertheless, he cautioned that Japan might be stronger and possess better institutions beyond his specific field and that therefore his opinions must be understood within this context. Also, the respondent commented that Japan is doing well in attracting the research community by holding conferences at which top people are presenting. Regarding the quality of Japan's education, the respondent said that he was not very familiar with the Japanese education system and so he could not adequately comment on it.

In his view, most of the top researchers in his field are in the United States, Germany, and the UK, and they have made significant advances in his field in the past five years. The UK, for instance, managed to catch up with the former leader in his field by increasing its research capacity through increased funding and having many more good young researchers contributing to the field. Also, Italy and Denmark were said to be quite competitive, too.

Among the leading institutions in Germany, the respondent named the Forschungszentrum Jülich, the Fritz Haber Institute of the Max Planck Society in Berlin, and several universities. In the UK, the University of Oxford, the University of Cambridge, and the London Centre for Nanotechnology were said to have been very successful in attracting highly qualified people, especially from within Europe. In the United States, the leading institutions were said to include the Massachusetts Institute of Technology, Harvard University, and Northwestern University.

On the future of his field in the next five years, he said that the strong countries will likely remain strong with their improved infrastructure and that he expects no significant change in the international rankings.

For Germany, specifically, its educational system (though good) would benefit from a stronger integration of theory and practical research, as is presently the case in the United States and the UK. The current German education system, in his opinion, is too formalized. Students, he said, go through a great deal of theory without linking it to practical research until they begin their dissertation work. Then, once they are in their dissertation stage, they are thrown into doing practical work without accompanying theory. Also, instruction is too formal, with little personal interaction in the initial phase of graduate school, changing only after students enter the dissertation stage.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

First of all, Japan lacks a highly qualified pool of researchers in his field. Perhaps this is a language issue; perhaps they are not as well trained. Good infrastructure and good people typically occur simultaneously—as in the United States and the UK—but, he said, he was not certain that this was true for Japan.

Second, he said, he has the impression that it is difficult for foreign researchers to be integrated into Japan's work system. Individual decisions, he underscored, are driven by the attractiveness of a country's overall research environment, including the funding opportunities available and respect for independent research, in addition to having highly qualified students and the possibility of tenure. When foreign researchers going to Japan are offered only temporary positions, it does not make Japan a very attractive place to pursue a career. Then, there is the living environment in Japan, which might be a less attractive option for foreign researchers.

What are your recommendations for Japan?

First, he said, Japan should improve its professional and social landscape to make the country more attractive to foreign researchers. To encourage international research collaborations, Japan must open permanent positions to foreign researchers. It must also have a broad and highly qualified pool of researchers and students, good funding opportunities, and an attractive living environment to appeal to researchers and their families.

Second, Japan must provide access to facilities (e.g., high-performance computing centers). Europe has been relatively successful in overcoming barriers tied to where researchers live and work. But, he stressed that "infrastructural networking" in the EU provided other benefits, such as increased openness, better exchange of information, and stronger research networks. For researchers in Germany, the major funding sources are the Max Planck Institute, national funds (e.g., the German Federal Ministry of Education and Research and DFG), and the EU. The EU, in particular, he said, has promoted networking and collaboration across national research communities.

Third, having a variety of active small groups that can work independently is more productive than having a strongly centralized "big father" telling them what to do—this, he said, is his impression of Japan.

Finally, to improve the quality of education, it is important to begin with broad study for about three years, then allow for deep specialization. He said that students must be led to the frontiers of knowledge in their area of specialization. They need to see where current knowledge stops and where new questions appear. Further, students should have maximum freedom to select their specialization and access to high-quality researchers, and researchers need access to high-quality students. This access to top people may be a bigger attraction than money.

Summary 46

Field and Subfield(s):	Nanotechnology and materials science; Materials science, metals (3)
Location:	U.S.
Status:	Established
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	High

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

The respondent said that Japan has done extremely well in producing groundbreaking work in metals materials science. For example, he cited three researchers connected with Nagoya University who won the Nobel Prize in Physics. Two of the three winners, Toshihide Maskawa and Makota Kobayashi, completed their postgraduate training at Nagoya University, while Yoichiro Nambu completed his postgraduate training at the Imperial University of Japan and subsequently pursued advanced studies in the United States. Thus, he believes, "clearly they [Japan] must be doing something right."

In his opinion, the seven former imperial universities are the best in Japan. Number one, by far, is the University of Tokyo. Kyoto University, Osaka University, and Tohoku University could all belong to the second spot. Kyushu University is lower down, perhaps sixth or seventh, but, he said, "it is still way better than the private universities." He noted that Akihisa Inoue at Tohoku University is the most cited researcher in the field. However, Inoue was recently appointed president of the university. This, the respondent stressed, is a classic example of a productive person being taken out of research and put in an administrative position, saying, "this is the end of his [Inoue's] career as a researcher and that is a great loss for Japan."

The respondent also described Japan's S&T capacity as "excellent" and "superb." Japanese laboratories were said to be very well equipped. Japan's strength is also reflected by the fact that Japan is a major developer and manufacturer of all the equipment everyone uses. He said that electron microscopes used at U.S. laboratories are all manufactured in Japan, and all by the same company (JEOL Limited). Japanese companies, he said, all make superb equipment.

The respondent also said that Japan's method of funding programs is "far better than the way it goes here in the U.S." MEXT, he says, does a good job in allocating Japanese government funds to laboratories, particularly those at the former imperial universities. Each department receives block grants that are divided up among the researchers, so the base level of funding for each professor is very good and provides a stable source of research funds to researchers, who can also apply for additional outside grants.

