NATIONAL SCIENCE BOARD

TOWARD A MORE EFFECTIVE ROLE FOR THE U.S. GOVERNMENT IN INTERNATIONAL SCIENCE AND ENGINEERING

National Science Foundation

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National Science Board
Task Force on International Issues in Science and Engineering

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PREFACE

The significance of science and technology in the global context has grown dramatically, and both private sector and government cooperation in international science and engineering have assumed more prominent roles. Many problems of the 21st Century will demand more information, more participation by the scientific communities of all nations, and more cooperation between these communities and political decision-makers. Not only does the scientific enterprise thrive on the open flow of ideas, but international cooperation in science and engineering also helps create a universal language and culture based on commonly accepted values of objectivity, open-mindedness, tolerance, sharing, objectivity, and free inquiry.

This report, *Toward a More Effective Role for the U.S. Government in International Science and Engineering*, focuses on how to improve the effectiveness of the Federal role in international science and engineering. It presents the findings and recommendations developed by the Task Force on International Issues in Science and Engineering and approved unanimously by the National Science Board. The report is based on an extensive review of relevant policy documents and reports, a process of hearings and consultations with experts and stakeholders, and invited commentary from individuals representing a wide range of perspectives.

On behalf of the National Science Board, I want to commend Dr. Diana Natalicio, the chair of the task force, and the other task force members—Drs. John Armstrong, Pamela Ferguson, Mary K. Gaillard, Stanley Jaskolski, Jane Lubchenco, and Luis Sequeira of the National Science Board; and Karl Erb, Director of the National Science Foundation's Office of Polar Programs—for their outstanding work in pulling together this important and complex report. Dr. Alan Rapoport, Division of Science Resources Statistics, provided outstanding and tireless support as the Executive Secretary to the task force.

The Board is especially grateful for the strong support provided throughout by the Director of the National Science Foundation, Dr. Rita R. Colwell, and by the Deputy Director, Dr. Joseph Bordogna.

Eamon M. Kelly
Chairman

Acknowledgments

The National Science Board is grateful to the many people who provided testimony at meetings, hearings, and symposia held by the task force, as well as those who provided comments on drafts of the report. Their names are listed in an appendix to the report.

Many National Science Foundation staff members, too numerous to mention individually, assisted the task force in its activities. We would like to acknowledge the critical contributions of Marta Cehelsky, Executive Officer, National Science Board, who guided and supported all aspects of the Board's effort; Richard Ries, NSF Division of International Programs, who served as the NSF Office of the Director liaison to the task force and also advised on both the content and participants for the Symposium on International Models of S&T Budget Coordination and Priority Setting co-sponsored by the task force; Eugene Wong, former Assistant Director of NSF's Engineering Directorate, who was an original member of the task force; Frances Li, who served as Executive Secretary to the task force for the organization of its hearings; and Edward Murdy and Angela Sykes of the Division of International Programs and Robert Webber, Office of Information and Resource Management, who helped organize and assisted in the task force's information gathering phase and who helped plan and arrange the three hearings that were held with invited speakers.

The National Science Board Office staff provided essential support to the task force's activities. Several staff deserve special recognition, including Jean Pomeroy, Daryl Chubin, Gerard Glaser, and Janice Baker who provided helpful feedback and guidance.

The preparation of this report was in its final stages when the terrorist attacks of Tuesday September 11, 2001 occurred. The disaster and its aftermath emphasized the extraordinary interconnectedness of today's world and, along with a newly realized vulnerability, the strength, resilience, and vibrancy of our society and economy.

During the Second World War, it became apparent that science and engineering could make immense contributions to national security and other national goals. In some sense, it can be said that this realization was instrumental in the development of a pivotal role for the Federal Government in science and engineering and in the formation of a powerful and creative national research enterprise. The continued success of this enterprise is even more important now as the significance of advances in science and engineering in the global context has grown dramatically. The global economy rests on a highly articulated communication and information infrastructure and increasingly relies on knowledge and innovation for its growth and for its core processes.

The benefits of science and engineering, however, are not equally shared. In many cases, the gap between the least developed nations and those that have historically benefited the most from the global knowledge based economy has grown. However, all countries, including the poorest, need to build their science and engineering infrastructure capacity and especially their human capacity through education and training. Advances in science and engineering not only can, but will contribute to the generation of new opportunities, to the solution of problems, and to long-term and broad-based economic well being.

The recommendations in this report, developed over the past year, remain as relevant as before September 11, and their implementation even more compelling.

In addition to creating new knowledge, increased international collaboration in science and engineering research and education contributes to the emergence of a global culture that bridges the centrifugal and often conflicting forces of national and ethnic identities. In a contentious world, bilateral and multilateral cooperation in science and engineering help create a universal language and culture, based on commonly accepted values of objectivity, open-mindedness, tolerance, sharing, integrity, and free inquiry.

EXECUTIVE SUMMARY

INTRODUCTION

In the 21st century, advances in science and engineering (S&E) will to a large measure determine economic growth, quality of life, and the health and security of our planet. The conduct, communication, and use of science, all intrinsically global, are increasingly important in addressing many critical global issues. Awareness of the importance of investing in S&E research and education has grown throughout the world, and many countries have taken steps to expand such investments. The ability of science and engineering to contribute to societal goals, address global problems, and make useful contributions to foreign policy relies to a high degree on global communication and cooperation in science and engineering.

New ideas and discoveries are emerging from all over the world and the balance of S&E expertise is shifting among countries. Many research problems require scientists and engineers in different countries to work together. Collaborative activities and international partnerships provide increasingly important means of keeping abreast of new insights and discoveries critical to maintaining U.S. leadership position in key fields. They also contribute to building more stable relations among communities and nations by creating a universal language and culture based on commonly accepted values of objectivity, sharing, integrity, and free inquiry.

International S&E collaboration encompasses a complex network of activities, with numerous participants and stakeholders, including industry, universities, professional societies, international organizations, private foundations, and governments. In the context of the United States, the Federal Government has played a significant role over the years in promoting international S&E activities through the work of its agencies with S&E missions, and by supporting research with international dimensions by scientists and engineers at U.S. universities. Science and engineering have also been important components of major foreign policy issues, such as arms control and global climate change. The role of the Federal Government will continue to be critical in supporting communication and collaboration in science and engineering. How to improve the effectiveness of the Federal role in international science and engineering is the subject of this report.

The National Science Board (NSB)[1] has periodically assessed the role and needs of science and engineering in the international arena. In February 1999, the NSB established a Task Force on International Issues in Science and Engineering. The task force was charged with addressing two tasks. The first was to develop recommendations for strengthening the Federal institutional framework of policies and agency relations that support S&E research and education in an international setting. The second was to develop recommendations for an effective leadership role for the National Science Foundation (NSF) in international science and engineering in the 21st century.[2] The task force engaged in an extensive review of relevant policy documents and reports and held hearings and consultations with experts and stakeholders.

The following key themes emerged during this information-gathering exercise:

- The need for more effective coordination of the U.S. Government's international S&E and S&E-related activities and greater consistency in meeting its international commitments;
- The importance of increased international cooperation in fundamental research and education, particularly with developing countries and by younger scientists and engineers; and
- The need to improve the use of S&E information in foreign policy deliberations and in dealing with global issues and problems.

Based on these findings, the Board has concluded that serious re-examination of the United States Government's role in international S&E research and education and the contribution of these activities to foreign policy is essential. Retaining the status quo would jeopardize future U.S. economic and scientific leadership and diminish the Nation's ability to address important global problems. New approaches to the management and coordination of U.S. international S&E activities are needed if the United States is to maintain the long term vitality of the U.S. economy and its S&E enterprise. The Board urges implementation of seven specific actions and makes the following overarching recommendation:

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[1] The National Science Board serves as the governing board of the National Science Foundation and provides advice to the President and the Congress on matters of national science and engineering policy.

[2] The Board discharged this latter role by producing the report "Toward a More Effective NSF Role in International Science and Engineering." It is available on the NSB web site at the following url—http://www.nsf.gov/nsb/documents/2000/nsb00217/nsb00217.htm.

KEYSTONE RECOMMENDATION

The U.S. Government should move expeditiously to ensure the development of a more effective, coordinated framework for its international S&E research and education activities. This framework should integrate science and engineering more explicitly into deliberations on broader global issues and should support cooperative strategies that will ensure our access to worldwide talent, ideas, information, S&E infrastructure, and partnerships.

FINDINGS AND RECOMMENDATIONS

A. U.S. GOVERNMENT PREPARATION FOR, COORDINATION AND MANAGEMENT OF, AND COMMITMENT TO ITS INTERNATIONAL S&E RESEARCH AND EDUCATION ACTIVITIES.

Although U.S. Government involvement in international S&E related activities is growing, a clear picture of the activities of the various Federal agencies and the degree of coordination among them is lacking. Effective coordination and management require more extensive and more timely information about international S&E activities even though such information is often difficult to gather and interpret and mechanisms for communicating and sharing this information are not always adequate.

In many cases official international S&E agreements have no associated budget authority. Only a small fraction of overall Federal expenditures for international S&E activities is derived from specifically designated international program budgets. This lack of designation frequently leads to a paucity of funds for management, coordination, and communication of internationally focused activities. Appropriate structures and mechanisms for effective coordination and management are needed to eliminate unnecessary duplication, prevent inefficiencies, and facilitate synergy. An additional problem is the difficulty of maintaining interest in and support for long-term international projects, which has led to the United States becoming perceived at times as an unreliable international S&E partner.[3]

RECOMMENDATION 1

The Office of Science and Technology Policy (OSTP) should strengthen its international focus to ensure an effective, integrated, visible, and sustained role in monitoring, coordinating, and managing U.S. international S&E research and education activities. As part of this effort, OSTP should actively encourage Federal agencies

[3] Two examples are the International Thermonuclear Experimental Reactor (ITER), which the Department of Energy withdrew from in 1999 due to budget cuts and the International Solar Polar Mission, which the National Aeronautics and Space Administration withdrew from in the early 1990s due to severe budget cuts.

to identify and increase the visibility of their international S&E research and education activities, to provide an adequate level of funding for these activities, and to allocate adequate funding and resources for their coordination and management. The Office of Management and Budget should prepare an annual international S&E budget crosscut, similar to its annual research and development (R&D) budget crosscut, that includes international activities found outside specifically designated international program budgets.

Recommendation 2

OSTP should encourage agencies to develop more effective mechanisms for gathering and disseminating information about U.S. collaboration and partnerships in international S&E activities and similar activities in other countries, with emphasis on fundamental research and S&E education.

Recommendation 3

The United States Government should promote the development of international S&E policy aimed at facilitating international cooperation in research and education. The formulation and implementation of policies related to areas such as immigration, intellectual property rights, and the exchange of scientific information and personnel should include consideration of their impact on international cooperation in research and education.

B. Encouragement and Facilitation of Expanded S&E Research and Education Collaboration and Partnerships with Other Nations, Particularly by Younger Scientists and Engineers and with Developing Countries.

Scientific leadership requires access to people, knowledge, and S&E infrastructure, wherever they are found. The ability to communicate and interact with scientists and engineers in all corners of the globe greatly benefits the U.S. S&E enterprise as do the contributions of foreign-born scientists and engineers who migrate to the United States and work in our universities and research laboratories.

Two areas deserve special attention: increased participation in international S&E activities by younger scientists and engineers and increased collaboration with developing countries.

Participation by Younger Scientists and Engineers: U.S. students who study and conduct research abroad not only learn more about the countries they visit but also enhance their skills and capabilities, ultimately making them more productive participants in the U.S. labor force. However, it is often difficult to convince younger scientists and engineers to become involved in international cooperative S&E research and education activities because of limited incentives and a widespread perception in many fields that time spent abroad may be detrimental to one's career.

Recommendation 4

Federal agencies should encourage and support policies and programs that provide incentives for expanding participation in international cooperative research and education activities by younger scientists and engineers.

Collaboration with Developing Countries: Knowledge and human capital are supplanting physical capital as the major ingredients for sustainable economic development. Most developing countries are aware of the need to build their science and engineering infrastructure capacity, and especially their human capacity through education and training. In the S&E realm, traditional forms of development assistance are being replaced by international cooperation that contributes to sustainable development through creation of the necessary infrastructure, including human resources. Interaction through collaboration and partnerships is not only more likely to promote sustainable development in today's world but also to make developing countries more effective partners in global problem solving.

