

Science Policy in the 21st Century: Bilateral Cooperation in a Multilateral Context-

Proceedings of the Seventh US-Japan Joint Science Policy Seminar

A. Overview

The seventh US-Japan Joint Science Policy Seminar took place from May 11-14, 1998, in Hilo, Hawaii. Hiroshi Inose, Director-General of the National Center for Science Information Systems in Tokyo, and Rodney W. Nichols, President and CEO of the New York Academy of Sciences, who serve as Co-Chairs of the US-Japan Cooperative Science Program, also co-chaired the seminar. The event was organized jointly by the National Science Foundation (NSF) and the Japan Society for the Promotion of Science (JSPS). William A. Blanpied, a Senior International Analyst at the National Science Foundation, served as general rapporteur.

Selection of the overall theme – *Bilateral Cooperation in a Multilateral Context* – was based on two assumptions:

first, since a growing number countries are actively engaged in scientific pursuits, multilateral modes of cooperation will become increasingly important; and

Over the years we have learned an enormous amount from one another. We have learned what to do and how to do it, and on occasion we have learned what not to do; this, too, is important.

D. Allan Bromley

second, the United States and Japan, which possess two of the world's most productive scientific enterprises, should call on their long experience of fruitful bilateral cooperation to strengthen multilateral cooperation, not only to serve their national and bilateral goals, but also to shape the multilateral framework essential for addressing widely shared global goals.

Participants included individuals from US and Japanese academic, industrial and government institutions, as well as several from other countries and regions, including China, Korea, Australia and Europe. Speakers and commentators were asked to consider steps that Japan and the United States might take, individually or in harmony, to strengthen multilateral cooperation, in part through existing multilateral organizations.

The seminar was organized into an opening session, which featured keynote addresses by the Japanese and US co-chairs, three plenary sessions supplemented by informal breakout discussions, and a final plenary session. The first of the three plenary sessions, entitled

“Expectations for Multilateral Organizations,” featured presentations by participants knowledgeable about multilateral organizations in which Japan and the United States are leading members, followed by critical commentaries by a Japanese and a US participant with experience in international applied science cooperation.

In the second and third plenary sessions (and associated small-group break out exchanges), participants considered two cases of multilateral cooperation in: first, in big science and engineering projects and programs; and second, in the broad area of education and human resources for science and engineering. During the final plenary session, participants exchanged views about the individual and collective conclusions they had reached as a result of their deliberations.

The next three sections highlight the principal themes presented by speakers in the opening session and the first three plenary sessions. Each section then summarizes key aspects of the discussions germane to the themes of these sessions, whether these took place during the sessions themselves, during associated break out sessions, or during the final plenary session. The final section reiterates the principal conclusions of the seminar. With a few exceptions, no attempt has been made to attribute ideas to specific individuals, save for those expressed in the prepared presentations.

A series of appendices contain: (A) the texts of special presentations by D. Allan Bromley and Norman Neureiter, (B, C, D, and E) abstracts of the prepared presentations from the opening and first three plenary sessions, (F) participants’ reflections on issues germane to the seminar, (G) a detailed schedule, (H) a full list of participants, and (I) a set of biographical sketches.

B. Roles and Expectations for Multilateral Organizations (Opening Session and Plenary Session I)

The keynote addresses by the two co-chairs established the context for the discussions during the remainder of the seminar.

Hiroshi Inose provided several examples of areas in which multilateral cooperation has become

Multilateral cooperation will promote further open and free exchange of scientific and technological knowledge between scientists and science policy makers.

Hiroshi Inose

highly desirable, if not essential. On the other hand, he emphasized that since effective multilateral cooperation is inherently more difficult to arrange, care should be taken not to engage in such cooperation unless a substantial value-added component can be identified. He offered the Human Frontiers Science Program (HFSP) as an example of such a value-added activity.

Rodney Nichols suggested that three responsibilities are associated with the leadership positions in world science which the United States and Japan enjoy; namely, the need to:

1. pursue global goals;
2. renew multilateral institutions; and
3. ensure the availability of adequate and appropriate data upon which viable policy options can be based.

Development and elaboration of these themes underlay the prepared presentations and discussion in the first plenary session and, implicitly, throughout the seminar. Taking the OECD's Megascience Forum as a case in point, Michael Osborne¹ pointed out several obstacles to multilateral cooperation among governments, suggesting that progress requires both patience and an understanding of differing cultural perspectives on cooperation, as well as the need to set realistic goals. Although an organization of governments, the Megascience Forum has enjoyed reasonable success in melding scientific and government perspectives from many countries. Importantly, since the Forum operates as a consultative or deliberative body, participants from different countries are able to be frank and open in providing information about their national programs, in expressing their personal opinions, and in discussing policies of the governments they represent. The Forum does not possess financial resources to support scientific projects and does not have authority to make binding decisions on member governments. Rather, it focuses on exploring substantive, long-term options, shaping a consensus where possible.

Vicki Sara² highlighted Australia's scientific capabilities, accomplishments, and future plans.

Multilateral organizations have an important role to play in furthering international cooperation. They allow all member countries, irrespective of size, an opportunity to debate generic issues.

Vicki Sara

She stressed that as a small country, Australia has had to remain acutely aware of the multilateral context of its policies and actions. She reminded participants that the multilateral system can only achieve that which member states are prepared to enable it to accomplish. For a small country like Australia, the international agenda is too large to involve itself in everything so that there is a need to concentrate in areas where national interests are closely engaged. The APEC Working Group on Industrial Science provides a useful forum both for remaining in close contact with developments in the Asia-Pacific region, and for developing cooperative activities that

can strengthen national scientific capabilities and enhance networking among countries in the region.

Jean François Stuyck-Tallandier³ stressed the importance of non-governmental multilateral organizations, particularly in view of the many current issues that either require an approach that is both multilateral and multidisciplinary, or which transcend and blend the interests of specific scientific disciplines. ICSU's non-governmental status allows it to take perspectives on these issues which are different and, often, less constrained than those of official, intergovernmental organizations such as the OECD and APEC. As such, it has the capacity to

-
1. Deputy Director, Science, Technology and Industry, OECD
 2. Chair, Australian Research Council
 3. Executive Director, International Council of Scientific Unions (ICSU)

provide objective policy advice to both governments and intergovernmental organizations. ICSU can also serve as a forum for exchanging best practice information, as in its new Program on Capacity Building in Science, which aims to foster improved science education at the primary levels, enhance public understanding of science, and assist scientific organizations in less developed countries to establish more effective channels of communication with their respective governments.