S&T training in Japan was also described as very good and at a very high level, and the Japanese government has done a lot to improve it in the past five or ten years.

The respondent does not think that there should be any policy-priority changes to increase international collaboration. Japan, he said, is excellent at encouraging collaboration, and "there is nothing they can do better." He added that it is extremely easy for international researchers to work in Japan. There is an abundance of funding opportunities (e.g., JSPS gives study and research awards for use in Japan). Researchers do not need a visa for stays of 90 days or less, so short visits are easy where immigration is concerned. He also said that the people are friendly. He said that he simply "cannot think of any way this situation could be improved."

The respondent said that he has been to Japan "a tremendous number of times" and also teaches there from time to time. All the time he has spent in Japan would probably account for more than three years of his life. He noted that he had taught a materials-science class in English but that students were not particularly prepared for a class in English. The situation was fine at the University of Tokyo, where students speak English well and always ask thoughtful questions in English. At Kyushu University, however, he said, English proficiency among students is quite poor. At the end of the class, when he got his reviews back, invariably about half the class was very enthusiastic, saying that he did a great job, that he was excellent, that he spoke slowly and was understandable, and that the exercise of learning in English was very important. The other half of the class, however, would comment that they were at a Japanese university and therefore should not have to take classes in English, that they did not understand a word, and that the whole exercise was pointless.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

He highlighted three main problems with S&T in Japan. First is the "horrendous" lack of female participation. In the classes he taught, he said, there were usually about 60 students, of whom only two were female. These female students would sit silently together at the very back of the classroom. There are virtually no female professors, aside from a couple of women here and there who come from China. Japan, in his opinion, is losing half of its workforce because it does not encourage women in science. This is a serious issue, especially in a country where the workforce is already diminishing due to a small and aging population.

This, he said, is in stark contrast to China, where women are well represented. Since China has so many female scientists there, some of them invariably come to Japan and do well. However, Japanese women do not get that far, and the few Japanese women who go into science at the undergraduate level would leave Japan for Ph.D. programs overseas and never come back, especially if "they're any good." The female postdoctoral fellow he has running his laboratory, for instance, is now married with family in the United States and would not return to Japan.

The second biggest problem (although much smaller than the absence of women in science) is the compulsory retirement age. Most public universities have a mandatory retirement age of 63. At the University of Tokyo, it is 62 years old. According to the respondent, "when you retire you're out, you're completely gone, you have nothing more to do with the university." This is in contrast to the United States, where professors can convert to emeritus status. He said that these retired scientists in Japan "are just finished, even if they were at the height of their productive research years." They do not leave for other countries because they want to remain in Japan, so they teach at private universities, which have a later retirement age of around 70. However, these are teaching positions only, and the professors do not conduct research. This policy can therefore cut out many years of productive research.

Lastly, there is no understanding that people may wish to devote their entire careers to research. He said that, when researchers reach a certain career point in Japan, there is "considerable pressure" to go into higher-level administrative positions at the universities. As with the compulsory retirement age, this is a "very short-sighted" policy that cuts people out in the prime of their research careers and results in an enormous amount of lost productivity. The respondent noted that many of his friends have been in this situation and are very unhappy about it. These colleagues, he said, have to accept the administrative assignments even if they do not want to.

What are your recommendations for Japan?

He believes that the lack of females in Japan's S&T is "absolutely the number one problem and it trumps all other problems. There is absolutely no encouragement given to women, and this needs to be rectified." He believes that changes must be made through MEXT to encourage minorities to engage in S&T.

Summary 47

Field and Subfield(s):	Nanotechnology and materials science; Materials science, polymers (1)
Location:	EU
Status:	Rising star
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	Moderate

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

"Japan is absolutely competitive" in his field of research, said the respondent. He cited Japan's invention of carbon nanotubes, though adding that other countries have produced groundbreaking research since and that today the United States is the leader in carbon nanotube research, followed by Japan and Europe. Japan, however, continues to produce the most-detailed and -difficult work when the highest technical capability is required. Japan is also the leader in microscopy.

According to the respondent, the key Japanese researchers in these areas hold prominent positions and have good access to funding. Some of the leading institutions in these areas are the Meijo University, the University of Tokyo, the technology cluster in Tsukuba, and NIMS—all of which the respondent has some familiarity with.

The respondent believes that Japanese research infrastructure is also at the top end, having likely better equipment than the top U.S. institutions, and this is especially true in microscopy. Also, the respondent said that his impression is that it is not too difficult to find money for research or travel in Japan.

In terms of management and organization of research institutions, he said that the United States might be better than some European countries, such as Italy, for example, where it can take up to two years to get a grant approved and often the award is only a small portion of the full amount needed. In the United States, he said, feedback is much quicker, grants provide sufficient money, and oversight on how grant money is spent is done "with a light touch." However, he noted that grant applications to NSF in the United States can take much longer to process than applications in Europe. In particular, he emphasized that preparing research proposals in the United States could be very time-consuming, since proposals can average about 60 pages in length. In contrast, the national grant applications in the UK are about six pages in length.

The respondent said that he could not comment on Japanese science education. Regardless, he said, he believes that the United States has the best educational system in the world. Although undergraduate education in continental Europe is more challenging, takes longer to complete, and gives students a deeper knowledge than the system in the United States (and Britain), the system in continental Europe puts less emphasis on connecting experiments and real-life problems. The U.S. and British systems also give students more hands-on experience. Then, in graduate training, he said, a Ph.D. program in the United States is longer (five years versus three in the UK), which allows more time to enable better training. However, he said, he has faith that the British system will improve. For example, new programs are becoming more like the U.S. system, requiring four years to complete with the first year focused on practical knowledge and training.