Recommendation 5

Federal agencies should encourage development of human and physical infrastructure for science and engineering in developing countries through partnerships with international, multilateral, and private organizations providing support to developing countries for S&E research and education.

C. Science and Engineering Information for Foreign Policy and Global Problem Solving.

For several years there has been growing concern that the attention given to science and engineering in foreign policy deliberations is inadequate. Consistent with a number of earlier studies on this topic, the recent National Research Council (NRC) report, *The Pervasive Role of Science, Technology, and Health in Foreign Policy: Imperatives for the Department of State,*[4] emphasized the need for a fundamental change in the orientation of the U.S. foreign policy community. Specifically, the report recommended strengthening the capabilities of the State Department in areas involving S&E considerations through the commitment of agency leadership, an improved organizational structure, and an informed and motivated staff.

[4] National Research Council, Office of International Affairs, *The Pervasive Role of Science, Technology, and Health in Foreign Policy: Imperatives for the Department of State,* Washington, DC. 1999.

Recommendation 6

The U.S. Government, especially the Department of State, with its primary responsibility for U.S. foreign policy, should recognize and address the importance of science and engineering in achieving its objectives. Mechanisms should be identified to improve communication among science officers, other U.S. embassy personnel, and science and engineering staff of other Federal agencies, including those working abroad, to facilitate sharing of information critical to planning and decision making, and to improve the general flow of information on critical S&E issues.

Recommendation 7

The U.S. Government should strongly endorse the spirit of the recommendations of the 1999 NRC report to the State Department and ensure that responses to those recommendations are implemented expeditiously. Because developing an appropriate U.S. capability in this arena requires a long-term concerted effort, effective change will require a multi-year, multi-Administration, and bipartisan response, with appropriate levels of funding.

Conclusion

The development of an effective framework for science and engineering in the international arena is a critical priority for assuring U.S. global leadership in the decades ahead. This framework must be based on clear policy objectives and effective institutional arrangements, and supported by appropriate development and sharing of information. The findings and recommendations presented in this paper identify key areas for attention and action. The National Science Board is prepared to assist in this endeavor.

CHAPTER ONE

INTRODUCTION

In the 21st century, advances in science and engineering (S&E) will to a large measure determine economic growth, quality of life, and the health and security of our planet. The conduct, communication, and use of science, all intrinsically global, have become increasingly important in addressing many critical global issues. Awareness of the necessity of investing in S&E research and education has grown throughout the world, and many countries have taken steps to expand such investments. As a result, high-quality science and engineering research are no longer the domain of only a small group of countries. The ability of science and engineering to contribute to societal goals, address global problems, and make useful contributions to foreign policy relies to a high degree on global communication and cooperation in science and engineering. Such collaboration is also critical to creating an environment that is conducive to enhancing communications among diverse people and building on the values of cooperation, open-mindedness, and tolerance.

"Science and technology have never been more essential to the defense of our nation and the health of our economy." President George W. Bush (March 2001)

International S&E collaboration encompasses a complex network of activities, with numerous participants and stakeholders, including industry, universities, professional societies, international organizations, private foundations, and governments. In the context of the United States, the Federal Government has played a significant role over the years in promoting international S&E activities through the work of its agencies with S&E missions, and by supporting research with international dimensions by scientists and engineers at U.S. universities. Science and engineering have also been important components of major foreign policy issues, such as arms control and global climate change. The role of the Federal Government will continue to be critical in supporting communication and collaboration in science and engineering. How to improve the effectiveness of the Federal role in international science and engineering is the subject of this report.

The National Science Board (NSB)[5] has periodically assessed the role and needs of science and engineering in the international arena. Given the growing importance of science and engineering in the global setting, the Board decided that it was time for a fresh look at this topic. It established the NSB Task Force on International Issues in Science and Engineering in February 1999 and

[5] The National Science Board serves as the governing board of the National Science Foundation and provides advice to the President and the Congress on matters of national science and engineering policy.

charged it with meeting two objectives. The first was to develop recommendations for strengthening the Federal framework of policies and agency relations supporting fundamental research and education in an international setting. The second was to develop recommendations for an effective leadership role for the National Science Foundation (NSF) in international science and engineering in the 21st century. (See Appendix A for the task force charge.)

In its first year, the task force focused on gathering information. Given the limited number of serious policy evaluations of international S&E issues during the previous decade, the task force felt it important not only to conduct a comprehensive literature review, but also to hold discussions with a broad array of stakeholders.

The following key themes emerged during this information-gathering exercise:

- The need for more effective coordination of the U.S. Government's international S&E and S&E-related activities and greater consistency in meeting its international commitments;
- The importance of increased international cooperation in fundamental research and education, particularly with developing countries and by younger scientists and engineers and;
- The need to improve the use of S&E information in foreign policy deliberations and in dealing with global issues and problems.

The Board concluded that serious re-examination of the United States Government's role in international S&E research and education and the contribution of these activities to foreign policy is essential. Retaining the status quo would jeopardize future U.S. economic and scientific leadership and diminish both the Nation's security and its ability to address important global problems. New approaches to the management and coordination of U.S. international S&E activities are needed if the United States is to maintain the long-term vitality of the U.S. economy and its science and engineering enterprise. The Board therefore urges implementation of seven specific actions and makes the following overarching recommendation.

Keystone Recommendation

The U.S. Government should move expeditiously to ensure the development of a more effective, coordinated framework for its international S&E research and education activities. This framework should integrate science and engineering more explicitly into deliberations on broader global issues and should support cooperative strategies that will ensure our access to worldwide talent, ideas, information, S&E infrastructure, and partnerships.

Process for Developing the Task Force Report

- Planned and held hearings with invited speakers representing a wide range of perspectives;
- Convened an international symposium on models for S&T budget coordination and priority setting, cosponsored with the NSB Committee on Strategic Science & Engineering Policy Issues;
- Received briefings from key representatives of Federal agencies, including OSTP, DOD, DOE, DOS, EPA, NASA, NIH, NSF and NOAA;
- Arranged a comprehensive literature search to identify and review key documents;
- Prepared a guidance report for the NSF Director—"Toward a More Effective NSF Role in International Science and Engineering"—containing the Board's recommendations for an effective leadership role for NSF in international science and engineering in the 21st century[6]; and
- Prepared a transition paper for the new Administration forming the basis for this report which is a more comprehensive report on international science and engineering responding to the first task force objective of strengthening the Federal role in international S&E research and education.

[6] The report is available on the NSB web site at—http://www.nsf.gov/nsb/documents/2000/nsb00217/nsb00217.htm.

CHAPTER TWO

THE CONTEXT FOR INTERNATIONAL S&E ACTIVITIES

INCREASING GLOBALIZATION

The contributions of science and engineering research and education will continue to be key determinants of economic growth, quality of life, and the health and security of our planet in the 21st century. The environment in which these activities occur is becoming more global. Globalization—the worldwide integration of nations through trade, capital flows, diffusion of information, movements of people, and operational linkages among firms and other organizations—has been a key feature of the latter part of the 20th century and will become even more important during the 21st. Advances in transportation, information, and communication technologies have diminished the importance of international boundaries. Events in one country can now have major—sometimes instantaneous—effects in countries geographically far removed.

Both the volume of information and its rate of diffusion are expanding rapidly throughout the world. Flows of people, goods, services, and ideas are transcending national borders on an unprecedented scale. In the late 1990s, the ratio of U.S. trade (exports plus imports) to Gross National Product (GNP) approached 25 percent, its highest point in at least a century.[7] During the same time period, capital flows into and out of the United States peaked as a percent of U.S. GNP—the former at 8 percent, the latter around 5 percent.[8] This phenomenon is not occurring only in the United States. In 1999, foreign direct investment flows both in and out of Organization for Economic Cooperation and Development (OECD) countries reached record levels: more than 2.5 percent of their combined Gross Domestic Product (GDP) for inflows and 3.0 percent for outflows.[9] The ratios of world trade to world GDP increased from 25 percent in 1960 to its high of 45 percent in 1997. This indicator of increasing globalization grew even more rapidly in low-income countries, rising more than three-fold, from 14 percent to 43 percent during the same period.[10]

[7] U.S. Council of Economic Advisers, *Annual Report of the Council of Economic Advisers, 2000*. p. 202, chart 6-2.
[8] *Annual Report of the Council of Economic Advisers, 2000*. p. 206, chart 6-4.
[9] U.S. Council of Economic Advisers, *Annual Report of the Council of Economic Advisers, 2001*. p. 151, box 4-1.
[10] The World Bank, World Development Indicators Data Base 2000.

The conduct of business is increasingly international, with firms establishing foreign subsidiaries, conducting research abroad, outsourcing production, and participating in international joint ventures or other types of international business arrangements. The role of the multinational company (MNC) has expanded. Worldwide, some 60,000 parent operations of MNCs and their 500,000 foreign affiliates account for roughly 25 percent of global output, one-third of it in host countries.[11] Dramatic advances in science and technology have both contributed to and arisen from this increasing integration of the global economy.

GROWING SIGNIFICANCE OF SCIENCE AND ENGINEERING IN THE GLOBAL CONTEXT

The scientific and engineering enterprise is itself increasingly global. The conduct of S&E research has become more international both through formal agreements and through more informal collaboration between individual researchers or groups of researchers. International boundaries have become considerably less important in structuring the conduct of research and development (R&D).[12]

"By its very nature, the science and engineering enterprise is global, often requiring access to geographically specific materials and phenomena and to dispersed expertise. It also requires the open and timely communication, sharing, and validation of findings. Certain issues and disciplines, for example, climate change and biocomplexity, are global in their very definition, and the proliferation of large, complex, and expensive projects and facilities has required participation and support from many nations." NSB Strategic Plan, 1998

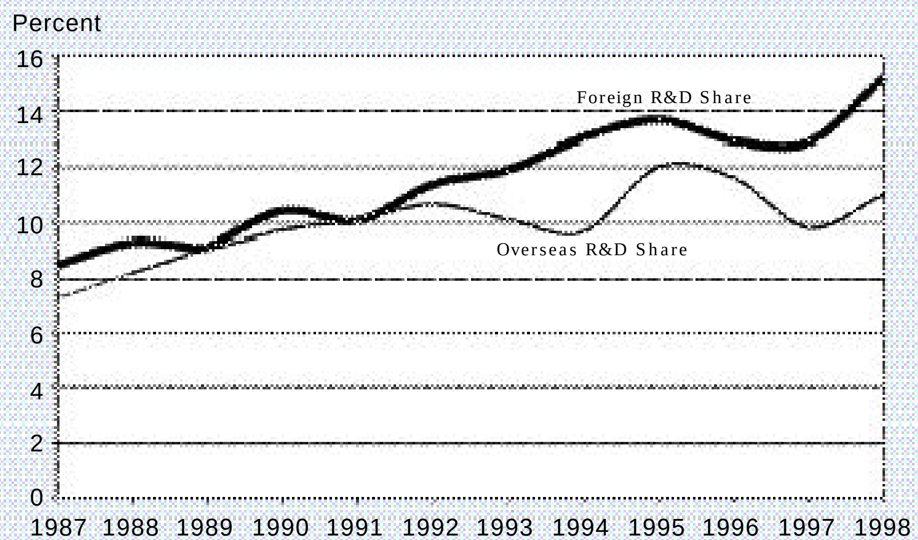
The proliferation of complex and expensive projects requiring large facilities and specialized instrumentation requires partnering among many nations to make the total cost affordable for those participating. Researchers' requirements for geographically specific materials and facilities transcend national boundaries. In addition, many research problems, both disciplinary and multidisciplinary, require scientists and engineers in different countries to work together. The global dimensions of the conduct of scientific activity are reflected in the patterns of citations to the literature. Internationally, close to 61 percent of all citations in 1999 were to foreign research, compared to 53 percent nine years earlier. These increases could be seen for most countries and most fields.[13] This growing globalization not only increases the international conduct of science but also advances the scientific process by providing opportunities for more open and timely communication, sharing, and validation of research findings.