Fumio Kodama's⁴ outlined a possible novel mode of multilateral cooperation in large applied science and technology projects, which he referred to as "options sharing". Rather than apportioning development of single components of a predetermined large project among participating countries or non-government entities, Kodama suggested that in many cases it could be advantageous for each to pursue feasibility studies on different technological options, allowing interested scientists and engineers from all countries to participate in studies of particular interest to them. Assuming agreement to share results were obtained at the outset, participating countries would obtain detailed information about a variety of approaches on which to base decisions concerning the options most appropriate for them.

While science aims at an absolute truth, technology aims at relative superiority. Determining the most meritorious technical option, therefore, is not possible unless all the options are demonstrated and compared.

Fumio Kodama

James McGroddy⁵ suggested that the problem of multilateral research cooperation should be parsed into three categories

according to the objective of a given program:

1. large-scale basic research programs of broad interest with few inter-country competitive implications;
2. large-scale programs aimed at addressing global-scale issues, including those associated with the environment; and
3. smaller scale international collaborations initiated at the level of individuals and groups and individual institutions, including industry, government laboratories and universities.

These categories are distinct in several respects, including the types of institutions involved, the degree of government and private sector involvement, and the implications for competitiveness. Although discussions of multilateral cooperation most often focused on the first two categories, Participants agree with McGroddy's suggestion that there is probably a great deal more cooperation going on in the third.

Priorities for Multilateral Organizations. Two persisting trends are having a decided impact upon multilateral organizations: on the one hand, increasing global expectations for science have led to heightened expectations that these organizations can facilitate a wider range of international cooperative activities. On the other hand, resources for science and for scientific

4. Professor, Graduate School of Engineering, University of Tokyo

5. The IBM Corporation (retired)

cooperation are constrained. Multilateral organizations, in common with national scientific organizations, must confront the problem of setting priorities for their activities, even as they face increasing pressure to take on additional responsibilities. Both the OECD and ICSU are reassessing their missions and streamlining their organizational structures to be in better positions to establish priorities and to carry out those priority activities more effectively. APEC, with its looser organizational structure, deals with priority setting by asking interested member countries to step forward and assume leadership for specific proposed activities.

Assigning new responsibilities to multilateral organizations in this period of streamlining without weighing priorities carefully would be counterproductive. Returning to Hiroshi Inose's keynote address, many worthy programs can be carried out either bilaterally or through flexible multilateral arrangements without invoking the full apparatus of an existing multilateral body. International cooperative ventures should be organized flexibly with a view towards minimizing complexity, while the temptation to create new multilateral organizations should be avoided. The organizations represented at the seminar have demonstrated that they are capable of carrying out high priority tasks effectively, provided their national members are willing to provide the financial and intellectual resources they require and, importantly, offer them strong and effective leadership.

Accomplishments and Potential. Multilateral organizations can be classified in various ways: e.g., official, intergovernmental organizations such as the OECD and APEC, vs. non-governmental organizations such as ICSU; or those that function primarily in a consultative mode as opposed to those whose decisions are binding on their national members. Consultative bodies, such as the OECD, ICSU and APEC, can be effective in promoting international cooperation by serving as fora for the exchange of information on national activities, experiences, plans, priorities, and differing perspectives on issues of common interest. Since multilateral organizations are composed of national members--be they governments or non-government institutions such as academies of science or professional societies--their success depends on the willingness of those members to be actively involved in their work. Involvement is likely to be enhanced in proportion to the extent that the activities of multilateral organizations yield results that are useful at national levels.

Multilateral collaboration is expected to contribute not only to sharing of cost and risk, and recruiting human resources, but also to formulation of creative concepts through the amalgamation of different cultures.

Teruo Kishi

In examining the potential of multilateral organizations to contribute to their members' objectives, it is useful to distinguish between two types of cooperation: (1) *programmatic cooperation*, in which two or more countries engage in jointly funded collaborative projects; and (2) *policy cooperation*, in which they exchange information and perspectives about issues of common interest. Multilateral organizations may be most effective when they emphasize policy aspects of cooperation, leaving it to participating governments or non-governmental organizations to negotiate the terms of specific programmatic collaborations. However, this is not invariably the case.

As the examples of OECD's Megascience Forum and ICSU's International Geosphere-Biosphere Program suggest, frank and detailed, policy-oriented explorations under the auspices of multilateral organizations can often result in genuine collaborative partnerships among subsets of members. Indeed, the Megascience Forum, whose working groups seek to blend government and non-government scientific perspectives, was characterized by one participant as having the character of a non-governmental body embedded in an official, intergovernmental organization. Participation in working groups is strictly voluntary; only countries in a strong interest in a particular set of topics send representatives to meetings of the respective groups. No doubt this flexibility is another important reason for the Forum's success.

Multilateral organizations have achieved considerable success with science and technology data and indicators in furthering both policy and programmatic cooperation. In notes prepared prior to the seminar, Jennifer Bond⁶ emphasized that, "in order to understand better the new global economy, and the changing issues, structure, priorities, and opportunities for science and engineering resources, decisionmakers need to have national science and technology capabilities placed in a global context. This means that assessing national science and technology strengths and systems in isolation is no longer terribly meaningful--even for a large economy such as that of the United States. International comparisons are essential and they increasingly need to be done, not just in a national or bilateral mode, but in multilateral fora. Indicators of the globalization process itself are required and can best be constructed internationally."

Multilateral organizations have played an essential role both in developing standards to assure the international comparability of various categories of science and technology indicators data, and in developing new types of indicators required to characterize the evolving importance of science and technology to knowledge-based economies. The interplay between national authorities responsible for the collection and analysis of indicators data and multilateral organizations such as the OECD, APEC and the Organization of American States (OAS) has been an essential ingredient in the success which these organizations have enjoyed.

The reform and renewal of international institutions will be paced in large measure by the joint commitments of the United States and Japan to constructive changes.

Rodney Nichols

Globalization and the Responsibilities of Leadership. Regardless of the future status of existing multilateral organizations, trends towards growing international investments in science, the increasing prevalence of global-scale issues demanding

science-intensive assessments (such as those associated with the environment), and the imperative for global collaboration to address goals such as health, are unmistakable. D. Allan Bromley⁷ emphasized that, "as two of the nations having the strongest science and technology enterprises on the planet, we have both the opportunity--and more important--the

6. Director, Science and Engineering Indicators Program, National Science Foundation

7. Sterling Professor of the Sciences and Dean of Engineering, Yale University

responsibility, to work toward helping the rest of the world gain access to the quality of life that science and education can provide. We can help the developing world avoid some of the mistakes that we have made, and we can help it to reach its goals without some of the intermediate steps through which we have passed--sometimes more or less by accident."