Another advantage of the U.S. universities, he said, is that, when researchers are hired, they receive a starter grant to launch their initial research and, if good results are produced, they will have access to additional funding. He contrasted this with Europe (including the UK), where there is no starting funding, which makes it very difficult for young researchers to launch their careers, even though access to funding might be easier once they have established their credentials. For instance, in Germany, the respondent explained, one gains significant access to staff and funding following appointment as a full professor.

Over the next five years, the respondent said that he expects no significant changes in national leadership in his area of research and that countries that are currently strong will remain on top. He did mention, however, that competitive players might emerge in some areas. Research institutes in India and Saudi Arabia, Chinese universities (e.g., Peking University and Shanghai Jiaotong University), and a private firm in Russia are all building human capital and infrastructure to be active players in nanotechnology and materials science.

The global financial crisis, the respondent speculates, may be slowing the out-migration of researchers from India and China to places like the UK, where graduates may more likely choose to stay in academia than work in the private sector. Their decision to pursue a research career might even be a catalyst to a larger share of high-level researchers coming directly from U.S. and European universities. Finally, he said public-sector funding for research, too, might become more important when private industry is hurting a great deal from the global financial crisis.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

"There is nothing wrong with the Japanese system and institutions, per se," said the respondent, based on feedback from colleagues who have worked in Japan. He said that his own experience with Japanese researchers has also been positive. However, in his experience, older Japanese researchers tend to be a bit formal, and Japanese themselves function within a very formal structure. He said that the groups with which he has worked are deliberately mimicking the more informal structure and communication style that are common in the United States, but probably not all research groups in Japan are doing this.

As for Japan's research performance, the respondent said, he expects more than what he sees, given the superior funding and equipment available in Japan. In Europe and the United States, researchers have less and lower-quality equipment, but they produce more in quality and quantity. This led the respondent to conclude that Japan has managed to keep up with Europe and United States because of its superior equipment and that there is room to improve human capital in Japan.

As for Japan's effort to internationalize the domestic research environment, Japan's environment and culture (including language) may be simply too alien to European and American researchers. Programs like the Toshiba fellowship are quite attractive, but making a career and building a life in Japan can be quite challenging. Most European researchers in Japan return to Europe after stays of two to three years. By comparison, moving within Europe or to the United States is easier.

What are your recommendations for Japan?

The respondent said that he could not speak for Japan specifically. In general, having the right funding structure is critical to promoting excellence in research. Researchers in Europe and the United States are often required to demonstrate that their research has applied uses, which might necessitate collaboration with an industrial partner to guarantee that the research output will lead to a product. There should be support for much more "blue-sky research" (that is, fundamental, conceptual, not tied to application) because it often produces the most-important findings that are the foundations of scientific knowledge. He cited the establishment of blue-sky grants by the Imperial College in the UK as a very positive step. Further, it would be desirable if researchers could gain multiple research grants (in addition to initial grants) to keep exploring a question if the initial funding allocated was not sufficient, instead of having to apply for new funding with a different question.

He said that it would be ideal if a certain amount or percentage of funds would always be set aside to sponsor exploration of good ideas. Also, reducing the administrative burden in grant writing (e.g., shorter proposals and no lengthy mandatory reports) would leave more time for researchers to engage in scientific work. The publication of research results in peer-reviewed journals and an accounting of how research funds are spent should be all that is required. Finally, there should also be more awards for individuals at the beginning of their careers, and, as their credentials are established, access to funding should be eased. The respondent cited as examples two recent British grants for graphene research that are about £5 million each.

The establishment of the ERC in 2008 and a new way of funding research also hold promise for Europe. The ERC, he explained, provides up to 3 million euros in research grants over five years for individual researchers and significantly reduces the administrative burden associated with grant proposals. In the first year, 10,000 applications were received for 200 grants.

This contrasts with the situation in the United States, where the administrative burden and bureaucracy for research grants are much more onerous.

Finally, international exchanges—that is, spending time overseas for training and research collaborations—can be critical to improving S&T capacity. In the case of Japan, the respondent noted that the best Japanese scientists have all spent a significant amount of time abroad.

Summary 48

Field and Subfield(s):	Nanotechnology and materials science; Materials science, semiconductors (1)
Location:	EU
Status:	Established
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	High

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

The respondent said that Japan is well positioned to remain a leader in surface research. Japan, in his view, is also a leader (along with other Asian countries) in research on lithium-ion batteries and has brought important new approaches to photovoltaic research.

Overall, he thought, Japan is quite good in all interesting areas of materials science. He cited several examples of Japanese innovations: amorphous crystalline silicon cells (by Sanyo); injection cells (or semiconductor-electrolyte cells), in which electrolyte is substituted by gel-structured polymer electrolyte; and the use of titanium-dioxide as a photo catalyst. He said that all these ideas originated in Japan.

But often when the initial idea did not originate in Japan (e.g., the lithium-ion battery, which originated in the United States), Japan (in this case, Sony) has managed to turn ideas into commercial products.

The respondent said that the top institutions in Japan in his field include the University of Tokyo and various public and industrial research institutes. Among the public research institutes, he named AIST. Among the industrial research institutes, he named the Toyota Institute of Technology, which he described as a "company university." The difference between these institutions, the respondent said, is that the universities have considerable financial resources but relatively outdated laboratories and buildings, while the public and private research institutes are very well equipped. As an example of the latter, he cited the laboratories of NTT near Tokyo as the biggest and best equipped that he has ever seen.