Research collaboration internationally is on the rise in the industrial sector as well with a rising number of formal cooperative arrangements or alliances between firms, the growth of overseas R&D by way of both contracts and subsidiaries, and an increase in the number of industrial R&D laboratories abroad. The response to competitive factors has led to changing forms of cooperative activities. Most of the interregional alliances between firms sharing research and technology have been in two emerging areas—information technology and biotechnology.[14] A rising proportion of industrial R&D funding is also being

[11] *Annual Report of the Council of Economic Advisers, 2000.* p. 207, box 6-1.
[12] National Science Board, *Science & Engineering Indicators 2000 (S&EI 2000)*, p. 2-54.
[13] National Science Board, *Science & Engineering Indicators 2002 (S&EI 2002)*, figure 5-44.
[14] *S&EI 2000*, pp. 2-56, 2-57 and *S&EI 2002*, p. 4-39.

provided by foreign sources in a number of countries, reflecting increasing globalization of industrial R&D activities.[15] In fact, in 1998, foreign R&D spending in the United States as a proportion of company-funded industrial R&D in the United States reached a record 15 percent.[16] (See Figure 1.)

FIGURE 1. U.S. INDUSTRIAL R&D HAS BECOME MORE GLOBALIZED AS THE RATIO OF FOREIGN AND OVERSEAS R&D SPENDING TO COMPANY-FUNDED INDUSTRIAL R&D IN THE UNITED STATES HAS INCREASED DURING THE PAST DECADE.



NOTES: Foreign R&D refers to R&D performed in the United States by U.S. affiliates of foreign parent companies. Overseas R&D refers to R&D performed abroad by foreign affiliates of U.S. parent companies.

DATA SOURCE: Science & Engineering Indicators 2002.

In addition to benefiting scientists and engineers, international S&E collaboration and partnerships are increasingly viewed as ways to open and expand markets and increase opportunities for economic exchange internationally. Scientific and technological advances have not only improved the channels for expanded markets, they have also stimulated the growth of high-technology industries. These industries have generally been more successful exporters than other more traditional industries, not only in the United States and other industrial countries but also in newly industrialized economies, especially within Asia.

SHIFTING WORLD S&E CAPABILITIES

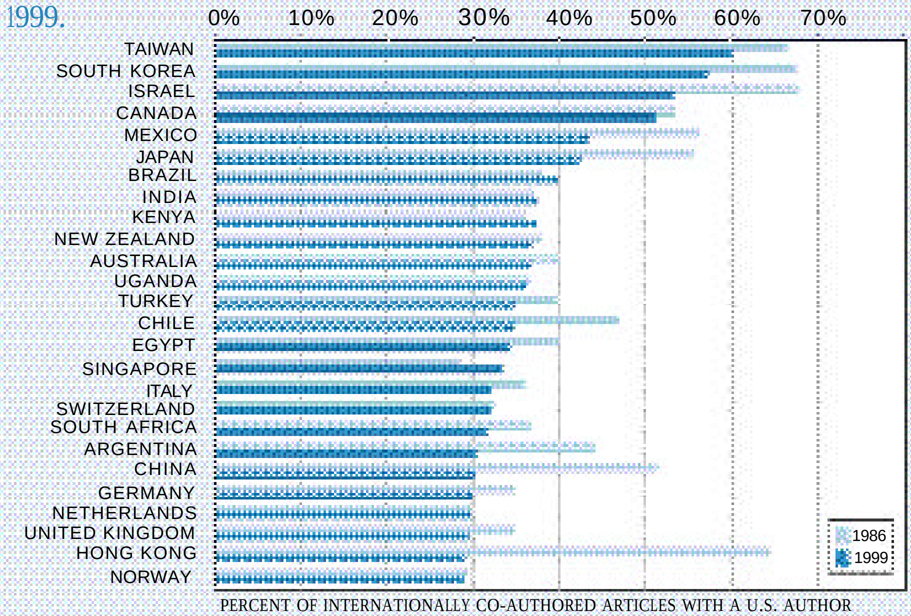
As opportunities for participation in international S&E partnerships increase, so does the urgency of taking advantage of them. Excellent science is no longer the domain of a small group of industrialized countries. In many OECD coun-

"The Internationalization of basic science and technology (S&T) activities, assets, and capabilities is accelerating, and current U.S. advantages in many critical fields are shrinking and may be eclipsed in the years ahead."
U.S. Commission on National Security/21st Century, Feb. 2001

[15] *S&EI 2002*, figure 4-35.
[16] *S&EI 2000*, p. 2-59 and figure 2-37.

tries the share of basic research in overall R&D is similar to the share in the United States, as is R&D as a percentage of GDP.[17] Other countries, including a number of newly industrializing economies are also beginning to spend percentages of their GDP on R&D similar to those of the OECD countries.[18] The balance of S&E expertise among countries is shifting, and new ideas and discoveries are emerging from all over the world. The U.S. share of internationally co-authored articles in other countries is declining overall and for most countries, indicating that new centers of activity and patterns of S&E collaboration are evolving.[19] (See Figure 2.)

FIGURE 2. THE PERCENTAGE OF INTERNATIONALLY CO-AUTHORED ARTICLES INVOLVING ONE OR MORE U.S. AUTHORS HAS DECLINED FOR MANY CONTRIES/ECONOMIES BETWEEN 1986 AND 1999.



NOTE: Countries/economies ranked by share in 1999.
DATA SOURCE: Science and Engineering Indicators 2002.

The development or strengthening of national scientific capabilities in several world regions is also indicated by continuation of a long-term decline in the U.S. share of total scientific publications. During the 1986-1999 period, the number of U.S. articles declined by 10 percent from its high earlier in the decade, while those of Western Europe and Asia rose by 30 and 80 percent, respectively.[20] Another indicator of the worldwide expansion in advanced S&E capabilities—particularly evident in Europe, Asia, and the Americas—is the expansion of S&E doctoral programs and graduate education reform to improve the quality of research and build national innovation capacity.[21] The importance of foreign science and technology to the United States is also shown by the fact that foreign-origin patents represent nearly half (45% in 1999) of all patents granted in the United States.[22]

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[17] *S&EI 2000*, figures 2-30 and 2-33 and *S&EI 2002*, p. 4-45.
[18] *S&EI 2000*, text table 2-14 and *S&EI 2002*, text table 4-13.
[19] *S&EI 2000*, pp. 6-49, 6-50 and *S&E I 2002*, text table 5-19.
[20] *S&EI 2002*, figure 5-32.
[21] *S&EI 2000*, p. 4-16 and *S&EI 2002*, p. 2-41.
[22] *S&EI 2000*, p. 7-21 and *S&EI 2002*, p. 6-21.

Collaborative activities and international partnerships are an increasingly important means of keeping abreast of important new insights and discoveries critical to maintaining the U.S. leadership position in key fields and contributing to U.S. economic growth. While the main emphasis in the U. S. Government's support of R&D is on health, defense, and medical sciences, other countries emphasize different activities. In Japan, for example, the emphasis is on energy related activities.[23] There are also differences in emphasis in the S&E literature across countries. Some emphasize the life sciences, others the physical sciences, engineering, and technology.[24] This differential emphasis across countries indicates that the U.S. S&E community can benefit by expanding its scientific knowledge base through international collaboration not only in fields where it plays a more dominant role, but also in fields where it is less dominant.

INTERNATIONAL EDUCATION AND MOBILITY OF SCIENTISTS AND ENGINEERS

The realization of the importance of science and engineering to quality of life and economic growth and the recognition that people are the main agents of knowledge transfer have led many countries to strengthen their higher education systems, particularly in S&E fields, to improve their S&E enterprises and meet the needs of the 21st century workforce. Recognition of the importance of a skilled workforce for economic growth has also led to international competition for workers and the evolution of a global and highly mobile S&E workforce. The continued international mobility of the S&E workforce relies on a policy of openness that, within a framework of appropriate national security considerations, encourages the free circulation of scientists and engineers across national borders. The U.S. science and engineering enterprise benefits from such international exchange and from the contributions of foreign-born scientists and engineers who migrate to the United States and work in our universities and research laboratories.[25]

"As the intrinsic nature of science is universal, its success depends on cooperation, interaction, and exchange, often beyond national boundaries. Therefore, ICSU strongly supports the principle that scientists must have free access to each other and to scientific data and information. It is only through such access that international scientific cooperation flourishes and science thus progresses."
from ICSU Statement on Freedom in the Conduct of Science (1995) in 2000 report

One indicator of mobility of S&E personnel in the world is the proportion of foreign born faculty in U.S. higher education. Of the 225,000 S&E faculty teaching in four-year institutions in 1997, 45,000 were foreign born.[26] Many firms have R&D sites outside their own countries that are often established to tap knowledge and skilled labor from competitors and universities around the globe, including direct employment of local talent.[27]

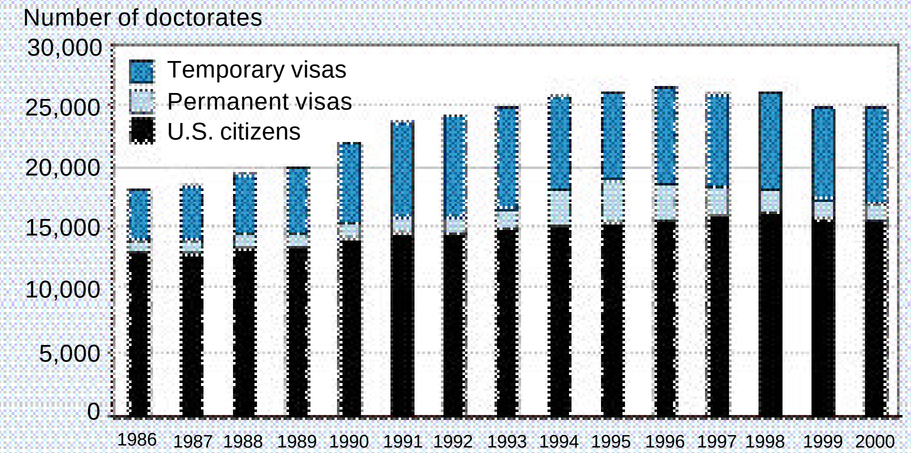
Many industrial countries attract a large number of foreign students to their universities. The United States, the United Kingdom (U.K.), Japan, and France all have a high percentage of foreign students in their doctoral S&E

[23] *S&EI 2000*, p. 2-51.
[24] *S&EI 2000*, p. 6-47.
[25] National Science Board, "Statement on Open Communication and Access in Science and Engineering," May 4, 2000.
[26] *S&EI 2000*, p. 4-37 and text table 4-11.
[27] *S&EI 2000*, pp. 2-58, 2-59.

"In recent years, as scientific and technological research in other countries has increased, our nation's academic dominance has eroded in a growing number of fields. The likelihood that the quality of both research and instruction at colleges, universities, and research centers in Europe, Asia, and elsewhere will continue to improve reflects a central reality of our time: education and human capital have become the determinants of national power and well-being."
John A. Marcum, *Chronicle of Higher Education*, May 2001

programs. During the late 1990s, foreign students earned 44 percent of the doctoral engineering degrees in the U.K., 43 percent in Japan, 30 percent in France, and 49 percent in the U.S. Foreign students earned more than 31 percent of mathematics and computer science Ph.D.s in France, 38 percent in the U.K. and 47 percent in the U.S.[28] (See figure 3 for U.S. distribution of S&E Ph.D.s by citizenship.)

Figure 3. Between 1986 and 2000, 30 to 40 percent of U.S. doctoral S&E degrees were earned by foreign citizens.



DATA SOURCE: Science & Engineering Indicators 2002.

Many of the foreign students educated in these countries remain and many others go home. For example, about 53 percent of the foreign students who earned U.S. S&E doctorates in 1992 and 1993 were working in the United States in 1997. The stay rates were higher in the physical and life sciences and in engineering and lower in the social sciences. However, the stay rates tend to differ more by country of origin than by discipline. A much larger percentage of engineering doctoral recipients from India and China than from Korea were working in the United States in 1997.[29] The growth of increased opportunities in home countries, including the expansion of higher education in many developing countries, is likely to increase the number returning.

A number of countries are also making concerted efforts to encourage the return of their best and brightest scientists and engineers.[30] For instance, in the 1990s, the number of doctoral recipients from South Korea and Taiwan reporting plans to stay in the United States declined as these countries increased their capacities to absorb the majority of U.S.-trained doctoral scientists and engineers.[31] Their return is contributing to a rise in their countries' education and research capabilities in addition to providing both an opportunity and a rationale for continued international collaboration with U.S. scientists and engineers.