Although existing multilateral organizations should not be asked to take on additional tasks lacking the resources to carry them out effectively, national science policies and programs in both the United States and Japan should be formulated and implemented with due regard for their international implications. Priority setting is an important case in point. The need to set priorities for scientific investments at national levels has now been accepted, although perhaps reluctantly, in most countries. The imperative to address global issues on a multilateral basis, including the need to assist less developed countries to increase their own scientific capabilities, suggests that the priority setting problem should be internationalized by asking how available national resources should best be apportioned between national and multilateral endeavors.

New economic conditions have opened the possibilities for peacetime cooperation on a global scale. This is a major trend visible in large science projects policies since the beginning of the 1990's.

Michael Osborne

The United States and Japan have a responsibility to take the lead in planning and acting in a broader multilateral context with a view towards exercising the responsibilities emphasized by Bromley. They can, for example, begin to conceptualize national priorities in a multilateral context. They can also take the lead to increase the effectiveness of existing multilateral organizations by insisting that the tasks taken on by those organizations are appropriate to their resources and consistent with their particular strengths.

These steps, as Rodney Nichols observed in his keynote address, are among the important responsibilities of leadership.

C. Multilateral Cooperation in Big Science and Engineering (Plenary Session II)

"It goes almost without saying," as Robert Eisenstein⁸ emphasized in notes prepared prior to the seminar, "that cooperation (and collaboration) has been an essential hallmark of science since the dawn of the scientific method. It makes its appearance in many ways: from the early exchange of ideas and results and simple apparatus, to today's enormous multinational laboratories which host projects costing hundreds of millions, to billions, of dollars."

Building on Eisenstein's remarks, issues associated with multilateral cooperation in big science projects and programs may well have emerged as particularly salient because they underline challenges and opportunities inherent in multilateral research cooperation more broadly. These issues include, for example:

- the need for setting priorities within and across scientific disciplines,

8. Assistant Director, Mathematical and Physical Sciences, National Science Foundation

- the need to reconcile or, at least, harmonize varying national interests and, within national systems, to reconcile the perspectives of scientists and governments;
- issues associated with data and information requirements;
- special problems regarding the involvement of scientists from less developed countries; and
- the implications, for national research systems, of trends towards the internationalization of science policy.

During the first plenary session, James McGroddy proposed a typology of collaborative projects based on their intended outcomes. A direct way to distinguish among big science programs themselves is more descriptive than analytical. Namely, one can consider two categories: (1) those that depend on large-scale central facilities (e.g., particle accelerators, telescopes, drill ships), and (2) distributed projects or programs requiring coordinated activities by scientists at many geographically separated locations (e.g., human genome research or global change research). Toshimitsu Yamazaki⁹ and Nicklas G. Pisi¹⁰ presented case studies of research requiring distinctly different types of central facilities: namely, particle physics and ocean drilling. Tsuneyuki Morita¹¹ presented a paper on integrated assessment—a methodology that relies heavily on the results of distributed big science projects to develop policy options to address global-scale issues, many of them associated with the environment. Finally, Zhu Xuan¹² described a number of big science projects underway in China, with particular emphasis on that country's desire to share those resources internationally.

Whatever partnership mechanism is selected the process itself will require extraordinary patience, drive, and political skill. But there is no question that a success in this area is as dramatic as it is rewarding.

Robert Eisenstein

The explicit examples of multilateral cooperation considered in the prepared presentations focused on scientific research. However, it was also clear that many of the same considerations germane to cooperation in big science apply equally well to large-scale engineering projects, particularly in fields such as earthquake engineering where commercial competitive advantage is not an overriding concern. Indeed, international cooperation among engineers is essentially for virtually all cooperative big science ventures, particularly those requiring a large central facility such as an optical telescope, a particle accelerator, or a drill ship. This dependence of cutting-edge research on sophisticated engineering capabilities is a prime example of the complex interactions between science and technology that underlies progress in both areas. Thus, in many instances the term “big science” can be taken as shorthand for “big science and engineering”.

-
9. Supervisor, Japan Society for the Promotion of Science
 10. Professor, College of Ocean Sciences, Oregon State University
 11. Japanese National Institute for Environmental Studies
 12. Secretary General, Chinese Academy of Sciences

Participation in Big Science and Engineering Programs. The prevalence of big science and engineering programs in an increasing number of fields, coupled with their cost and complexity, is the most obvious reason why issues associated with multilateral cooperation and cost sharing have achieved such saliency. Experience indicates, however, that effective multilateral cooperative agreements among governments are often difficult to negotiate. For that reason, cost savings alone rarely provide an adequate basis for sustained, high quality multilateral cooperation. The availability of a wider pool of intellectual resources may be the most compelling reason for negotiating multilateral cooperation in big science and engineering programs as, indeed, it is for cooperation in science and engineering more broadly. In the case of distributed programs whose success depends on the coordinated efforts of scientists at dispersed geographical locations, marshaling intellectual resources on a multilateral basis is essential. Particularly in the case of central facility projects, it is essential to involve scientists and governments of all potential participating countries from the earliest conceptual planning and design stages. Multilateral organizations can provide a neutral venue where scientists, engineers and their governments can exchange information and perspectives and initiate discussions that may lead to cooperation on specific projects.

The ability of governments to contribute to the construction and operating costs of any cooperative, central facility-based research program will necessarily vary. However, scientific participation in such programs should not be determined primarily by the financial contributions made by a participating country's government. A scientific council on which each contributing national member has an equal vote, independent of their financial contributions determines the detailed research programs at many large-scale facilities. This arrangement is consistent with the principle that priorities for proposed research projects should be determined by means of a bottom-up approach based on the merits of proposed projects. Participating governments, which bear the cost of the programs carried out at large-scale facilities, expect them to deliver the best possible results. They should therefore support such a bottom-up approach on the grounds that that is the most effective way of achieving that end.

The key significance of big science programs is to explore the frontier science in mankind's cognition of nature. In addition, it is to train new generations of leading researchers in science and technology

Zhu Xuan

Access to Big Science and Engineering Programs. If, as experience indicates, multilateral cooperation can be an effective means for a big science or engineering facility to deliver the best results, then some provision should be made for the participation of scientists and engineers whose governments have not contributed to its construction and operating costs. From this perspective, there is considerable appeal to the guidelines of the International Committee on Future Accelerators (ICFA), which specify that participation in the research programs at particle accelerators should be open to scientists from all countries based solely on the merits of their proposed projects. On the other hand, these guidelines may not be applicable in all circumstances and to all disciplines. If, as may be the case, an increasing proportion of future big science and engineering facilities will be financed on a multilateral

rather than a national or bilateral basis, the ICFA open access principle might lead some governments to conclude that there is no need for them to make a contribution to a given facility, since their scientists and engineers can gain access whether or not they contribute.