Where human capital is concerned, he said that Japan appears to have a wealth of it and that research groups are well staffed.

The respondent said that he believes that research success is strongly correlated with the percentage of gross domestic product (GDP) invested into research. Europe, the United States, and Japan all have a long history of investing in research. In addition, "professors" are highly regarded in these societies, which also helps to recruit people into the field.

Japan, in his opinion, was said to have a relatively high readiness to take risks in research, as reflected by its investment in new systems. Japanese research was described as relatively innovative and prepared to investigate unclear areas if the issues are interesting. By comparison, he said, research in Germany is more risk-averse, and funding is provided more for topics in which the scope is clear and other countries are conducting research.

Finally, he rated Japan's education as very good in assisting students in acquiring both theoretical and experimental knowledge.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

In the respondent's view, organizational structure in Japan is very hierarchical, and it hinders creativity. People are assigned to follow up on ideas (along with regular "checking in" rituals) rather than given time to be creative and follow up on their own ideas. The respondent compared this with Germany, where groups are also organized around a professor but where doctoral students and postdoctoral fellows enjoy more autonomy in their research approach and more critical communication and compromise occur between senior and junior staff. In Asia, the researcher with the longer experience is the master. He is assumed to know more about everything and is expected to teach the young ones. As a result, younger researchers have less autonomy and are not inclined to be critical of "old knowledge."

Another problem with this hierarchical structure is that the best and brightest are not always the ones recruited. Typically, a retiring professor is replaced, or succeeded, by his preferred "student," who may or may not be well qualified for the position. The respondent said that this makes the system less open to younger or more-critical researchers who think differently from or question the established professor. However, one advantage of such a system, he said, might be continuity in an investigative approach to avoid sudden changes according to the latest "trends."

In this connection, he said, rigid structures and unwritten rules also seem to hinder non-Japanese researchers from working in Japan. For non-Japanese, becoming a professor in Japan appears to be more difficult than in the United States. When staying only temporarily in Japan, researchers are not expected to learn how to operate within these structures and unwritten rules. Although non-Japanese researchers may not be expected to know these structures and rules, they cannot advance without learning them and learning to operate within them.

In his own experience, he received a high level of cooperation when working with Japanese colleagues. But, in general, the level of cooperation is greater when working with colleagues in the United States and Europe. Japanese students and researchers, too, seem more reluctant to go abroad, and Japanese students generally have lower proficiency in English than their peers in Europe.

Then there is also a kind of mindset among Japanese students who work very hard to sail through the rigorous admission process of the leading Japanese universities. But, once they are enrolled, they do not appear to want to apply themselves any more. He said that it is as if they feel that good grades and graduation will just be awarded to them without additional exertion. Not that Japanese students and researchers do not work long hours—they do—but they seem to be less effective than their peers in Germany and the United States. He has seen students and faculty falling asleep in his lectures in Japan and in staff meetings because people are so exhausted by the long working hours, and such behavior seems to be condoned or treated with empathy. In Germany, the respondent said, falling asleep in a staff meeting is unthinkable.

Finally, Japanese education appears to have no critical distancing from the findings. He has seen students and researchers draw conclusions based on preexisting knowledge without critically questioning this knowledge. He said that this tendency toward thinking that "if it is written someplace it must be true" seems to be a general characteristic of Asian countries (and might be even stronger in China). In the United States and Europe, he said, there is a stronger tendency to question. Such difference may be attributed to the Enlightenment in Europe, whereas knowledge transfer in Asian society occurs within the context of a "master-disciple" relationship.

What are your recommendations for Japan?

International collaboration will contribute to excellence, and international collaboration must begin at the student level. Students, he said, need to be more proficient in English, and they need to spend time overseas, if they plan to pursue an academic career. Inviting foreign lecturers to come to Japan helps (e.g., activities sponsored by JSPS), but it is not enough. He insisted that more Japanese researchers and students must go abroad. In Germany, he said, it is rare for anyone to be appointed a professor without have spent some time conducting research abroad. In short, international experience is a basic requirement.

Further, it is people rather than institutions that are truly engaged in collaborative activities. Hence, concluding more research agreements, for example, between institutions in Japan and overseas is not enough. Japanese must go abroad. Yet, few seem to want to do it, and there seems to be little incentive for them to do so. In Germany, for example, many projects need postdoctoral fellows, and Germany does not have enough graduates to satisfy this demand. He said that many Chinese postdoctoral fellows are coming to Germany to take advantage of these opportunities. In fact, the respondent said, he now has six Chinese postdoctoral fellows, as well as Russian and Indian researchers, in his laboratory. University programs in China and India are producing high-quality researchers, and many are going to the United States and Europe for higher salaries.

As for the method of instruction, in his experience, training in theory and experiment can occur in tandem. Students should experience the key concepts both theoretically and experimentally and should also be encouraged to take a critical view on things, especially because often research proofs taken as accepted knowledge are later shown to be wrong. In Europe, the respondent opined, there is a tendency toward more-superficial university education, with less of a clear distinction between in-depth and more-superficial education. This, he believes, is a result of mass education, in which all are put through the same system instead of allowing a distinction between those who want to go into depth and pursue an academic career and those who prefer more-practical study. One should recognize that there are students with more or less ability and differentiate. In Germany, the previous system assumed the earlier recognition and differentiation of students with varying abilities by establishing two types of universities (polytechnic and normal universities). In Japan, the respondent said, people know very well which universities conduct in-depth studies and which focus more on broader, practical studies. Similarly, he explained, in the United States, there is also a clear differentiation between the top universities and other universities that aim at more-basic knowledge transfer.