[28] Data for Japan are from 1997, for France from 1998, and for the United Kingdom and United States from 1999. *S&EI 2000*, pp. 4-33, 4-34, and text table 4-10 and *S&EI 2002*, figure 2-34.
[29] *S&EI 2000*, pp. 4-35, 4-36.
[30] James Glanz. "Trolling for Brains in International Waters." *The New York Times*, April 1, 2001. Geoffrey Maslin. "Australia Invites Leading Academics to Apply for Generous New Fellowships." *The Chronicle of Higher Education*. V47, Issue 34. May 2, 2001.
[31] *S&EI 2000*, pp. 4-34, 4-35.

21ST CENTURY PROBLEMS NEEDING GLOBAL S&E SOLUTIONS

For a growing array of issues that are global in nature, science and engineering are key to dealing with them effectively. These issues include climate change, genetically modified organisms, energy conservation and utilization, infectious diseases, disaster prevention and management, national security, population growth, immigration policy, sustainable development, intellectual property rights, and open exchanges of scientific information.

- Disagreements exist over the extent and significance of global warming and the costs and benefits of measures proposed to reduce it. Since the impacts of climate change are not limited to any one country or region, any effort to deal with it will have to be internationally coordinated. To be successful, it will also necessitate at least general agreement on the science underlying the various positions and the active participation of scientists and engineers familiar with the various and complex aspects of the issue.

- The safety of genetically modified organisms is another issue about which there is a great deal of controversy. There has been considerable international pressure for establishment of a biosafety protocol that regulates such organisms. However, there is disagreement about what requirements should go into such a protocol. Although safety is not the only factor being considered, an international scientific consensus on the safety of such organisms might contribute to more effective international negotiations on this issue.

- Protecting human health and reducing the spread of infectious diseases such as AIDS, tuberculosis, cholera, and ebola also require a concerted international effort and advances in science and engineering. The risks of both catching and dying from infectious diseases are especially high in many of the developing countries where extreme poverty and associated conditions are conducive to the rapid spread of such diseases. The increasing movement of people across national boundaries also makes it increasingly difficult to limit the spread of such diseases. Improved information and tracking systems as well as cooperative research efforts directed at understanding the biological mechanisms and epidemiological aspects of disease are needed to combat the spread of these diseases by facilitating more effective prevention and treatment.

- A concerted international effort is also needed to increase countries' preparedness for natural disasters. Natural disasters extract a heavy toll on both lives and property, with extensive human and financial losses. The increasing concentration of population in areas that are prone to such disasters magnifies the impacts of such events. International science and engineering cooperation can lead to both better predictive capabilities and strategies to reduce the impact of these disasters.

Most of these and other complex and systemic biological, economic, political, and ecological problems of the 21st century will demand more information, more participation by the scientific and engineering communities of all nations, and

"Issues like export control, nuclear safety and non proliferation, fuel and energy resources, infectious diseases, adequate and safe food and water supply, global warming, migration, drug trafficking, intellectual property rights — all these and more define the new, 21st Century international security environment. Our perception of what national security means needs to change, and our funding needs to change to reflect these concerns."
Senator Jeff Bingamon (March 2001)

"Intrinsic to science are two attributes integral to successful scientific efforts in this area [interacting with governments in mitigating conflicts]:
▪ First, science is by nature international in its scope and its activities. Further, international cooperation has been normal in the scientific enterprise. Scientists maintain a transnational dialogue among themselves, exchanging information and ideas and reaching for consensus on various topics. The permanent intellectual communication framework used by scientists for mutual cooperation within science can also be useful for contact and cooperation between scientists on other matters of conflict.
▪ Second, 'scientific culture' includes a group of shared attributes that can prove helpful when dealing with conflict situations. The culture includes a common language and a belief in the universality of truth. Other shared attributes are an 'organized skepticism' that expresses itself in a

suspension of judgment and the detached scrutiny of beliefs in terms of empirical and logical criteria. These shared attributes, combined with a rational approach to problem solving even amidst emotional conflicts, help scientists play an important, a possibly unique, role in mitigating international conflict."
Alexander Keynan
The Scientist, March 1999.

"The rapid rise in international cooperation has spawned activities that now account for more than 10 percent of government R&D expenditures in some countries. A significant share of these international efforts results from collaboration in scientific research involving extremely large 'megascience' projects. Such developments reflect scientific and budgetary realities: Excellent science is not the domain of any single country, and many scientific problems involve major instrumentation and facility costs that appear much more affordable when cost-sharing arrangements are in place. Additionally, some scientific problems are so complex and geographically expansive that they simply require an international effort. As a result of these concerns and issues, an increasing number of S&T related international agreements have been forged between the U.S. Government and its foreign counterparts during the past decade."
NSB *Science & Engineering Indicators 2000*

more cooperation between these communities and political decision-makers. These issues will not only affect U.S. national security but could also affect future global security. Increased international collaboration in S&E research and education will itself help expand the knowledge base for scientific consensus and will thus improve the international policy deliberations in many areas.

International S&E cooperation also helps build more stable relations among countries, communities, and individuals by creating a universal language and culture based on commonly accepted values of objectivity, sharing, integrity, and free inquiry. Acceptance of such values is critical to the resolution of many problems and issues being addressed in the international arena.

U.S. Governmental Collaborations in International S&E Research and Education

U.S. governmental collaboration in international S&E related activities is a growing phenomenon. A 1999 General Accounting Office (GAO) report shows that seven agencies—the Department of Energy (DOE), the National Aeronautics and Space Administration (NASA), the National Institutes of Health (NIH), the National Institutes of Standards and Technology (NIST), the National Oceanic and Atmospheric Administration (NOAA), NSF, and the Department of State—participated in 381 bilateral agreements between research agencies and their counterparts in foreign governments and international organizations and in 140 multilateral agreements to conduct international cooperative research, provide technical support, or share data or equipment.[32] Fifty-four of these agreements were broad-based bilateral arrangements between the U.S. Government and governments of foreign countries—commonly referred to as "umbrella" or "framework" agreements. Overall, the United States collaborated with 57 countries, 8 international organizations, and 10 groups of organizations or countries. In terms of numbers, U.S. agencies had the greatest number of agreements with Japan (78). After Japan, U.S. science and technology (S&T) agreements were most commonly reported with Russia (38), China (30), and Canada (25).

Among the seven agencies that GAO reviewed, DOE participated in the largest number of official international S&T agreements (257). This total included almost 100 multilateral agreements with the International Energy Agency, which represents the United States and 23 other countries with common scientific interests and priorities. NASA was second among the seven agencies in terms of participation in total international S&T agreements (127, including 15 multilateral agreements with the European Space Agency).

The GAO accounting includes only official, formal agreements and therefore does not capture government-supported collaboration that frequently takes place between individual researchers or groups of researchers outside the framework of these formal agreements. Communications advances, particularly the Internet, have contributed to the growth of these more informal collaborations.[33]

[32] *S&EI 2000*, p.2-54.
[33] S. Teasley and S. Wolinsky. "Scientific Collaboration at a Distance." *Science*, Vol. 292, pp. 2254-55, 2001.

COORDINATION OF U.S. GOVERNMENT SUPPORTED INTERNATIONAL S&E ACTIVITIES

The increasing U.S. governmental collaboration in international S&E-related activities makes effective coordination and integration of such activities more important than ever. Unfortunately, even the formal international collaboration is frequently uncoordinated. It is not necessarily part of a coherent and integrated plan. Much of it is characterized by poor communication or insufficient data, so that little information is being shared.

The Office of Science and Technology Policy (OSTP) in the Executive Office of the President provides general oversight, integration, and direction of the U.S. Government's international S&E activities. Within OSTP, the National Science and Technology Council (NSTC) was established by the President to coordinate Federal science and technology policy and the diverse parts of the Federal R&D enterprise. The NSTC's Committee on International Science, Engineering, and Technology (CISET) is charged with providing interagency coordination in the international arena. CISET was established to address significant international policy, program, and budget matters that cut across agency boundaries. It provides a formal mechanism for interagency policy review, planning, and coordination, as well as exchanges of information regarding international science, engineering, and technology. In recent years, it has been co-chaired by OSTP's Associate Director for National Security and International Affairs and the Department of State's Undersecretary of State for Global Affairs.[34] Other NSTC committees address international issues directly in their purview (e.g., the Committee on Earth and Natural Resources). Also, there are a number of other entities within the White House with both an interest in and responsibility for various aspects of international S&E policy including the National Security Council and the National Economic Council. These overlapping and shared interests and responsibilities make coordination and management of international S&T activities even more complex and challenging.

The Department of State plays a leading role in a number of interagency international activities involving S&E research and education. It coordinates support for a number of vice-presidential-level bilateral commissions that accord considerable priority to S&E-related activities. It develops the concepts, frameworks, and details of umbrella intergovernmental S&E agreements and coordinates and negotiates them with its foreign counterparts. It also reviews and approves requests from other agencies for authorization for negotiating and signing memoranda of understanding and other agreements dealing with international S&E issues.[35]

It is clear that a number of government offices and agencies have key roles in developing and coordinating U.S. international S&E efforts. However, the current framework does not ensure effective communication and interaction and a close and continuing relationship among these organizations.

"In the Executive Branch over many years, however, there has been a crazy-quilt of poorly defined responsibilities for science and technology in international affairs. Agencies have inconsistent strategies and inadequate resources. Programs are frequently knotted up with conflicting policies, erratic funding, and micromanagement. Only rarely are efforts properly knitted together, and then only by ad hoc mechanisms of coordination. The results have been poor, hardly befitting America's extraordinary assets in science and technology, and the consequences have been frustrating to Congress as well as to the President and the Secretary of State."

Rodney W. Nichols, Carnegie Commission on Science, Technology, and Government, 1993

[34] Staff from the Department of State's Bureau of Oceans, Environment and International Affairs serve as nominal executive secretary of CISET.

[35] National Research Council, Office of International Affairs, *The Pervasive Role of Science, Technology, and Health in Foreign Policy: Imperatives for the Department of State*, Washington, DC. 1999. See pp. 64-67 for a broader and more detailed discussion of the role of the Department of State in interagency international S&E activities.

CHAPTER THREE

PROBLEMS, CHALLENGES, AND RECOMMENDATIONS

During the NSB task force's information-gathering process and its deliberations, three major issues emerged as immediate critical challenges for the United States Government with regard to its international S&E research and education policy. (See Appendix B for summaries of the three hearings organized by the task force and Appendix C for a list of participants in the hearings and other aspects of the task force's work.)

- The need for more effective U.S. Government coordination of its international S&E and S&E-related activities;
- The need to strengthen international cooperation in fundamental research and education, particularly with developing countries and by younger scientists and engineers; and
- The need to improve the use of S&E information in foreign policy deliberations and in dealing with global problems.

A. COORDINATION OF THE U.S. GOVERNMENT'S INTERNATIONAL S&E ACTIVITIES

Although there are few sources of systematic information, particularly trend data, on international cooperative S&E and related activities, the limited information available suggests such activities supported by the Federal Government are increasing. However, a clear picture of the activities of the various Federal agencies, the degree of coordination among them, and how well they are integrated is lacking. More and better information is needed to ensure that appropriate structures and mechanisms exist for the coordination and management needed to eliminate unnecessary duplication, prevent inefficiencies, and facilitate synergy.

"In addition to the scarcity of funds, the efforts of many Federal agencies on the international front are underappreciated and undervalued. Many of the things they are asked to do are essentially unfunded mandates. The absence of line items for most international activities prevents agencies from being fleet-footed enough to react and deal with international issues, particularly in developing countries, in any coherent way with long-term support."
Alan Hecht, Former Principal Deputy Assistant Administrator, EPA (Summary of key points at NSB hearing, July 1999)

Overall leadership for international science and engineering policy lies in the White House within OSTP. However, the focus of OSTP is necessarily selective, directed at the early stages of an issue and at critical day-to-day issues of diplomacy and security that most often pertain to "science for policy." Since the office is small, the preponderance of the activity related to international S&E is limited to policy development and policy making, with implementation and follow-through left to the agencies. Although CISET has been a valuable contributor to interagency coordination, its role appears to fluctuate over time. In recent years, its role has been less visible. In the future, U.S. leadership will require more visible and consistent attention to longer-term issues of "policy for science."