A more realistic principle may be that governments of all countries whose scientists and engineers make systematic use of a large-scale facility should make some sort of payment--whether in terms of cash, in-kind contributions, or intellectual resources. The latter provision may be particularly important for less developed countries. The time horizon of the proposed principle can also be interpreted liberally by recognizing that, in the future, several less developed countries, such as China, are likely to possess world class facilities that scientists and engineers from developed countries--including the United States and Japan--may want to utilize. Thus, Chinese scientists with meritorious proposals might be granted access to existing big-science facilities with the expectation that "payment" will be made in the future by means of access to facilities in China.

Scientists from developed countries can also help less developed countries create world class facilities more rapidly by contributing their own intellectual resources to that end. However, the extent to which it is feasible or necessary for each country to have even moderate size facilities in all important scientific fields is limited, suggesting that concrete steps should be taken to involve governments of less developed countries in the management of multilateral facilities, some of which might be located in an appropriate developing country.

Access to Data. The objective of any large-scale science or engineering facility or distributed program is, of course, to produce results which, in the first instance, means to produce data.

Connected by a global information infrastructure, centers of excellence all over the world would function as the key nodes for multilateral scientific and technological cooperation
Hiroshi Inose

Data from big science and engineering programs is both voluminous and, in view of the capabilities of modern information and communications technologies, readily accessible to potential users at remote locations--at least in principle. The questions of when, to whom, and under what conditions the data from big science programs should be made widely available, while perhaps less difficult to resolve than the issue of participation in the conduct of large-scale research programs themselves, may be equally significant--particularly since they affect a wider circle of potential users. Because the scientists and engineers who conduct research at large-scale facilities or who are directly involved in large-scale distributed programs

expend considerable financial and intellectual resources in planning and implementing their projects, they have a legitimate right to first use of the resulting data. On the other hand, in the typical case in which their research is funded by one or more governments as a public good, other scientists, as well as qualified members of the larger public, also have some right of access. Widespread dissemination of scientific data resulting from research at public facilities is also consistent with a long-standing principle that information basic research results should be made widely and freely available. . The problem is primarily a matter of timing -- allowing the original researchers the right to analyze and publish their results first.

It is essential that policies regarding data access are made clear and transparent to all potential participants in big and engineering programs from the outset. A policy followed at several large facilities and in many distributed programs grants proprietary rights to the data to the originating experimenters for a specified period of time, normally 18 to 24 months, after which is made widely available. This appears to be a practice that ought to be widely encouraged.

The large amounts of raw data typically generated by big science and engineering programs are often expensive to analyze and interpret. Frequently, such data can be analyzed in a variety of ways, depending on the type of information the analysis is designed to extract so that data interpretation can be regarded as creative research. Conditions of access to raw data and to interpreted data may well differ, since in the latter case some reasonable return—intellectual or monetary depending on circumstances—is justified for the expense and intellectual effort that went into the interpretation. In short, neither raw nor analyzed data should be regarded as free or even cheap goods. However, current attempts to provide stringent copyright protection to value-added electronic data bases containing information derived by research supported by public funds could seriously impede the free flow of scientific information.

Scope of Big Science and Engineering. The outcome-based typology of international cooperation suggested by James McGroddy during the first plenary session indicates the breadth of the big science and engineering enterprises. Although his third category dealing with cooperation in the pre-competitive stages of commercializable research was not discussed explicitly in the plenary session on big science, the fact that many, although certainly not all of the issues addressed also apply to cooperation in engineering, underscored the importance of that category. Cases in both his first and second categories were presented and their implications discussed. In particular, Tsuneyuki Morita's presentation on the uses of scientific information to address

Areas of strategic global importance such as the environment, food and energy benefit from multilateral cooperation.

Vicki Sara

options for addressing global-scale policy issues provided a measure of the growing importance of McGroddy's second category. Clearly the scope of international cooperation in big science and engineering is considerably broader than was often conceived a few years ago, since it encompasses not only central facility-based projects and distributed programs, but also the policy-relevant analyses of resultant data designed to address global-scale issues. One significant implication is that active interest in furthering multilateral cooperation—and in the outcomes of such cooperation—extend beyond the relevant science and engineering disciplines to government policymakers and the informed public.

As data generated by big science and engineering programs becomes more voluminous and complex as well as increasingly accessible electronically, data-related issues take on a life of their own. Information technologies also make possible widespread access to large scale data bases for use in social and behavioral science research including, importantly, the science and

technology indicators data required for the formulation and interpretation of science policy. The utility of these types of data greatly increases when they are available in comparable form from many countries and, additionally, are accessible to users on a multilateral basis. For these reasons, large-scale databases and collections should themselves be regarded as having critical big science aspects spanning James McGroddy's first and second categories. It follows, as Jennifer Bond suggested, that the development and use of large-scale databases should be considered on a multilateral basis.

Social Returns on Public Investments in Big Science and Engineering. In most countries, national investments in scientific facilities and research are now recognized as essential to social and economic vitality. Recognition of the social impacts of research, coupled with rising costs and constrained budget environments have resulted in increased demands on the part of governments to justify research investments in terms of social returns. This is particularly the case for big science projects and programs, particularly for those that involve multilateral participation. National governments want to be assured that there will be a reasonable social return on projects and programs for which costs--and therefore benefits--are shared with other countries. On the other hand, governments also recognize the potential of multilateral cooperation in leveraging financial and intellectual resources, particularly in the case of distributed programs that address global-scale issues.

What big multilateral science programs bring to education is that by their very nature they are often multidisciplinary. Because they involve many countries, they also have to operate on a team basis, they have to work by consensus.

Nicklas Pisiias

Because most countries are concerned with education and human resource development and are coming to regard international experience as essential to the education of future generations of scientists and engineers, integrating an educational component into plans for big science and engineering projects and programs is an appropriate means for assuring some reasonable level of acceptable social return. One of the benefits of Japan's participation in the Ocean Drilling Program and Australia's contribution to the Gemini Project (a multilateral cooperative project to construct and operate identical 8-meter optical telescopes in the Northern and Southern Hemispheres) is the enhancement of education and human resource development through big science and engineering projects.

D. Human Resources for Science and Engineering (Plenary Session III)

Researchers in a particular science or engineering discipline or related set of disciplines, regardless of their nationality or country of residence, can usually agree about the intellectual problems of greatest current interest in their fields and about promising lines of research to address them. For this reason, a conceptual basis normally exists for the design of multilateral big science and engineering programs, even though associated financial and political problems may be difficult to resolve. In contrast education and human resource development--even at advanced levels--are closely associated with national cultures, while formal education systems differ considerably among countries. As a case in point, in Japan relative uniformity in university entrance requirements prevails in the national, local public, and private universities,

while the curricula and standards for primary and secondary education are under the control of the central government. In contrast, the US Government has no control over education at any level. Higher education is the province of state universities and a diverse system of private colleges and universities, while authority for primary and secondary education is vested in state and local governments. For these reasons, it is difficult, although certainly not impossible, to arrive an effective international consensus about the details of many education and human resource issues--or about actions that should be taken to address them.