Finally, in terms of managing research, it is important to provide merit-based promotion opportunities for young researchers.

Summary 49

Field and Subfield(s):	Nanotechnology and materials science; Materials science, semiconductors (2)
Location:	EU
Status:	Established
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	High

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

The respondent said that Japanese laboratories are very well equipped with state-of-the-art instruments. He said that he is impressed by Japan's intensive national S&T planning—in particular, in selecting fields for increased funding. He said that having some 50 people from the highest levels of industry and academia come together to participate in large councils to plan new initiatives is simply not done in Sweden, where this respondent works. Further, decision-making processes in these large councils in Japan appear to be quite efficient.

In terms of significant accomplishments made by Japan in his field, the respondent said, Japan now leads the world in high-temperature connectivity, even though much of the work on this was done in the United States. Japan was also said to be strong in neutrino, materials, microelectronics, and nanoelectronics research—all areas in which Japan has stayed in the forefront but not as the world's top leader. As for other fields in the basic sciences, the respondent said, Japanese scientists appear to be well funded. For example, leading Japanese researchers have large detectors for studying elementary particles.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

Japan may be "too well equipped," considering that it does not have enough human capital to make full use of its high-quality facilities. In his experience, he said, when there are too few technicians to maintain equipment, researchers must invest their time to set up experiments and maintain the instruments—time that might otherwise be spent doing research.

Similarly, the respondent said that, although he did not know too much about the management of research organizations in Japan, he has the impression that administration is a bit top-heavy in Japan.

Other than this, the only weakness, he said, that is apparent to him is the inability of Japanese researchers to critically question problems and issues. This inability, in his view, traces back to weaknesses in training students to become critical thinkers at the college level. Also, culturally in Japan, researchers hardly ever criticize or challenge their superiors. In fact, only higher-level or senior researchers in Japan seem at ease with expressing criticism openly.

The respondent said that he had visited several laboratories in Japan for a period of several months each and felt that his experience was fairly similar to exchange visits at institutions in the United States and Europe. He did not conduct many experiments because his stays were short and the instructions for equipment were all in Japanese.

He said that foreign researchers could find it difficult to gain full acceptance as equal partners in Japanese society at the professional and social levels. Perhaps, he said, this is a result of Japan being a rather hierarchical society and one not accustomed to assimilating foreigners into its homogeneous environment. Personal relationships and networks, too, matter a great deal. Here, again, foreigners in Japan are disadvantaged.

What are your recommendations for Japan?

Most fundamentally, Japan should expand access to full-time and tenure positions for foreign researchers in Japan. He stressed that the system must decide how foreign researchers can meet their teaching requirements if classes are conducted in Japanese. This may not be a big issue if foreign faculty can teach in English and if Japanese faculty do not get preferential treatment in picking courses for instruction.

Summary 50

Field and Subfield(s):	Nanotechnology and materials science; Physics, basic (1)
Location:	EU
Status:	Established
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	Moderate

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

The respondent said that both individual Japanese researchers and Japanese institutions are very strong in the field of theoretical physics. He reported seeing major advances in Japan in his field, especially in the past five years. Japan, he said, has also established completely new subfields. In all respects, he said, he considers Japan as on par with other leading nations, and he expects this to remain the same in the coming years. Kyoto University and the University of Tokyo were perceived as particularly strong. Visiting several Japanese universities a few years ago, our respondent said, he found the experience very positive and was very impressed by the facilities. He said that he has yet to engage in any joint research with Japanese researchers but noted that one of his students is currently at Kyoto University and is reportedly enjoying the experience there.

He said that Japan is probably better positioned than other countries to attract young people to work in science because the prestige of science has not deteriorated as much in Japan as in most other countries.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

The respondent said that it is widely known that opportunities for foreign researchers are very limited in Japan. Thus, he had not considered an extended stay, like a sabbatical, in Japan. Further, in his view, Japanese science is a closed community, and he did not expect it to completely change in the foreseeable future.

What are your recommendations for Japan?

He made no recommendations, emphasizing that Japan is well positioned in international research in the theoretical science.

Summary 51

Field and Subfield(s):	Nanotechnology and materials science; Physics, basic (2)
Location:	EU
Status:	Established
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	Low

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

Due to his lack of "experience with the Japanese situation," the respondent said, he should limit his comments to the situation in Europe. The problem with physicists, in his view, is that they "mainly like to do what they do and to change that is really tedious." In his own experience, he said, he had a difficult time changing fields within physics. It has also been difficult to get physicists to participate in industrial research. He said that European countries have been striving to integrate research in universities and industries, but researchers in academia and industry mistrust each other.

The respondent said that he does not expect Japan to reach the forefront of the field in the next five years. For high-energy physics, the best place to be is CERN (the European Organization for Nuclear Research), on the border between France and Switzerland, and in Germany, which has several high-energy facilities. Such infrastructure is absent in Japan, even though, he said, there are "some nice facilities in Kyoto [University] but nowhere else." He said that he knows that Japanese researchers from different institutions visit CERN for their work.