In many cases official international S&E agreements have no associated budget authority. Only a small fraction of overall Federal expenditures for international S&E activities derives from specifically designated international program budgets. Federal agency expenditures for international activities (with the exception of the Department of State and the U.S. Agency for International Development (USAID)) are justified and budgeted primarily in terms of contributions to the programmatic rather than the international objectives of the respective agencies. This programmatic approach frequently leads to a paucity of funds for management, coordination, and communication of internationally focused activities.

An additional problem is the difficulty of maintaining interest in and support for long-term international projects. The absence of follow-through on several high profile scientific projects has led at times to our international partners regarding us as unreliable.[36] Congress has generally been unwilling to set aside multi-year funding for such projects at their outset, resulting in discontinuities and requiring considerable effort by agencies and the Executive Branch to assure sustained funding. The importance of stable funding to the success of large-scale international science and engineering projects cannot be overemphasized.

The foregoing points to the importance of creating an effective infrastructure for coordination of international S&E policy. Effective coordination and management require extensive and timely information about international S&E activities. Currently, such information is often difficult to gather and interpret, and mechanisms for communication and sharing this information are not always adequate. A number of agencies collect and disseminate information about science and engineering activities in other countries, and the National Science Foundation and the Office of Naval Research (ONR) have overseas offices for this purpose. However, additional information and better mechanisms of communication are needed, especially relating to the resources directed towards international S&E activities by individual Federal agencies. In its biennial publication, *Science and Engineering Indicators*, the National Science Board provides information about science and technology throughout the world, placing U.S. data in an international context. The Board plans to expand and increase the visibility of its international coverage in future volumes of *Indicators*.

[36] Two examples are the International Thermonuclear Experimental Reactor (ITER), which the Department of Energy withdrew from in 1999 due to budget cuts and the International Solar Polar Mission, which the National Aeronautics and Space Administration withdrew from in the early 1990s due to severe budget cuts.

A variety of U.S. Government policy development processes, including those for S&E, often fail to include specific consideration of direct and indirect impacts on international cooperation. The interplay of policies or activities relating to areas such as immigration, intellectual property rights, and data exchange may have unintended consequences, resulting in barriers to effective cooperation in international S&E activities. Similarly, policies of other countries related to intellectual property rights, access fees, restricted access to facilities, and visa problems also create impediments to international S&E cooperation.

RECOMMENDATION 1

The Office of Science and Technology Policy (OSTP) should strengthen its international focus to ensure an effective, integrated, visible, and sustained role in monitoring, coordinating, and managing U.S. international S&E research and education activities. As part of this effort, OSTP should actively encourage Federal agencies to identify and increase the visibility of their international S&E research and education activities, to provide an adequate level of funding for these activities, and to allocate adequate funding and resources for their coordination and management. The Office of Management and Budget should be encouraged to prepare an annual international S&E budget crosscut similar to its annual research and development (R&D) budget crosscut, that includes international activities found outside specifically designated international program budgets.

RECOMMENDATION 2

OSTP should encourage agencies to develop more effective mechanisms for gathering and disseminating information about U.S. collaboration and partnerships in international S&E activities and similar activities in other countries, with emphasis on fundamental research and S&E education.

RECOMMENDATION 3

The United States Government should promote the development of international S&E policy aimed at facilitating international cooperation in research and education. The formulation and implementation of policies related to areas such as immigration, intellectual property rights, and the exchange of scientific information and personnel should include consideration of their impact on cooperation in research and education.

B. ENHANCING AND EXPANDING U.S. INTERNATIONAL S&E RESEARCH AND EDUCATION

"The growth of modern communications technologies, coupled with the existence of cutting-edge scientific research programs in foreign countries, has made it both possible and scientifically useful for the United States to leverage our own investments in research with those taking place in foreign nations. Not only does this allow U.S. researchers access to unique research, it also allows them to reap the full benefits of that research at a fraction of the cost."
U.S. House Committee on Science—Hearing Charter, International Science. (1998)

Scientific leadership requires access to people, knowledge, and S&E infrastructure, wherever they are found. Effective collaboration and partnerships in S&E activities with other nations are key to achieving this access. Such cooperation is also critical to raising the collective international capacity to solve global problems in environment, health, energy, disaster management, and other areas with an important S&E dimension and, in the long term, contributing to economic growth, national security, and quality of life. Collaboration with other countries also makes it possible for the United States to leverage its S&E research and education investments and allows U.S. researchers to obtain the full benefits of collaborative research while sharing the financial costs with others.

Two areas deserve special attention: increased participation in international S&E activities by younger scientists and engineers and increased collaboration with developing countries.

Participation by Younger Scientists and Engineers: U.S. students who study and conduct research abroad not only learn more about the people and culture of the countries they visit but also enhance their skills and capabilities, ultimately making them more productive participants in the U.S. labor force. In the private sector, international experience is highly marketable. It is also increasingly a requirement for success in conducting business. U.S. researchers learn from their peers in other countries, and collaboration with them helps in solving important fundamental research problems on which continued U.S. leadership depends. However, it is often difficult to convince younger scientists and engineers to become involved in international cooperative S&E research and education activities because of limited incentives and a widespread perception in many fields that time spent abroad may be detrimental to one's career. Re-entry after a sojourn abroad may put the young person outside the normal cycle of academic life. Young scientists and engineers may also need assistance re-connecting with networks, assessing opportunities that would make best use of their new skills, and in dealing with an atypical career path with respect to their U.S. colleagues. There is also less emphasis in the U.S. higher education system than in the past on learning a second language. An absence of foreign language skills among many younger scientists and engineers also may limit the opportunities for collaboration in a number of countries.

"Our production sectors will be effective competitors only if they have the knowledge base, including workers and staff who are knowledgeable about other countries, to develop effective strategies for competing. At the same time, the knowledge generated by international collaboration will help serve our foreign and economic policy more generally by producing new knowledge on the institutional arrangements in other countries, by increasing our understanding of the cultures of other countries, and by increasing the knowledge base to compete with them."
Edward Schuh, 2000 AAAS Annual Meeting

Foreign students and researchers coming to the United States learn about U.S. culture and values. Those who remain in this country are an important addition to our S&E workforce and those who return home bring a deeper understanding of U.S. culture and values to their own countries. This cross-fertilization, with U.S. scientists and engineers spending time abroad and foreign scientists and engineers spending time in the United States, is important in enhancing communication among diverse people and building on the values of cooperation, open-mindedness and tolerance that are necessary for solving many of the critical problems facing the world.

In a recent study focused on re-envisioning the Ph.D., U.S. students indicated that international graduate students in the United States are more aware than American students of what is going on in the world. The U.S. students also indicated a need to acquire a more global perspective and said that they wanted more concrete ways to understand their education and training within the context of the global economy. [37]

RECOMMENDATION 4

Federal agencies should encourage and support policies and programs that provide incentives for expanding participation in international cooperative research and education activities by younger scientists and engineers.

Collaboration with Developing Countries: The world economy is changing and knowledge and human capital are supplanting physical capital as the major ingredients for sustainable economic development. Although favorable natural resource positions may continue to be a source of growth in some developing countries, a skilled work force and scientific and technological capabilities are likely to be much more important factors. In addition to having a major impact on long-term economic well being, science and technology also help provide solutions to many of the problems that afflict the poorest countries, including health and natural and man-made disasters. Most developing countries are aware of the need to build their science and engineering infrastructure capacity, and especially their human capacity through education and training. Developing new tools and technologies, building networks of research organizations to promote research, and enhancing indigenous research capacity will help to ensure sustainability and self-reliance in carrying out future research relevant to their diverse needs.

Particularly in the S&E realm, traditional forms of development assistance such as foreign aid are being replaced by a new emphasis on sustainable development through creation of the necessary infrastructure, including human resources, for participation in the S&E arena. Supporting the training of people and the creation of conditions where those people can work at top levels in their countries is a critical priority.

The developing countries are a source for diverse S&E talent and knowledge, produce key imports, and provide a market for exports. Also, because of U.S. entrepreneurial and innovative leadership, the S&E knowledge obtained through international collaboration provides mutual benefits to the United States as well as the developing countries. Expanding scientific and technological cooperation with these countries may also be a vehicle to achieve other important goals, such as improved relations and support for the U.S. position on an array of global issues.

"For developing countries the global expansion of knowledge contains both threats and opportunities. If knowledge gaps widen, the world will be split further, not just by disparities in capital and other resources, but by the disparity in knowledge. Increasingly, capital and other resources will flow to those countries with the stronger knowledge bases, reinforcing inequality. There is also the danger of widening knowledge gaps within countries, especially developing ones, where a fortunate few surf the World Wide Web while others remain illiterate. But threat and opportunity are opposite sides of the same coin. If we can narrow knowledge gaps and address information problems, it may be possible to improve incomes and living standards at a much faster pace than previously imagined."
John Daley, World Bank, 1998

[37] Jody D. Nyquist and Bettina J. Woodford. *Re-envisioning the Ph.D. What Concerns Do We Have?*, University of Washington, 2000, pp. 21, 28. Funded through the Pew Charitable Trusts.

"In a world where globalization and competitiveness are the rule, progress requires that developing countries find areas in which they are significantly better than their competitors because of a better trained work force, favorable natural resources, or scientific and technological capabilities. Science and scientists can play an important role in determining those choices and implementing development strategies."
Jose Goldemberg, *Science*, 1998

Since a number of international and multilateral organizations have recently taken a fresh look at scientific and technological support to developing countries, this is an especially auspicious time to focus on the U.S. Government's role with respect to developing countries. In 1997, USAID established a policy on research support that laid out the standards and criteria for determining research priorities.[38] In the past, the World Bank has mainly responded to client demands in this area rather than taking an integrated approach. But in the 1998-1999 "World Development Report on Knowledge for Development," a flagship statement, the Bank stressed the role of knowledge in the process of development.[39] The Inter-American Development Bank has recently unveiled a new strategy on science and technology to take a systems approach to ensure that all the pieces in national innovation systems are available to ensure that technological development can take place.[40] The World Bank and the United Nations Education, Scientific, and Cultural Organization (UNESCO) convened a task force on higher education in developing countries whose report, issued in 2000, concluded that without more and better higher education, developing countries will find it increasingly difficult to benefit from the global knowledge-based economy.[41] Private foundations also play a role in promoting international S&E research and education cooperation. The United States is in position to strengthen its collaboration with all of these types of institutions, allowing leveraging of resources, reducing costs and risks, enabling activities that might not have been undertaken otherwise, and bringing U.S. S&E expertise into the planning process at an early stage.

RECOMMENDATION 5

Federal agencies should encourage development of human and physical infrastructure for science and engineering in developing countries through partnerships with international, multilateral, and private organizations providing support to developing countries for S&E research and education.

C. FOREIGN POLICY AND GLOBAL PROBLEM SOLVING

"Today the United States is in an unenviable position. Among the world's leading nations, its process for developing foreign policy is the least well coordinated with advances in S&T and the policies affecting them."
J. Thomas Ratchford, *Science*, 1998.

While science and technology have always influenced foreign policy, and vice versa, there is growing concern that foreign policy and related deliberations on many issues of international importance give inadequate attention to science and technology. Today, it is especially important to include them as an integral

[38] Testimony by Ray Kirkland, Associate Assistant Administrator for Population, Health, and Nutrition, Global Bureau, United States Agency for International Development, at the NSB International Task Force Hearing on Global Science and Engineering: Foreign Perspectives, Multicultural and International Organizations, November 16, 1999, Arlington, VA.
[39] Testimony by Michael Crawford, a science and technology specialist at the World Bank, at the NSB International Task Force Hearing on Global Science and Engineering: Foreign Perspectives, Multicultural and International Organizations, November 16, 1999, Arlington, VA.
[40] Testimony by Laurence Wolff, Senior Consultant for Education Unit, Sustainable Development Department, at the Inter-American Development Bank, at the NSB International Task Force Hearing on Global Science and Engineering: Foreign Perspectives, Multicultural and International Organizations, November 16, 1999, Arlington, VA.
[41] The World Bank/UNESCO, Task Force on Higher Education and Society, *Higher Education in Developing Countries: Peril and Promise*, Washington, DC. 2000,

part of foreign policy development, in light of the rapid S&E advances underway throughout the world and the proliferation of problems having an important S&E dimension. Science and technology play a large role in a number of issues with international ramifications including nuclear nonproliferation, use of outer space and space-launch technology transfer, population growth, trade issues, intellectual property rights negotiations, food supply, global climate change, infectious diseases, terrorism, energy resources, disaster prevention and management, and encryption technology, to list just a few.