It ought to be possible to articulate some science goals and concepts that transcend culture, even though they are communicated through cultural mechanisms.

Shirley Malcom

Despite this, there was a consensus among seminar participants that education and human resources issues are the most important of those that the international scientific community must address.

A good deal though not necessarily all cooperation on these issues is likely to be policy-related rather than programmatic. Multilateral organizations can play key roles in facilitating such cooperation, for example by:

- serving as fora for the exchange of information about best practices,
- promoting the international mobility of young scientists,
- fostering the development of internationally comparable human resources indicators, and
- helping assure that education-related components are integrated into the design of multilateral big science programs.

Shirley Malcom's¹³ presentation underlined the wide range of issue associated with the development and uses of human resources for science and engineering, ranging from formal education at the primary and secondary levels, to graduate education, post-doctoral training, and subsequent career development. In the United States, professional organizations such as the American Association for the Advancement of Science (AAAS) play critical roles in monitoring the health of the science education field, advocating quality education, and serving as guardians of the standards of conduct within scientific disciplines. A high priority for the AAAS and other professional societies has been to develop effective strategies to extend quality science education and careers to all.

Yasufumi Sakatani¹⁴ highlighted recent reforms in Japan's national university system, consistent with the Science and Technology Basic Plan adopted by the Government of Japan in July 1996. An important feature of the Basic Plan is to encourage greater numbers of young scientists to pursue advanced training and research careers in science and, in particular, to reward those who demonstrate creativity in research. To these ends, the Basic Plan has established the goal of creating 10,000 doctoral and post-doctoral positions by the year 2000.

13. Director, Education and Human Resources, American Association for the Advancement of Science
14. Deputy Director-General, Ministry of Education, Science, Sports and Culture

Sook-II Kwun¹⁵ described Korea's aspirations for human resources development in the context of the government's Five-Year Science and Technology Plan. He stressed the need to make better use of the potential of females in the science and technology workforce.

Tsuneo Nakahara¹⁶ provided a provocative commentary on the human resources needs of industry. He began by positing a borderless economy for the 21st century, suggesting that the development of industry in industrialized and less developed countries was likely to be focused on new industry creation and on productivity improvement, respectively, even though these aspects are obviously related. Human resources needs not only for science and engineering expertise, but also for creativity, entrepreneurship, and ethics, might best be addressed multilaterally.

Susanne Huttner¹⁷ used the development of the biotechnology industry in California as a case study illustrating the ways in which industrial needs can shape the content and structure of graduate education in science. At least one major California biotechnology company makes use of PhD scientists throughout the enterprise, including its finance and marketing divisions and, of course, its research divisions. There is considerable concern about future directions of graduate education in the United States, arising from the view that graduate training programs are not keeping pace with the changing importance of basic research to the national and international economy.

There is considerable concern about the future directions of graduate education in the United States. How basic research and graduate training evolve will impact both local and international economic development.

Susanne Huttner

Formal Education and Training at Advanced Levels. Japanese and US perspectives differ somewhat on the most critical issues at the level of graduate education and post-doctoral training. In Japan, there is a strong emphasis on increasing the number of PhD scientists who aspire to research careers, on increasing the number of post-doctoral research positions in universities and public research institutions, and on encouraging greater individuality and creativity on the part of young scientists and engineers. In the United States, there is concern about imbalances between supply and demand for highly trained scientists in various disciplines, as well as concern that the prevalence of post-doctoral appointments may indicate that in too many cases these positions constitute holding patterns for new scientists while they seek positions from which to launch their research careers. In both countries, there is concern that the content of graduate education may not provide adequate preparation for the demands of the new century. Both countries also agree on the imperatives for greater involvement of industry in defining human resources needs and on the introduction of a substantial international component into graduate education.

Changing Workforce Requirements. Although there is convincing evidence that progress in scientific research is an essential component of the innovation processes that underlie

15. Professor of Physics, Seoul National University

16. Executive Advisor to the CEO, Sumitomo Electric Industry, Ltd.

17. Director, University-Industry Cooperative Research Program, University of California

continuing social and economic vitality, research is by no means the sole determinant of innovation. In both the United States and Japan, education in science and engineering may still be overly conditioned by the linear model which assumes that advances in basic research within traditional scientific disciplines will automatically lead to socially relevant outcomes. There is a clear need to link science and engineering education at all levels, particularly the graduate level, more closely with other sources of innovation, particularly within private industry.

That having been said, it is also true that industry's human resources requirements are highly field specific. Information technology has been advanced, in part, by self-taught individuals with entrepreneurial skills who often lacked a great deal of formal education in science or engineering. In contrast, the equally new biotechnology industry relies heavily on people with training at the PhD level, not only for its research requirements but for related business functions as well. Research-related training will continue to be important, particularly in those fields which rely on multidisciplinary to foster expertise in addressing global-scale problems.

There are increasing demands for recurrent education of adults based on the idea of life-long learning.

Universities are [also] beginning to prepare for heated competition for students resulting from the decrease in the 18 year-old population.

Yasufumi Sakitani

In Japan, there is considerable concern that insufficient numbers of young people are pursuing demanding careers in research. Similar concerns expressed in the United States a decade ago have abated somewhat. One reason may be the difference in demographic trends. In the United States, the number of 18 year olds in the population declined until the mid 1990s, but is once again rising. In Japan, it is estimated that by 2010 the 18-year-old population will have declined by 40 percent from its 1992 level. Faced a decade ago with a declining college age population and, therefore, a declining number of young people electing scientific careers, the United States created programs—only partially successful—which aimed to reach out to populations who were (and remain) underrepresented in science and engineering: primarily women, ethnic minorities, and foreign immigrants. Japan may seek to adapt these practices and experiences to its own future science and engineering workforce requirements.

Lifelong Learning. In his keynote address, Hiroshi Inose envisioned a future in which information technologies would be used extensively to link centers of excellence in various research fields into virtual global centers. This concept could be expanded to provide unparalleled, multilaterally based educational opportunities, including flexible lifelong learning experiences. Judging from the experience of the past 20 years, the new century will almost certainly be characterized by the emergence of unanticipated challenges and opportunities resulting from advances in science and technology. If so, then education systems will have to be flexible enough to provide the knowledge and skills required to meet changing workforce requirements. The importance and prevalence of lifelong learning are likely to intensify, particularly in countries that are committed to providing educational opportunities for those who beyond the traditional age of university entrants. In the United States, universities have

often developed lifelong learning programs in cooperation and consultation with industrial firms. The availability of information technologies has enhanced the potential of such programs by providing students with remote access to course materials and by promoting cooperation in curriculum development among several institutions.