In the Netherlands, the respondent reported, a change in funding policy has provided large sums of money to young researchers to build up their own research groups. This has helped to attract young researchers to the country. Sustaining this as a long-term policy, in his opinion, can be very beneficial to raising S&T capacity. His research group received funding for a research program that will last more than a decade. Having secured such long-term support, he said, his research team can better focus on research rather than writing grant proposals.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

He stressed that scientists should not have to constantly compete for money. For example, small research groups in Italy must "fight for the money," unlike their peers in Germany, who receive support from a centralized structure.

Perhaps the lack of interest in overseas training and research experiences among Japanese students and researchers might also be a handicap. The respondent noted that he has rarely seen nuclear physicists from Japan visiting his institution. This left him to question just how "international" Japan is.

What are your recommendations for Japan?

The main thing is to have good scientists. Funding is necessary to educate them, attract them to accept employment opportunities and stay, and support their research. In his opinion, when a society does not value science, access to funding for science becomes more difficult.

Summary 52

Field and Subfield(s):	Nanotechnology and materials science; Physics, basic (3)
Location:	U.S.
Status:	Established
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	Low

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

The respondent said that Japan has not been a significant player in gravitational wave physics until recently. Coming from a place of "significant weakness," Japan was said to be now at the forefront and pushing to be a big player, but it is not yet a challenger to the U.S. leadership. In the 1960s and 1970s, and into the 1980s, Japan was not a major presence in astrophysics, with the exception of a few singularly good astrophysicists. Then, in 1990, the country was said to "come out of nowhere" through the effort of a number of young people.

The respondent named Seiji Kawamura the top Japanese experimentalist and said that the University of Tokyo has been influential in the field through the work of its Institute for Cosmic Ray Research. He said that another astronomical center just outside Tokyo has also been doing very good work. Kyoto University was said to be a major player on the theory side, and Japan was said to have "a handful of superb theorists." The respondent also noted strength at Osaka University. Some very interesting and important accomplishments were said to have been made on the small scale (e.g., by individuals or by making very specific measurements). For instance, the Japanese were said to be significant collaborators in the Laser Interferometer Gravitational Wave Observatory (LIGO), second only to the UK and Germany in contribution.

The leading countries were said to be the United States, the UK, Germany, and Russia (at least a few years earlier, and it is expected to recover). Surprisingly weak, according to the respondent, are Italy and France.

The respondent also said that he is not sure how people can be educated to think creatively. The American system, in his view, seems to be "clearly very good" at educating people to think creatively, and the Russian system used to be as well. China has been improving in this regard in the past decade. In fact, he noted that the "very best person in the field" is from China and that he finds superb young Chinese scientists eager to return to China.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

The respondent said that Japan appears to "have the organizational ability to pull off large-scale projects." These projects were said to be organized "far more tightly" than large scientific collectives in the United States, but they produce roughly comparable levels of success.

He said that the Japanese system "does not seem to give younger people space to be brilliant." When they are doing something routine, he said, the Japanese approach is more effective. However, when branching into new areas, "there's a problem with the Japanese approach." He commented that even the Soviet Union allowed its brilliant young people to have significant roles in innovation, despite centralized decisionmaking.

The respondent said that he has had some superb young Japanese scientists in his laboratory. One of these, who returned to Japan, was "clearly one of the several very best people in the world," but, because of the structure of hierarchy in Japan, it would not be possible for him to be a leader in Japan. In Japan, the respondent said, only those with superior political connections and high prestige become leaders of laboratories.

What are your recommendations for Japan?

For people intending to perform cutting-edge research, it is important that "they have received enough of the tools to explore ideas as they come along, but also have high creativity when it comes to pursuing new ideas." These, the respondent noted, are "the most difficult things to find in your people." He said that he has seen these talents in roughly the same proportions from his graduate students from Japan and elsewhere in the world.

Summary 53

Field and Subfield(s):	Nanotechnology and materials science; Physics, applied (1)
Location:	Russia
Status:	Established
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	High

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

The respondent took the view that there has been little groundbreaking change in the field of applied physics in the past five years, despite overall progress. No specific country, institution, or individual was identified as being a global leader. In this connection, the respondent declined to name his pick of top institutions and researchers in Japan, for ethical reasons.

Where Japan's strength is concerned, the respondent said, Japan has a wealth of human capital, comparable to other countries. Japanese researchers were described as thorough in their approach to scientific problems and precise in their experimental work, and the Japanese were said to be an "industrious and assiduous people." As for infrastructure, it is a good sign to see laboratories existing in Japan.

Another field in which Japan could hold a leading position is nanomaterials. The respondent said that Japan's scientists and engineers have great potential to leap forward in computer science, where they currently lag behind.

In his view, Japan's technology ability is "surely higher than in the most of economically advanced nations," but "technological ideas are wandering in the air. It is easier to catch and improve them than to propose a new scientific idea."

Finally, he said, he expects Japan to produce "a great breakthrough after the next five years."

What do you think are the weaknesses or hindrances to greater excellence for Japan?

Except in a few scientific fields, Japanese representation in the science citation index was observed as lower than the world average, but, our respondent said, the situation is gradually improving.

On research management, the respondent underscored the importance of individual creativity. He said, "if we wish to have non-ordinary scientists we must allow them free thinking. It means that we ought to encourage young as well as older scientists to develop their own ideas, not only those belonging to the chief." In his opinion, Japan's scientific establishment suffers from "superfluous centralization."

What are your recommendations for Japan?