In 1998, the Department of State requested that the National Research Council (NRC) initiate a study of the contributions that science, technology, and health can make in the formulation and implementation of foreign policy and suggest how the Department might better carry out its responsibilities to that end. Consistent with a number of earlier studies on this topic, the NRC report, *The Pervasive Role of Science, Technology, and Health in Foreign Policy: Imperatives for the Department of State,*[42] emphasized the need for a fundamental change in the orientation of the U.S. foreign policy community. The report recommended strengthening the capabilities of the State Department in areas involving S&E considerations through the commitment of agency leadership, an improved organizational structure, and an informed and motivated staff. The report also noted the need to increase available resources to implement the report's recommendations. As of late 2001, a number of changes have already taken place at the Department in response to the recommendations made in the NRC report. Some of these include the appointment of a Science and Technology Advisor to the Secretary of State, an increase in the number of external S&E fellows from private organizations and Federal agencies, and the holding of a number of S&E roundtables for senior officers at State and other U.S. Government agencies.

The National Science Board concurs with NRC's conclusions and notes that a number of Federal agencies are in a position to assist State with respect to advice, information, and data on S&E issues affecting foreign policy decisions. For example, NSF, with its broad mandate in basic research and S&E education is in a position to make its expertise available on a wide range of fundamental science and engineering issues. Also, U.S. agencies with significant S&E responsibilities (for example, ONR, DOE, and NOAA) frequently have information and staff located in the United States and abroad that can serve as valuable resources to U.S. foreign policy staff. This resource is especially important since the number of science officers has decreased markedly in recent years at a time when S&E advice on foreign policy and other global issues has become more important than ever. However, increased assistance by other agencies may be difficult without both an additional Federal investment in financial and human resources and a strong signal at the highest levels of government that increased cooperation and coordination are desired objectives.

"Issues involving science, technology, and health (STH) have moved to the forefront of the international diplomatic agenda. Other vital issues linked to technological developments pervade longer-range foreign policy concerns. In addressing these issues, expert STH knowledge is essential to the anticipation and resolution of problems and to the achievement of foreign policy goals. Precisely because STH developments are a pervasive global force, they cannot be isolated from the fundamental workings of foreign policy, and effective foreign policy must reflect a comprehensive approach within the Department [of State] to integrating STH competence into policy and program formulation and execution."
National Research Council, 1999

[42] National Research Council, Office of International Affairs, *The Pervasive Role of Science, Technology, and Health in Foreign Policy: Imperatives for the Department of State*, Washington, DC. 1999.

"That is why scientific societies across the globe must take a more active role in helping political leaders and the public make more informed decisions. It's not enough to recognize that every nation today needs its own scientific capacity—both to address local issues and to take advantage of the vast resources of science. This scientific capacity also needs to be organized in a way that gives it a powerful voice."
Bruce Alberts, *The Scientist*, May 2000

However, reliance solely on U.S. institutions to improve the integration of science and engineering with foreign policy and global problem solving will not be enough. International organizations around the world may also have to take a more active role. There are a number of such organizations—both governmental and non-governmental—that already play a role in science and engineering activities on an international scale. International organizations having long-standing interests in this area include the OECD, several United Nations agencies, including UNESCO, and the International Council for Science (ICSU). Additionally, last year in order to address related issues of international concern, a group of science academies from around the world, the InterAcademy Panel, announced formation of a new organization, the InterAcademy Council. This organization plans to bring together scientists, engineers, and medical experts to provide advice to international bodies such as the United Nations system and the World Bank on issues involving science and technology.

RECOMMENDATION 6

The U.S. Government, especially the Department of State, with its primary responsibility for U.S. foreign policy, should recognize and address the importance of science and engineering in achieving its objectives. Mechanisms should be identified to improve communication among science officers, other U.S. embassy personnel, and science and engineering staff of other Federal agencies, including those working abroad, to facilitate sharing of information critical to planning and decision making, and to improve the general flow of information on critical S&E issues.

RECOMMENDATION 7

The U.S. Government should strongly endorse the spirit of the recommendations of the 1999 NRC report to the State Department and ensure that responses to those recommendations are implemented expeditiously. Because developing an appropriate U.S. capability in this arena requires a long-term concerted effort, effective change will require a multi-year, multi-Administration, and bipartisan response, with appropriate levels of funding.

Chapter Four

Conclusion

This report has emphasized the changing nature of the world, characterized by increasing globalization and greater reliance on science and engineering. The confluence of these factors obliges the United States Government to re-examine its role in international science and engineering research and education, especially its management and promotion of international S&E collaboration and the relationship of science and engineering to foreign policy and global problem-solving.

The development of an effective framework for science and engineering in the international arena is a critical priority for assuring U.S. global leadership in the decades ahead. This framework must be based on clear policy objectives and effective institutional arrangements, and supported by appropriate development and sharing of information. The findings and recommendations presented in this report identify key areas for attention and action. The National Science Board is prepared to assist in this endeavor.

Selected Bibliography

Alberts, B. 1998. “Toward a Global Science.” *Issues in Science and Technology* 14(4).

Alberts, B. 2000. “Commentary: Science Must Help Set the Global Agenda.” *The Scientist* 14(17):6.

Advisory Council on Science and Technology (ACST). 2000. “Reaching Out: Canada, International Science and Technology, and the Knowledge Based Economy.” Report of the Expert Panel on Canada’s Role in International Science and Technology. Ottawa: ACST.

Ailes, C.P. 1988. “New Directions for U.S.-Latin American Cooperation in Science and Technology.” Arlington, VA: SRI International Science and Technology Policy Program.

Ausubel, J. H. 1995. “Science International - a U.S. View of Its Institutional Needs.” *Interdisciplinary Science Reviews* 20(2):104-109.

Bagla, P. 1998. “Global Environment Facility - Science Moves up Ladder in Push for Sustainable Growth.” *Science* 280(5362):374-375.

Bernthal, F. 1999. “Science and Foreign Policy.” *Issues in Science and Technology* 16(1):6-7.

Bingaman, J. (Senator). 2001. “Toward a Changing Definition of National Security: Science, Technology, Health, and International Affairs.” A speech at the Secretary of State’s Open Forum, Washington, DC. March 14, 2001.

Bundesministerium for Bildung und Forschung. 2000. “Bundesberict Forschung 2000” (Federal Report on Research, 2000: Research for the Formation of the Future). Bonn, Germany.

Bush, G.W. (President). 2001. Remarks at a meeting March 28 at the White House with 150 high technology executives naming Floyd Kvamme as one of the co-chairmen of the President’s Council of Advisers on Science and Technology (PCAST).

Carnegie Commission on Science, Technology, and Government. 1992a. *Science and Technology in U.S. International Affairs*. New York: Carnegie Corporation.

——— . 1992b. *Partnerships for Global Development: The Clearing Horizon.* New York: Carnegie Corporation.

Commission of the European Communities, Communication(s) from the Commission to the Council, the European Parliament, the Economic and Social Committee and the Committee of the Regions. 2000. *Towards a European research area* (Brussels, 18 January 2000).

——— . 2001. *The International Dimension of the European Research Area* (Brussels, 25 June 2001).

Congressional Research Service. 1998. “International Science and Technology Issues: Summary of a Report to the Committee on Science.” Report 98-353 STM. Washington, DC: Congressional Research Service, the Library of Congress.

Daly, J. 1998. “Strategy Working Paper Science and Technology in the World Bank.” In *Knowledge for Development, World Development Report*. Washington, DC: World Bank.

Fukuyama, F. 1999. “The Great Disruption: Human Nature and the Reconstitution of Social Order.” *The Atlantic Monthly* 283(5):55-80.

Georghiou, L. 2001. “Evolving Frameworks for European Collaboration in Research and Technology.” *Research Policy* 30(6):891-903.

Gerrard, J. 1996. “The Importance of International Cooperation in Science and Technology.” *SRA Journal of the Society of Research Administrators* 28(1-2):29-32.

Glanz, J. 2001. “Trolling for Brains in International Waters.” *The New York Times*, April 1, 2001.

Goldemberg, J. 1998. “What is the Role of Science in Developing Countries?” *Science*, 279(5354):1140-1141.

Guruswamy, L. 1999. “Science and Foreign Policy.” *Issues in Science and Technology* 16(1):7-8.

Hamilton, L. H. 1999. “Science and Foreign Policy.” *Issues in Science and Technology* 16(1):5.

Hecht, A. (Principal Deputy Assistant Administrator, EPA). 1999. Testimony at National Science Board hearing on “The Global Framework and Modes of Interaction in International Science and Engineering” Friday, July 30, 1999.

International Council for Science (ICSU). 2000. *International Council for Science: Year Book 2001.* Paris, France.

Keynan, A. 1999. “Commentary: Cooperation: The International Role of Scientists.” *The Scientist* 13(6):12.

Loy, F.E. 1999. “Science at the State Department.” *Issues in Science and Technology* 15(4).

Marcum, J.A. 2001. “What Directions for Study Abroad? Eliminate the Roadblocks.” *The Chronicle of Higher Education* 47(36), the Chronicle Review.

Maslin, G.. 2001 “Australia Invites Leading Academics to Apply for Generous New Fellowships.” *The Chronicle of Higher Education* 47(34).

Miller, H. I. and Conko, G. 2000. “The Science of Biotechnology Meets the Politics of Global Regulation.” *Issues in Science and Technology* 17(1):47-54.

Moore, J. H. 1999. “Science and Foreign Policy.” *American Scientist* 87(3):194.

National Research Council, Office of International Affairs. 1999. *The Pervasive Role of Science, Technology, and Health in Foreign Policy: Imperatives for the Department of State.* Washington, DC.

National Science Board. 1982. "Statement on Science in the International Setting." NSB 82-313. Arlington, VA: National Science Foundation.

——— . 1984. "Roles and Responsibilities of the National Science Foundation for Aspects of International Cooperation Related to the Health of American Science." NSB 84-132. Arlington, VA: National Science Foundation.

——— . 1986. "Roles of the National Science Foundation with Respect to Science and Engineering in the Non-Industrialized Countries." NSB 86-206. Arlington, VA: National Science Foundation.

——— . 1987. "The Role of the National Science Foundation in Polar Regions." NSB 87-128. Arlington, VA: National Science Foundation.

——— . 1988. "Report of the NSB Committee on Openness of Scientific Communication." NSB 88-215. Arlington, VA: National Science Foundation.

——— . 1989a. "Report of the NSB Committee on Foreign Involvement in U.S. Universities." NSB 89-90. Arlington, VA: National Science Foundation.

——— . 1989b. "Loss of Biological Diversity: A Global Crisis Requiring International Solutions." NSB 89-171. Arlington, VA: National Science Foundation.

——— . 1990. "Science and Technology Integration in Europe and Influences on U.S.-European Cooperation." NSB 90-172. Arlington, VA: National Science Foundation.

——— . 1998. *National Science Board Strategic Plan*. NSB 98-215. Arlington, VA: National Science Foundation. Available at http:///www.nsf.gov/cgi-bin/getpub?nsb98215.

——— . 2000. *Science & Engineering Indicators 2000*. NSB 00-1. Arlington, VA: National Science Foundation. Available at http://www.nsf.gov/sbe/srs/seind00/start.htm.

——— . 2000. "Statement on Open Communication and Access in Science and Engineering adopted at the 35th meeting, May 4, 2000" NSB 00-106. Arlington, VA: National Science Foundation.

——— . 2002. *Science & Engineering Indicators 2002*. NSB 02-1. Arlington, VA: National Science Foundation. Forthcoming at http://www.nsf.gov/sbe/srs/seind02/start.htm.

Nichols, R.W. 1993. "International Affairs: Science and Technology in U.S. International Affairs." In *Science, Technology, and Government for a Changing World*, The Concluding Report of the Carnegie Commission on Science, Technology, and Government. New York: Carnegie Corporation.

—— . 1999. "Science and Foreign Policy." *Issues in Science and Technology* 16(1):5-6.

Nyquist, J.D. and B. J. Woodford. 2000. *Re-envisioning the Ph.D. What Concerns Do We Have?* University of Washington. (Funded through the Pew Charitable Trusts).