In the United States, a great deal of lifelong learning takes place informally, as scientists and engineers assume positions in a variety of organizations throughout their careers, often moving between research institutions in the academic, industrial and government sectors. Such intersectoral mobility is also an effective means for knowledge transfer among these sectors. Mobility has been much less common in Japan with its tradition of lifetime employment in a single organization. Various provisions of the July 1996 Science and Technology Basic Plan, particularly the creation of fixed term appointments both for young scientists and creative mid-career scientists, are designed to increase intersectoral mobility. Greater involvement of private industry with the university system could also provide a basis for enhanced employment flexibility by providing Japanese scientists with direct experience about industrial needs and perspectives at early stages in the careers.

The problems that science needs to solve can only be addressed at an international level. We have to find new organizational modes. We also need to involve different kinds of people. This defines our challenge for the 21st century.

Peter Tindemans

Education for Non-Specialists and Public Understanding of Science. Recognition of the persuasive impacts of science and technology on all significant aspects of society has resulted in new requirements for public accountability by scientists and by

government officials responsible for the support of their research. Genuine accountability requires that scientists, engineers and policymakers communicate openly and effectively with the informed public and, reciprocally, that the informed public is prepared to engage in an effective dialogue about research and its social impacts. In addition, a reasonable level of science and technology literacy has now become essential in many careers and occupations. It follows that serious, continuing activities to increase public understanding and awareness of science and technology are vital to both the health of science and to larger society in which scientists and engineers pursue their work.

Programs are underway in many countries, including the United States and Japan, to enhance understanding and awareness for adults. Studies have demonstrated, however, that such programs are likely to be most effective for those who have already had a reasonable exposure to science during their school and university years. For these reasons, the problem of ensuring that non-specialists are provided with quality education in mathematics, science and technology is essential, with the primary and secondary school levels perhaps the most important. In the United States, serious efforts are underway to improve education in these areas at these levels. The issue is taken seriously in Japan as well.

Internationalization of the Science and Engineering Workforce. The globalization of science, technology and the economy implies that in the new century, the science and engineering workforce itself will assume a growing international character. If so, then the

introduction of a global perspective into science education is imperative, while the design of lifelong learning programs will have to take into account the international context of science and technology. This is particularly the case at the post-doctoral and graduate levels, where well structured experiences working in foreign research facilities for six to 12 months or more can establish a firm foundation for future, internationally-oriented careers. Although fellowship opportunities are available for US graduate students and post-doctoral scholars to obtain such working experiences abroad, there is a widely shared consensus that insufficient numbers of students avail themselves of those opportunities, in part because many of them are concerned that they will not be able to locate a reasonable entry-level research position when

Science and engineering are underlain by universal principles. In this sense, we may say that science and technology embodies the idea of globalization and a borderless world.

Tsuneo Nakahara

they return to the United States. Reasonable numbers of young Japanese scientists at the graduate and post-doctoral levels avail themselves of research opportunities in the United States, despite analogous concerns with regard to securing research positions at home.

One way to increase the number of science students with foreign working experience would be to make that experience a requirement for the PhD degree. More immediately, foreign research experience can be linked directly with the research interests of a senior adviser or prospective future employer so that

it becomes an integral component of a student's career development. In cases where arrangements for foreign research experience can be made with an industrial firm with research facilities in a foreign country, international and intersectoral mobility can be promoted at the same time.

Big science and engineering programs managed on a multilateral basis provide superlative opportunities for international education at advanced levels. These programs can involve students in cutting-edge science and technology, while providing international perspectives at the working level. Students gain experience at early stages in their careers in carrying out complex, large-scale research projects, experience that can prove to be valuable for a variety of future careers. Thus, educational components might be integrated from the outset into the design of big science and engineering programs. Making the education opportunities associated with big science and engineering programs available to students from less developed country would greatly enhance the science and engineering capacities of those countries and accelerate their ability to contribute to the international scientific enterprise.

The contributions of foreign born and educated scientists and engineering have been key factors in the development of centers of excellence in the United States. In contrast, few of the relatively small number of US graduate students and post-doctoral scholars who avail themselves of opportunities for research experiences abroad select institutions in Japan. Possible reasons include language and cultural barriers and, more broadly, the perception that Japan's research enterprise is a closed system. Removal of these perceived barriers, to the extent that they have any validity, would be important not only for Japan and the United States, but also for the international scientific enterprise as well.

Data and Information Requirements. Seminar participants agreed that education and human resources development are the key factors that will determine the continued vitality of science internationally. If so, national governments need to integrate these factors—including their international dimension -- into their science policies. Sound policies, of course, must be based on sound data. Therefore, it is essential to have reliable, internationally comparable data that can illuminate significant aspects of education and human resources issues, such as: trends in the formal education of scientists and engineers at all levels, including lifelong learning; the changing character of the science and engineering workforce; and levels of public understanding and awareness of science and technology. Looking to the future vitality of multilateral science, good data are required on trends in the international flows of scientists and engineers at all levels and in all sectors, including private sector mobility, where little reliable data currently exists.

E. Conclusions

Rodney Nichols, in his keynote address, addressed three challenges to the participants:

1. pursue global goals;
2. renew multilateral institutions; and
3. define and ensure data requirements, particularly for diverse R&D inputs and at outputs and for human resources.

Principal conclusions arrived at during discussions throughout the seminar in terms of these three challenges were as follows:

Multilateral institutions play an essential role not only in facilitating the intergovernmental agreements that are often necessary for actions needed to enable research, but also in integrating the rising talent from developing countries.

Rodney Nichols

Pursuing global goals. A central assumption underlying the theme of the seminar is that global goals agreed upon as being essential by the United States and Japan ought to be pursued through some form of cooperation, including multilateral cooperation where feasible and appropriate. Reciprocally, science-related issues that concern several countries, including less developed countries, should be taken seriously by the United States and Japan. From these perspectives, high priority global goals for both the United States and Japan can be defined in terms of their potential to be addressed cooperatively. An outcome-based typology of cooperative

projects such as that presented in the first plenary session can serve as a useful guide for assigning priorities to shared goals:

1. large-scale basic research programs of broad interest;
2. programs aimed at addressing global-scale issues, such as those associated with the environment; and
3. smaller scale collaborations to advance pre-competitive stages of research.

The roles and interests of private industry, academia, professional societies and national governments will necessarily differ for projects in each category. However, individuals and institutions with at least a potential interest in a given cooperative project should be kept informed as it is conceptualized and implemented. Cooperative projects should be conceptualized in as broad an international context as is feasible and should be organized flexibly to provide the possibility of broadened participation as they evolve.