First, he stressed that providing sufficient funding for scientific research is critical, whether it is for research within Japan or international collaborations. In his view, with modern communication technology at our disposal, joint research activities need not require participants to come together to work in the same space. Rather, with proper task assignment, researchers can use information and communication technologies to support their work and collaboration. For instance, the raw experiment could be performed in one laboratory, while data processing could take place in another lab that is better prepared for the task. Of course, such an approach requires well-managed and flexible systems of joint grants (for example, research supported by the U.S. Civilian Research and Development Foundation). The respondent said that he has seen successful partnerships and urges Japan to become involved in them. Japan should take advantage of such mechanisms to expand overseas training opportunities for its students and researchers. When visiting a British laboratory, for example, he said, "one can see that at least one-third of the staff are Chinese undergraduate students, Ph.D. students, or post-docs but almost never [any] Japanese collaborators."

There should also be an open competition of ideas in every university department and scientific institution in Japan. This would encourage the best ideas to come forward regardless of the age, seniority, or reputation of the scientists behind them.

Regarding near-term versus long-term goals, basic research should be Japan's near-term priority because the basic sciences lay the foundation for long-term goals. As for determining the long-term goals, Japan should look to its unique environment to find the answers. As a country with a poor endowment of energy and natural resources, Japan's main efforts must be aimed at creating energy-saving and environment-friendly technologies (including supercritical fluid technologies) and developing alternative energy sources and storage possibilities. Another area of focus might be in the health area. Despite good medical services in Japan, the respondent said that "the state of healthcare sciences [in Japan] cannot be recognized as advanced" and stressed that advances in the basic sciences are needed to turn this situation around.

As for improving Japan's education system, Japan, too, must go back to the "roots of the problem." It is a common mistake, in his view, to simply pump a great deal of knowledge into students, most of which may turn out to be useless. The main aim of education should instead be to develop creative thinking. This is not easy because teachers and professors have to possess the same rare quality of creative thinking. One way to nurture talented scientists is through competition at all education levels that aims to demonstrate the ability to think rather than mere "knowledge about everything." Japan, he counseled, should also attempt to understand why Japanese engineers are internationally renowned yet the same cannot be said of its scientists. To take this further, perhaps scientists and engineers would benefit from specialized education programs that they can freely enter and leave.

Summary 54

Field and Subfield(s):	Nanotechnology and materials science; Physics, applied (2)
Location:	EU
Status:	Established
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	Low

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

The respondent said that applied physics is somewhat new as a field and that he considers Japan to be competitive in computer programming but not good at the level of theoretical, groundbreaking research. Japan, in his view, invests a great deal of funds and energy in the area, including having good infrastructure and administrative support, but only copies the work of others and develops the computational or implementation aspect. The University of Tokyo and Osaka University were named as the top institutions in Japan. Overall, he said, Japan is good with hardware and software, but not doing as well in theoretical developments. Thus, at this time, he would be open to collaborating with Japanese researchers but expect their contribution to be only in computational developments.

As such, he would expect Japan's undergraduate and graduate systems to prepare students well in computing but not in advancing theoretical research. He described Japanese researchers as systematic and hardworking but said that, as they are lacking a strong theoretical background in training, they cannot effectively engage in research to advance the field. In his view, as long as such a bias persists in Japan, he does not expect the quality of Japan's work to dramatically improve. Instead, he said, he is more hopeful of the situation in China and India, where he has seen greater support for theoretical research. Other countries doing well in theoretical development are the United States, Germany, and France.

Although the United States has been leading the field, he said, Europe is catching up because of Europeans' creativity and flexibility in putting together research teams and doing interdisciplinary work. He said that he has seen more Japanese researchers collaborating with peers in Europe than in the United States. Teamwork, he underscored, is especially important in this field because "the input is physics and the output is chemistry." The high-performing countries are Germany, Italy, the UK, Switzerland, and France—though, in the case of France, its academic community appears reluctant to explore this field. However, he said, Europe's rise is not certain, given the enormous bureaucratic burden that prevails in European countries.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

He said that Japanese researchers seem arrogant and poorly grounded in theory. Further, Japan has money and people but lacks the approach and leaders to change the way S&T are driven in this field.

What are your recommendations for Japan?

Japan must strengthen its theoretical foundations in the field and achieve this by setting both short- and long-term priorities. To develop a good system, he suggested two approaches. The first is to attract top people to establish Japan as their residence. The second is to organize conferences to introduce new and high-quality research to Japan. In the case of the United States, he said, after World War II, the country recruited top scientists from all over the world to settle and work in the United States. At that time, "few people engaged themselves in theoretical endeavors." Eventually, the United States became a leader in the field, and a U.S. journal, *Physical Review Letters*, is the top journal in the field. In his view, Japan today is where the United States was after World War II, and it can use incentives to attract top researchers from the rest of the world. The alternative approach of organizing seminars and collaborations is, in his view, not sustainable. He said that no country has achieved excellence in this fashion. He said that seminars and visiting professors do not leave enduring capabilities after the seminars end or visitors leave. Still, either of these policies will take a number of years to have some impact on scientific production.

He also emphasized that Japan should also send more researchers abroad. He said that many Japanese study abroad but that the number is not enough to sustain high-quality research in this area. In his view, sending more Japanese researchers abroad is critical to Japan's future in S&T as a whole. Since it is very difficult for Americans and Europeans to adapt to Japanese society, sending Japanese researchers abroad to upgrade their skills is the solution.

Summary 55

Field and Subfield(s):	Nanotechnology and materials science; Physics, applied (3)
Location:	EU
Status:	Established
Gender:	Male
Nationality:	Non-Japanese
Professional experience in or with Japan:	Low

What is the overall competitiveness of Japan in your area(s) of research, in general, and what are Japan's strengths in research?