Observatoire des Sciences et des Techniques. 2001. "The European Research Area: a New Frontier for Europe?" *La Lettre OST*, Special Issue, No. 22.

Organization for Economic Cooperation and Development (OECD). 1995. "Connections Among Scientists, Agencies, and Governments in Decision Making for Regional and/or Global Megaprojects." Paris: OECD Megascience Forum.

——— .1998. "Workshop on Global-scale Issues: Strengthening the Interaction between Science and Policy-Making." Paris: OECD Megascience Forum.

——— .n.d. "Report of the Sub-Group on Legislative and Administrative Barriers in Megascience Cooperation." Paris: OECD Megascience Forum.

Ratchford, J.T. 1998. "Put Science and Technology Back into Foreign Policy." *Science* 282(5394):1650.

Raymond, S.U., Editor. 1996. *Global Cooperation in Science, Engineering, and Medicine: A Preliminary Assessment of Goals and Systems*. New York: New York Academy of Sciences.

Redfearn, J. 1997. "International Collaboration - ESF Hopes to Be Voice of European Science." *Science* 278(5342):1395.

Schmitt, R.W. 1999. "Science Savvy in Foreign Affairs." *Issues in Science and Technology* 15(4).

Schuh, G. E. 2000. "Competitiveness, Research, and Global Development: How Will the United States Compete?" Topical Lecture presented at the 2000 American Association for Advancement of Science Annual Meetings. Washington, DC.

Teasley, S. and S. Wolinsky. 2001. "Scientific Collaboration at a Distance." *Science* 292(5525):2254-55.

United States Commission on National Security/21st Century. 2001. "Road Map for National Security: Imperative for Change." The Phase III Report of the Commission. Washington, DC.

U.S. Congress, Office of Technology Assessment (U.S. OTA). 1994. "Perspectives on the Role of Science and Technology in Sustainable Development." OTA-ENV-609. Washington, DC: U.S. Government Printing Office.

U.S. Department of Commerce, Technology Administration, Office of Technology Policy. 2000. *International Science and Technology: Policies, Programs and Investments*. Washington, DC.

U.S. House of Representatives, Committee on Science. September 1998. "Unlocking Our Future: Toward a New National Science Policy." Washington, DC: U.S. Government Printing Office.

——— .1998. Hearing Charter, National Science Policy Study: International Science. Washington, DC.

——— .1995. "International Partnerships in Large Science Projects." OTA-BP-ETI-150. Washington, DC: U.S. Government Printing Office.

U.S. Council of Economic Advisers. 2000. *The Annual Report of the Council of Economic Advisers*. Washington, DC: U.S. Government Printing Office.

——— . 2001. *The Annual Report of the Council of Economic Advisers*. Washington, DC: U.S. Government Printing Office.

Wagner, C. 1997. “International Cooperation in Research and Development.” Washington, DC: Rand Critical Technologies Institute.

Wagner, C. and N. Bernstein. 1999. “U.S. Government Funding of Cooperative Research and Development in North America.” Washington, DC: Rand Critical Technologies Institute.

Wagner, C., A. Yezril, and S. Hassel. 2000. “International Cooperation in Research and Development: An Update to an Inventory of U.S. Government Spending.” Washington, DC: Rand Science & Technology Policy Institute.

Wagner, C., I. Brahmakulam, B. Jackson, A. Wong, and T. Yoda. 2001 “Science and Technology Collaboration: Building Capacity in Developing Countries.” A report prepared for the World Bank. Washington, DC: Rand Science & Technology Policy Institute.

Watkins, J. D. 1997. “Science, Technology, and Foreign Policy.” *Science* 277(5330): 1182-1185.

Williams, N. 1997. “International Collaboration - Cold War Thaw Leads to Turmoil in NATO Science.” *Science* 278(5339):795.

World Bank. 2000. World Development Indicators Database 2000. Washington, DC.

World Bank/UNESCO Task Force on Higher Education and Society. 2000. *“Higher Education in Developing Countries: Peril and Promise.”* Washington, DC.

APPENDIX A

CHARGE TO TASK FORCE ON INTERNATIONAL ISSUES IN SCIENCE AND ENGINEERING

NSB-99-32

February 18, 1999

CHARGE
NSB TASK FORCE ON
INTERNATIONAL ISSUES IN SCIENCE AND ENGINEERING

The significance of science and technology in the global context has grown dramatically and both private sector and government cooperation in international science and engineering have assumed a more prominent role. The complex and systemic biological, economic, and ecological problems of the 21st Century will demand more information, more participation by the scientific communities of all nations, and more cooperation between these communities and political decision-makers.

Within its Strategic Plan (NSB-98-215) the National Science Board has identified the global context of science and engineering as a topic of major importance. The Plan expressed the need for a fresh assessment of the roles and needs of science and engineering in the international arena and for a coherent strategy that supports a productive relationship between scientific and foreign policy objectives.

The NSB Task Force on International Issues will undertake two tasks.

1. With respect to science and technology in the international context, the task force will:

- Review the role and contributions of science and engineering research and education in both highly developed and developing countries and examine the Federal institutional framework of policies and agency relations that support fundamental research and education in the international setting;
- Assess the experience of other nations with respect to key issues in science and engineering, research and education; and
- Develop recommendations for enhancing the Federal institutional framework of policies, agency relations, and international cooperation.

2. With respect to the NSF role in international science and engineering research and education, the task force will:

- Review the NSF role in fostering international cooperation in fundamental science and engineering research and education and in their coordination with foreign policy; and
- Develop recommendations for an effective leadership role for NSF in international science and engineering in the 21st century.

In conducting its work, the task force will consult widely with other agencies and organizations and with science and technology officials of other countries.

Eamon M. Kelly
Chairman

Appendix B

Summary of Task Force Hearings

Hearing on the Global Framework and Modes of Interaction in International Science and Engineering

Friday, July 30, 1999
8:00 a.m. – 3:20 p.m.
National Science Foundation, Room 1235, Arlington, Virginia

Hearing on the Global Economy, Human Resources, and International Exchanges

Friday, October 29, 1999
8:30 a.m. – 4:00 p.m.
National Science Foundation, Room 1235, Arlington, Virginia

Hearing on Global Science and Engineering: Foreign Perspectives, Multicultural and International Organizations

Tuesday, November 16, 1999
9:00 a.m. – 5:30 p.m.
National Science Foundation, Room 1235, Arlington, Virginia

AGENDA

THE GLOBAL FRAMEWORK AND MODES OF INTERACTION IN INTERNATIONAL SCIENCE AND ENGINEERING

Friday, July 30, 1999–Room 1235

8:00 a.m.	**Welcome and Introduction,** Diana Natalicio, Chair, NSB Task Force on International Issues in Science and Engineering
8:10 a.m.	**Keynote Speakers: What Are the Challenges and/or Issues?** Rita Colwell, Director, National Science Foundation D. Allan Bromley, Sterling Professor, Yale University
9:00 a.m.	**I. Panel: Role and Responsibilities of the U.S. Department of State** (Stanley Jaskolski, Moderator) John Boright, National Academy of Sciences Rodney Nichols, New York Academy of Sciences J. Thomas Ratchford, George Mason University Mary Beth West, U.S. Department of State Current or recent U.S. Science Counselors: Anthony (Bud) Rock, U.S. Embassy, Paris Paul Maxwell, University of Texas at El Paso Marco DiCapua, Lawrence Livermore National Laboratory John Zimmerman, Science Applications International Corp.
10:30 a.m.	**Open discussion**
10:45	**Break**
11:00 a.m.	**II. Panel: U. S. Government Agencies' Modes of Interaction** (Mary K. Gaillard, Moderator) Delores M. Etter, Deputy Under Secretary of Defense for Science & Technology Sharon Hrynkow, Assistant Director for International Relations, Fogarty International Center, NIH Rolland Schmitten, Deputy Assistant Secretary for International Activities, NOAA Robert S. Price Jr., Acting Deputy Assistant Secretary for Science & Technology Policy & Cooperation, DOE Michael F. O'Brien, Deputy Associate Director, Office of External Relations, NASA Alan Hecht, Principal Deputy Assistant Administrator for International Activities, EPA
12:45 p.m.	**Open Discussion**
1:00 p.m.	**Lunch** (By Invitation) **Luncheon Speaker: "Congressional Perspectives on Global S&E"** Michael Quear, House Committee on Science

2:15 p.m.	**III. Panel: The U.S. Government Policy Formulation Process** (Luis Sequeira, Moderator) Kerri-Ann Jones, former Associate Director, White House Office of Science and Technology Policy Richard Morgenstern, Senior Economic Counselor, U.S. Department of State James Decker, Deputy Director of the Office of Science, U.S. Department of Energy
3:15 p.m.	**Closing Remarks** Diana Natalicio
3:20 p.m.	**End of hearing**

Summary

I. Keynote Addresses: "What Are the Challenges and/or Issues?"

NSF Director ***Colwell*** noted that international activities are one of the highest priorities of NSF. In the United States, collaborations occur much more frequently within national borders than across them. The GEMINI project that involves seven countries was cited as an excellent example of international collaboration. Due to cost and complexity, support of large-scale projects demands international collaboration. Expanding the number of countries contributing to the global scientific enterprise will help us achieve a globally integrated scientific system. But the United States must focus on the evolving role of developing countries to help achieve this goal. It is in the long-term scientific interest of the United States to do so. Colwell posed three questions for the task force to consider: 1) What models might NSF adopt to facilitate the joint funding of international cooperation? 2) How can NSF involve more younger scientists and engineers in international cooperative scientific research and education? and 3) Should the NSF devote resources to establish partnerships with USAID, the World Bank, the Department of State, private foundations, etc. in order to make available scientific expertise?

Bromley asserted that science and technology were lacking in U. S. foreign policy. Consequently, this lack has caused difficulty in the past and will continue to do so in the future. Because the United States does not consider science and technology an integral part of its foreign policy, the Department of State (DOS) does not seek Foreign Service Officers with backgrounds in science to fill its science positions. Bromley recalled that during the Reagan Administration, an Executive Order to fill science posts with scientists was ignored. An idea to use the Foreign Commercial Service (FCS) to gather scientific information and data failed; NSB and NSF should try to revive this idea with DOS. Due to the lack of emphasis and integration of science and technology in foreign policy, the United States has become known as an unreliable partner in some major international projects; the International Space Station is an example of this, with design changes made by the United States without consulting its partners. The United States needs better communication with its partners.

II. Panel: Role and Responsibilities of the U.S. Department of State

Boright stated that the National Academy of Sciences (NAS) report on science at DOS is nearly completed and should be available in September. In his view, "science for policy" and "policy for science" overlap extensively. In the case of the former (science for policy), we must have a system for the global science community to integrate itself. This system, however, cannot be motivated by DOS and U.S. embassies entirely. DOS should be interested in doing "policy for science." DOS can be a player, but scientists will need to do the major work in this regard. Key issue is money. DOS has no money to fund international activities.

Nichols stated that the theme for this panel has been reviewed many times before, but getting changes implemented has and will be difficult. Quality of DOS staff work for international projects should be first-rate and uniform – it currently is not. Foreign Service Officers and Ambassadors do S&T but do not have much time to do it well. Nichols recommended clarifying not only DOS, but also government-wide objectives in S&T, setting priorities, and advocating needed resources. DOS needs more resources and not just in science. In the next century, the roles of various agencies involved in science will change: as the DOS role diminishes, the role of NSF and others will need to expand. OSTP must also increase its role. Currently, S&T in international affairs are not thriving at either NSF or DOS according to Nichols.

Ratchford reviewed previous reports on the subject. Process for integrating policy and science is very weak in the United States. U.S. technical agencies should be tasked to meet science policy needs of DOS. The NSF should play a special role in sending staff to overseas posts for temporary assignments as NSF has the human resources to do this.

West stated that resource constraints are extreme at DOS. Negotiations consume the bulk of staff time and demands are increasing as multilateral environmental issues proliferate. Since its creation in 1973, DOS/OES (Bureau for Oceans and International Environmental and Scientific Affairs) has initiated hundreds of bilateral and multilateral science activities. The role of DOS is to gather and use scientific information; science feeds the policy-making process. Science is one of the major foreign policy goals. Antarctic Treaty is an example of this. There are also science-focused international activities that support foreign policy for science (i.e., the Space Station). There is a clear need to strengthen DOS partnerships with technical agencies.