A global perspective based on genuine, well conceived working experience should be an essential element in the education of all future scientists, beginning at least at the graduate level, and international mobility should be promoted as an element of lifelong learning. Implementation of these imperatives requires, at a minimum, that countries strive to develop and maintain a foreign-friendly environment that will attract foreign researchers. This is also a prerequisite for creating and maintaining world class centers of excellence.

The most important common problem we face is the education of our young people. Progress in science really takes care of itself; that's not where the problem is. But science education is falling behind almost as rapidly as science is advancing.

Robert Eisenstein

Education and human resource development are the most important shared international goals, since they underlie the ability to address all other science-related global issues. Because private industry, academia, professional societies and governments all have a stake in human resources issues, they all need to be involved in addressing them. There is now considerable experience in planning and implementing large-scale research projects, including major distributed programs and those designed to address global-scale issues. If, as seminar participants agreed, education and human resources can be regarded as comprising a significant set of global-scale issue, the United States and Japan, together with their partners from other Asia/Pacific countries, might consider addressing them collectively with the same determination, planning, and coordination with which they currently address large-scale distributed research projects.

Renewing multilateral institutions. The multilateral organizations represented at the seminar have all demonstrated their capability to provide useful fora for exchanging information regarding best practices in addressing many of the global goals considered at the seminar. To some extent, they have also served well as loci for programmatic cooperation. Increasing their vitality and, therefore, their ability to serve as effective vehicles for multilateral cooperation requires that priorities for their activities be selected carefully with a view towards providing results useful at both national and international levels. Japan and the United States, as leading members of the OECD, APEC, and ICSU, can do a great deal for these organizations -- and for their own national interests -- by working in harmony to assure that both these imperatives are taken seriously by their own national members and by other members of the international scientific community.

The viability of multilateral organizations will be enhanced in proportion to the financial and, importantly, the moral support provided by their leading national members to address,

effectively, issues of high saliency. Multilateral organizations should not be asked to take on new tasks without being given sufficient resources to carry them out effectively. An obvious way to assure that they have adequate resources available to would be to establish rigorous priority setting procedures that could lead to the reduction or elimination of activities assigned low priorities. The United States and Japan could play an essential role in helping to define and implement priority-setting procedures.

In exploring feasible activities for multilateral organizations, it is essential to recognize that each of them has particular areas of strength and weakness. Greater interaction between existing multilateral organizations like the OECD, APEC and ICSU should be encouraged in activities where their interests overlap and where such interactions would promote their complementarities. The United States and Japan can help foster such complementary interactions.

An increase in the range and breadth of individual and institutional expertise required to address high priority scientific issues has been an undeniable characteristic of the past decade and is certain to persist into the new century. Multilateral organizations, to maintain their vitality, must also incorporate expanded disciplinary and sectoral perspectives. An appropriate

It is essential to have reliable, internationally comparable data that can illuminate significant aspects of education and human resources issues. Japan and the United States should join together in multilateral organizations to work with other countries to construct a truly global indicators system.

Jennifer Bond

way to accomplish this goal would be for national members of these organizations to broaden their own perspectives as well as their membership.

Defining and ensuring data requirements. Issues associated with the production, interpretation, dissemination, and accessibility of data cut across all topics discussed at the seminar. Both Japan and the United States have excellent science and technology-related data and strong science and technology indicators programs. Likewise, multilateral organizations have provided superlative venues for the development of common practices with respect to the indicators data required for informed decisionmaking on a range of science and technology policy issues. These organizations could build on this experience, individually and in concert, to address a wider range of data-related issues, and propose guidelines

concerning topics such as the conditions of access to raw data generated by large-scale research programs. A number of participants noted that while compensation for the intellectual effort and expense of interpreting and analyzing data is entirely reasonable, overly stringent copyright protection of value-added data bases containing data gathered at public expense could seriously impede the free flow of scientific information. This issue could also be addressed in multilateral fora.

Multilateral organizations can also serve as venues where national members can discuss and resolve issues that currently restrict the development of large, widely accessible data bases containing information pertinent to research in a range of social and behavioral science

disciplines, while assuring that confidentiality and legitimate intellectual property rights are respected. Finally, multilateral organizations can expand the indicators work that they have carried out successfully for so many years to develop a variety of internationally comparable indicators that can provide insights into important trends related to science and technology expenditures and education and human resources for science and engineering.

Participants agreed with Jennifer Bond's assertion that in view of the large number of important, tasks called for with respect to science- and technology-related data, data-related issues—including the development of indicators of globalization -- should be considered in the aggregate as an international distributed big science and technology infrastructure project. Because of its essential international aspects, the development of a big science perspective on data should be regarded as a high priority task for multilateral organizations.

Convergences and Responsibilities for the 21st Century. Rodney Nichols suggested that a fruitful way to think about priority issues for US-Japan scientific cooperation during the next five years would be to look beyond the earliest years of the new century and speculate about both trends in science themselves and the forces in global cooperation that would determine the context of a US-Japan joint policy seminar held not five but 20 years in the future. For guidance, it is instructive to speculate about how clearly participants in a seminar held 20 years ago could have envisioned the conditions that actually prevail today.

Representation at these joint seminars has always reflected the growing diversity of the scientific community. Next time, we must strive to include more social scientists and more women as participants.

Kunio Sato

By 1978 recombinant DNA techniques, first elucidated in 1974, already held out the promise of genetic manipulation and had also stimulated widespread public debate about the social impacts of research. The appearance of the first personal computers in 1975 hinted that computer access might not be limited to those associated with organizations able to afford the large mainframe devices that were then dominant. Yet, at a 1978 science policy seminar, only a starry eyed visionary could have predicted the significance that the biotechnology industry would assume by 1998. And even the most reckless visionary could not have foreseen the impacts that information technology would have on all aspects of society by 1998 including, significantly, scientific research and international cooperation.

Twenty years ago, the Cold War dominated international relations and, as a consequence, also determined national research priorities, particularly in the United States and several European countries. As one result, the government was then the primary source of national research and development (R&D) expenditures in the United States, investing 49.8 percent of the \$66.8 billion (2.12 percent of Gross Domestic Product or GDP) expended during that year, as opposed to about 46.5 percent invested by private industry. By contrast, in 1978 the Japanese Government accounted for 26.6 percent of that country's total national R&D expenditures of approximately \$20 billion (1.8 percent of GDP), with private industry accounting for 62.6 percent.