The respondent described Japan as good in reproducing and adapting products of the leading countries and as having good industry research programs (e.g., that of Sony). However, he did not regard Japan as innovative. For this reason, in his view, Japan will likely stay in its current position among the top countries and will not come close to the United States or Germany, the leaders in the field. He emphasized that U.S. success is built on individual initiative and the freedom to think. He believes that Japan has the human and financial resources to be innovative but that the right approach is missing. Also, he said, he believes that Japan lags behind because it copies what the leaders like the United States have done instead of focusing its energy on new endeavors.

Nevertheless, he reported seeing dramatic improvement in one area for Japan: communication. He said that there has been improvement not only in terms of English language skills but also in the way messages are delivered. Ten years ago, Japanese scientists went to conferences and did not speak well or answer questions correctly because they did not understand what was asked. Such poor performance seems to be a thing of the past.

In his view, the top Japanese institutions in his field are the University of Tokyo, Tsukuba University, and Osaka University. However, their strength, he underscored, is in implementation and not in the study of theory and fundamentals.

Japan's S&T capabilities were judged to be adequate and benefit from having good facilities and funding. He said that Japanese researchers also benefit from having a high level of administrative support. By comparison, researchers in Europe, he said, have to personally handle a great deal more paperwork in grant applications and "have to be their own travel agency, secretary, and copier [clerk]."

He rated Japanese education as generally high in quality but thought that it, too, lacked strength in theoretical formation and had an overemphasis on implementation. Still, in his opinion, Japan is not in a worse situation than Europe (e.g., Germany builds its strength in the field on the work of two to three very good institutions and groups of researchers). He noted Norway as another small country that has done well in applied physics in recent years, producing a disproportionately high number of publications. He attributed this success to political support for science (e.g., he said that the mayor of Oslo once met with all the participants of a professional congress) and funds that target activities that foster innovation. He said that the UK values independence and creativity in research but has serious funding problems across the field. Each university's situation varies widely, depending on its contributors and boards. He said that Britain especially suffered and lost its competitive position under Prime Minister Margaret Thatcher's government and that, while recovery efforts are under way, progress is slow. France was said to be not particularly good in this subfield and to suffer the same bureaucratic problems that plague academia in Europe. Germany, by comparison, has managed to do well in his field because it shares the Anglo-Saxon mindset of valuing independence and freedom in research. Nevertheless, the U.S. system is better. He strongly emphasized that the U.S. education and academic environment are the best in the world.

What do you think are the weaknesses or hindrances to greater excellence for Japan?

Japan's central problem in achieving scientific excellence is not the lack of funding or human capital but its general approach to scientific and technological development. Too much emphasis was said to be placed on practical aspects and not enough on the theoretical side. Describing this situation, the respondent made an analogy to the Roman and Greek civilizations: The Roman Empire left a legacy of production techniques, while Greek civilization gave us philosophy. He said that China is doing the same thing as Japan. He added that, to make it worse, Chinese researchers do a poor job copying (at least Japanese researchers have some fundamental understanding of theory in the field) and plagiarize extensively in their publications.

He cautioned against a high level of centralization. Central policy guidelines, he said, could be wrong (e.g., focusing funding on implementation or topics that are no longer relevant) and, thus, hinder Japan's potential to produce breakthrough research. The respondent did not see ties between academia and industry as inherently a problem but said that industry funding of academic research could reinforce the bias toward "practical" research.

So, while increased international collaboration is a good thing, it is not going to improve Japanese S&T as long as Japan does not change the way it approaches science.

What are your recommendations for Japan?

First of all, Japan's S&T policy has to take a balanced approach. Every country, in his view, needs to maintain a diverse portfolio of research projects across fields. Thus far, he said, Japan tends to follow and build on others' pioneering work. This is not a good strategy, not only because of the resulting lag in production but also because it tends to concentrate resources in a particular area. In his field, he believes that tradition is important but that the field is also well diversified, allowing enough topics and areas for universities and research centers to find their own niche and produce innovative research.

Universities in Japan should learn from the American system, he said. Specifically, there should be significant rewards for innovation and creativity, and individuals should be incentivized to pursue personal projects independently and freely without the interference of superiors or group structures or central policy directives. He stressed that it is individual initiative, rather than groups, that creates innovation.

S&T should be based on groundbreaking innovation and communicated via publication in the top journals in the appropriate subfields. Currently, academic achievement is valued only in terms of the number of publications or citations, without consideration to the journals in which they are published. This, he said, misleads and misguides scientific activities. Further, innovation is threatened as long as mere production is rewarded, no matter how repetitive or lacking in novelty (e.g., reproducing one experiment in slightly different conditions). He stressed that discoveries occur and Nobel prizes are awarded based on significant publications but not necessarily on having a large number of them.

Finally, Japan should invest more in collaboration programs—current ones being just five to ten years old—and encourage more collaboration.

References

Government of Japan, *Science and Technology Basic Plan (Provisional translation)*, March 28, 2006. As of February 2, 2009:
http://www8.cao.go.jp/cstp/english/basic/3rd-BasicPlan_06-10.pdf

"Rising in the East," *Economist*, December 30, 2008 (print edition).

Wong, Anny, Aruna Balakrishnan, James Garulski, Thor Hogan, Eric Landree, and Maureen McArthur, *Science and Technology Research and Development Capacity in Japan: Observations from Leading U.S. Researchers and Scientists*, Santa Monica, Calif.: RAND Corporation, TR-211-MRI, 2004. As of January 22, 2010:
http://www.rand.org/pubs/technical_reports/TR211/