Participants in a 1978 US-Japan Science Policy Seminar might not have been too surprised had they known that by the mid 1980s Japan's total national R&D expenditures, measured as a percentage of GDP, would surpass those of the United States so that by 1995 the respective R&D/GDP ratios for the two countries would be 2.8 and 2.5 percent, respectively. They would almost certainly have been unanimous in their applause had they known that the Cold War was destined to end in only a little more than a decade. But few US participants would have predicted -- or would have been comfortable with the implied consequences -- had they known that within 20 years, their government would account for only about 35 percent of national R&D expenditures, with private industry accounting for more than 60 percent. Likewise, few Japanese participants would have predicted that in 1995, their Diet would enact a Science and Technology Basic Law, one of whose most prominent features would be to emphasize the desirability of doubling the government's R&D investments over the 1992 level by the year 2000 so that the percentage of national R&D expenditures accounted for by the Japanese Government would be comparable to percentage expenditures by governments in the United States and the major Western Europe countries. Had they anticipated this potential bonanza, they might have been tempted to obtain some insights from their U.S. colleagues about the impacts of these additional funds on research in national universities and other public institutions.

The very concepts of the globalization of research and the economy were undefined in 1978, much less anticipated. Discerning scientists and engineers in both the United States and Japan

Although enforcement of [Korea's] Five-Year Plan became threatened by the economic crisis that started in November 1997, the new government recognizes that the increase of R&D power will help to solve the crisis.

Sook-II Kwun

had recognized for some time that substantial pockets of excellence existed in several less developed countries. Yet virtually all world class research was still being conducted in the United States, Japan, and Europe. A considerable amount of international scientific exchange and cooperation took place, as it had since the dawn of modern science. However, international collaboration involving multilateral planning and cost-sharing was confined almost exclusively European countries. The geosciences, which had planned and implemented a substantial multilateral distributed scientific program during the 1957-58 International Geophysical Year, offered the one major exception - a harbinger of the more ambitious international global change research program initiated during the late 1980s.

The impacts of human activity on the environment and the need to turn to science and technology for means to ameliorate their negative impacts had been recognized more than 10 years prior to 1978. But the extent to which human activities in one locality might alter the entire global environment was only dimly perceived, while the analytical tools required to establish casual links between specific human activities and their environmental consequences were primitive, at best. Today, acquisition of data and insights from a wide range of natural and social science disciplines, together with the urgent need to integrate the resultant scientific understanding into policy making processes, are recognized as being imperative to the future sustainability of the global ecosystem.

For many years prior to 1978, a sizable majority of scientists and engineers along with a handful of economists had been firmly convinced that research provides an indispensable foundation for social and economic development. In the United States, that conviction, as well as the anecdotes they provided, had begun to be heeded by the US government, as pilot programs to stimulate university-industry research cooperation were instituted by the National Science Foundation. Apparently in Japan, where private industry had long been the principal supporter of R&D, the tangible importance of research had been widely recognized much earlier.

Today, firm analytical evidence is available about the socio-economic importance of research, while references to the borderless, knowledge-based economy have become commonplace. Yet it is also now recognized that many kinds of knowledge, in addition to basic research in the natural sciences, underlie the innovative processes so essential to social and economic vitality.

What, then, will be the likely context of a US-Japan joint science policy seminar held 20 years in the future? Biotechnology and information technology will probably have become even more significant elements of the world economy than they are today. But to the extent that the rapid emergence of these two fields can serve as a guide to the future, changes in the social

and political context in which research is conducted and new generations of scientists educated will almost certainly have emerged from scientific advances now perceived only dimly, if at all.

If we can envision the future together, then we have a better chance of making it happen.
Jennifer Bond

Current trends toward private sector dominance in the support of R&D are likely to be accepted as the normal state of affairs by 2018, even though government support and involvement will continue to be indispensable. Even though the roles and relationships among the principal supporters and performers of research will probably continue to change, by 2018 they may well have been more clearly elucidated than they are today.

It is unlikely that by 2018 a completely satisfactory understanding, much less a resolution of, the host of global-scale issues confronting humanity will have been achieved. Yet by that time, approaches may have been found to problems inherent in establishing effective communications between the scientific and policymaking communities, and in involving the broader public in decisionmaking on issues associated with the impacts of research on society.

The detailed character the world of 2018 is, of course, unknowable, in part because of the unanticipated ways in which research areas will emerge, evolve, and affect the larger society. But trends toward a knowledge-based, multilateral framework are almost certain to persist. The United States and Japan, working in concert, can have a decisive impact on the directions in which those trends evolve.

As D. Allan Bromley reminded seminar participants, the United States and Japan, possessing as they do two of the world's most successful science and technology enterprises, have an

obligation to establish their research priorities in a multilateral context with a view toward assisting other countries to make more effective use of science and technology for social and economic development. If that responsibility is undeniable, so is the fact that it is in the best self interest of both countries to take action appropriate to that responsibility.

Selected References

- Government of Japan, *Science and Technology Basic Law*, November 1995.
<http://www.sta.go.jp/policy>
- Government of Japan, *Science and Technology Basic Plan*, July 1996.
<http://www.sta.go.jp/policy>
- National Science Board, *Science and Engineering Indicators-1998*, Arlington, VA: National Science Foundation, 1998 (NSB 98-1)
<http://www.nsf.gov/sbe/srs/seind98/start.htm>
- National Science Foundation, Division of Science Resources Studies, *Human Resources for Science and Technology: The Asian Region*, 1993 (NSF 93-303).
- National Science Foundation, Division of Science Resources Studies, *Asia's New High-Tech Competitors*, 1995, (NSF 95-309)
- National Science Foundation, Division of Science Resources Studies, *The Science and Technology Resources of Japan: A Comparison with the United States*, 1997 (Special Report NSF 97-324).
<http://www.nsf.gov/sbe/srs/nsf97324/start.htm>

National Science Foundation (NSF) Tokyo Regional Office Reports: The National Science Foundation's Tokyo Regional Office issues frequent Report Memoranda on policy developments related to the Foundation's mission as well as Special Scientific Reports prepared by NSF staff and by visiting US scientists in Japan. Both series are available through the World Wide Web as follows: <http://www.twics.com/~nsftokyo/reports.html>

Other Websites: NSF's international homepage provides links to the home pages of the Foundation's counterpart agencies in all parts of the world. Links to Asian, including Japanese, counterpart agencies homepages are available through:
<http://www.nsf.gov/sbe/int/asia.htm>

The NSF/Tokyo Office homepage provides information about Japanese science and technology as well as on opportunities for US-Japan cooperation in science and technology:
<http://www.twics.com/~nsftokyo/home.html>

The NSF/Tokyo Office homepage also provides links to the homepages of organizations with specialized interests in Japan, as well as homepages of government and private science and technology organizations and of national universities.

<http://www.twics.com/~nsftokyo/japan.html>