Rock gave the first presentation providing the perspective of an Embassy Science counselor. The function of Embassy Science Officers defies description as the role and function of a science officer have changed dramatically over the years. Science Officers actually occupy positions with special emphasis on issues with technical consequence; they are not science positions per se. Because S&T has helped transform world economies, Environment, Science, and Technology (EST) offices do S&T as it helps in the development of U.S. foreign policy. Addressing the promise of biotechnology is one example of this; however, the advancement of science is not the mission of a Science Officer. Science literacy is needed in science posts rather than scientists. Foreign Service Officers (FSOs) need to be able to distinguish a technical issue from a policy one. In his current capacity, Rock serves the needs of 23 technical U.S. agencies.

Maxwell saw his role as Science Counselor as that of an advisor, first to the Ambassador and then to main State. He also provided advice to other Federal agencies (i.e., OSTP) and non-government sectors. Maxwell stated that a science background is necessary in order to recognize opportunities. DOS needs to re-establish the Science Deputy Assistant Secretary (DAS) position in OES, perhaps as the Principal DAS. Additionally, DOS needs to recruit FSOs with science credentials. Finally, and most importantly, a clear, strong signal must be sent within and outside of DOS that science is a key component of U.S. foreign policy.

DiCapua described in some detail the work he did for a diverse clientele (i.e., NOAA, DOE, Health and Human Services) while he was Science Counselor in China. All issues that he worked on were rife with technical and foreign policy concerns. He said his biggest challenge was dealing with the political volatility of issues. "One size fits all" philosophy does not work well in embassies; what it takes to be a successful Science Counselor in Beijing is not necessarily the same thing it takes to become a successful Science Counselor in Paris. DiCapua agreed with the idea of having a cadre of temporary duty officers from other agencies for particular embassies.

Due to the great number of visitors he received, ***Zimmerman*** viewed his role as EST Minister Counselor in Moscow as more of a tour guide than a working scientist. In order to meet their specific needs overseas, Zimmerman remarked that the U.S. Department of Agriculture (USDA) established the Foreign Agricultural Service (FAS) and the Department of Commerce (DOC) established the FCS. In essence, they have created their own mini State Departments. Zimmerman suggested that NSF may wish to consider doing something similar.

III. Panel: U. S. Government Agencies' Modes of Interaction

Etter stated that research at the Department of Defense (DOD) is focused on security threats for the 21st century and that DOD international activities involve primarily research on materials, sensors and electronics, and telecommunications. DOD S&T is a partnership with service labs, the Defense Advanced Research Projects Agency (DARPA), universities, and industries. She also described programs with other government agencies (i.e., DOE, NASA) and other nations.

Hrynkow stated that the mission of the NIH is to uncover new knowledge that will lead to better health for all humanity. The Fogarty International Center is devoted entirely to international activities. NIH mechanisms for research support involve competitive grants and contracts, and training (intramural and extramural). At any given moment, there are 2000-3000 foreign scientists on the NIH campus, all of them paid for by NIH at a cost of $100 million per year. Fully half of all postdocs at NIH are from other countries. NIH works all over the world. The AIDS International Training and Research Program is a model for advancing global health agenda. The Biodiversity Program, cosponsored by USAID and NSF, screens tropical flora and fauna for new drugs. The Multilateral Initiative on Malaria involves the European Union (EU), Japan, and Africa. Nearly $70 million is devoted each year to support scientists from the developing world. In development are plans for partnerships in Health and Economics, Bioethics, Genomics, and Clinical Research. NIH also partners with NSF on the Ecology of Infectious Diseases.

Schmitten described how NOAA is collaborative by nature and how NOAA is decentralized with respect to international affairs. NOAA's international mission is environmental assessment and prediction, and environmental stewardship. Budgetary constraints limit NOAA's involvement internationally. NOAA is working with USAID, the U.S. Geological Service (USGS), and NSF on a number of international projects.

Price described how the DOE international mission is woven into all of their activities: national security, energy, and environmental monitoring. International offices are found throughout DOE divisions, however, international activities account for less than 1 percent of the DOE total budget. Work with developing countries was reborn under President Clinton and many new agreements were signed. He indicate that the new Secretary of Energy is interested in involving developing countries especially with regard to implementing the Kyoto Protocol. DOE and other agencies need to rethink strategies on how to better communicate science goals to the public in order to avoid international embarrassments such as the Superconducting Super Collider (SSC). DOE is in favor of sending more technical people to embassies but sometimes DOS balks at accepting them.

O'Brien stated that NASA has 3000 international agreements with more than 100 nations. Benefits to NASA are pooling of financial resources and access to foreign sites. International cooperation does have downsides: increase in management complexity, technical and programmatic risks as well as political risk. Guidelines for international cooperation must be mutually beneficial, partners must be government agencies, and projects must have technical merit. The best current example of international cooperation at NASA is the International Space Station (est. total cost = $50-60 billion) involving 15 nations working through 5 space agencies.

Hecht described the international mission of EPA: 1) protect U.S. citizens along U.S. borders; 2) reduce global threats; (3) reduce cost of environmental protection in the United States; 4) promote U.S. technology and services abroad; and 5) strengthen environmental protection overseas. EPA is very decentralized with multi-office mission responsibilities. EPA utilizes a number of modalities for international cooperation: technical assistance, training and capacity building, industrial ecology related to zero waste, and trade and environment issues, and research, both basic and applied. Hecht then listed a number of examples of international activities at EPA, some of which included developing countries. Typically, U.S. agencies are not fleet-footed enough to take advantage of opportunities, especially with developing countries.

IV. Luncheon Speech: "Congressional Perspectives on Global S&E"

Quear contends that Congressional support for international science cooperation is probably as nebulous and bifurcated as it is within the Administration. Due to the passing of George Brown, he fears that international science cooperation has lost its biggest supporter on Capitol Hill and there is no one poised to fill the void. Part of the problem with international science cooperation in Congress is that the definition of what is international science cooperation varies from person to person and agency to agency. Quear believes that the most successful partnership in science for the United States is with Israel. His opinion in based on the fact that a binational science endowment was bestowed by the U.S. Government back in 1976 and that the interest generated from the endowment supports the science partnership. There is no annual appropriation process and the Israelis feel they are equal partners. There is no similar model for any other country. Congressional funding for international science cooperation is not the problem; Quear has never seen any appropriations bill where the budget request for international activities was ever cut. The problem is getting agencies to set priorities and submit requests for international activities. He noted that Congress rarely receives any budget requests from the agencies specifically for international activities.

V. The U.S. Government Policy Formulation Process

Jones discussed three questions: 1) Is there a dichotomy between science for policy and policy for science? Her short answer was "Yes" and "No". It depends on where you are in a particular process, what issues you're dealing with, the situation, the country – it's highly variable. At the highest level of policy objectives, there is consistency. 2) How does the current science policy process work? Jones described the National Science and Technology Council, its Committee on International Science, Engineering, and Technology, and the role of the Office of Science and Technology Policy (OSTP). OSTP is the lead within the White House for science policy. OSTP is both proactive and reactive. OSTP connections to agencies are as important as OSTP connections to the White House. Congress is a player in the process and is constantly asking questions and providing suggestions. Highly technical issues are oftentimes easier to deal with than political or bureaucratic ones. The process identifies and tries to address long-term issues. The problem is really how to maintain momentum on a longer-term issue when you have so many competing issues. 3) What are the specific needs of the U.S. science and technology community in the international setting? Most importantly, "doors" need to open for scientists; this is what DOS does. Scientists also need resources for international activities. Who pays? What is really needed are more knowledgeable spokespeople for scientists to represent them in the international setting. More communication on the value of S&T is also needed. Industry does not always value international experience.

According to ***Morgenstern***, DOS is not now, never has been, and probably never will be, considered a scientific agency. Five U.S. agencies account for over 50 percent of the S&T budget, and DOS is not among them. He believes there is a continuum of science for policy and policy for science at DOS. Science goals for DOS: ensure that policymakers have ready access to information and analysis, and that this information is incorporated into policies; help to organize large projects; facilitate the S&T-type agreements by engaging in the political and diplomatic connections necessary to make scientific exchanges work; and build institutional connections essential for the long-term strengthening of science at DOS. Near-term objectives: bring in a senior science advisor; develop roundtables with scientists and senior DOS officials (one such roundtable has already been held); and improve science training of DOS officials. Only 5-6 percent of DOS officials have a science degree. However, a critical mass of trained people does not necessarily ensure that good science will follow.

Decker stated that international collaboration is a very integral part of the domestic programs at DOE. However, a separate budget for international activities at DOE would never make it through the budget process. The two largest areas for international collaboration are high-energy physics and fusion research. The most recent large international collaboration is the DOE/NSF partnership in constructing the large hadron collider (LHC). Foreign policy considerations are not usually the driver for science projects, but sometimes they can help initiate them (i.e., Japan, China, and Russia). Curiously, throughout the Cold War, DOE collaboration with Russia on fusion research and high-energy physics continued. At DOE, cooperative activities are identified at the scientific level and then brought to the Office of Science. For example, the DOE/NSF agreement on the LHC was done this way and has worked well. The most difficult part was dealing with Congress. Other countries that have parliamentary systems do not understand why we have such problems. The International Thermonuclear Experimental Reactor (ITER) is an example of a well-conceived, large international project that the United States will no longer be part of due to a changeover in Congress. Foreign support for large projects is essential, but it is very difficult to maintain political support in the United States for long-term projects. It is also difficult to get agencies to come to the table on large projects because they have to have a vested interest. For most fields of science, scientists cannot make significant international cooperation happen by themselves; government involvement is essential.

Agenda
Global Economy, Human Resources, and International Exchanges

Friday, October 29, 1999–Room 1235

8:30 a.m. **Welcome and Introduction**
Diana Natalicio, Chair, NSB Task Force on International Issues in Science and Engineering

8:45 a.m. **Introduction to NSF Overseas Offices**
Pierre Perrolle, Director, Division of International Programs]
NSF Overseas Offices
(Diana Natalicio, Moderator)
David Schindel, Director, NSF Europe Office
Masanobu Miyahara, Scientific Affairs Advisor, NSF Tokyo Regional Office [Interviewed by William Blanpied, Head, NSF Tokyo Regional Office]

9:30 a.m. **Role of Office of General Counsel in NSF's International Activities** Lawrence Rudolph, General Counsel, NSF

9:50 a.m. Break

10:00 a.m **Programs and Projects that Support International Exchanges: Views from the Field**
(Luis Sequeira, Moderator)

1. Ocean Drilling Program (ODP)
Kathryn Moran, Director, Ocean Drilling Program, Joint Oceanographic Institutions
Brian Huber, ODP Foraminifer Paleontologist, Smithsonian Institution

2. International Long-Term Ecological Research (ILTER)
James Gosz, Professor, Biology Department, University of New Mexico, and Chairman of the ILTER Network Committee
Debra Peters, Research Scientist, USDA-ARC, Jornada Experimental Range, and ILTER Researcher

11:15 a.m. **New Partnerships for New Opportunities in a New Era**
(Pamela Ferguson, Moderator)
Thomas Malone, University Distinguished Scholar Emeritus, North Carolina State University

11:45 a.m. **National and International Trends**
Robert Wood, President-elect, Industrial Research Institute

12:15 p.m. **Lunch** – *(Informal buffet lunch provided for invited speakers and NSB* members)

1:00 p.m.	Introduction of Keynote Speaker Diana Natalicio **Keynote Address: The Globalization of International Science & Technology** Roland Schmitt, President Emeritus, Rensselaer Polytechnic Institute
1:45 p.m.	**Industry Perspectives** (Mary K. Gaillard, Moderator) Gordon Brunner, Chief Technology Officer, The Procter & Gamble Company Warren M. Strauss, Director of Global Worldwide Regulatory Organizations, Monsanto Corporation
2:30 p.m.	**Human Resources** (Mary K. Gaillard, Moderator) Richard F. Vaz, Associate Dean, Worcester Polytechnic Institute Natalie A. Mello, Director of Global Operations, Interdisciplinary and Global Studies Division, Worcester Polytechnic Institute Robert Grathwol, Director, Washington Office, Alexander von Humboldt Foundation
3:15 p.m.	**Break**
3:30 p.m.	**State Perspective** (Diana Natalicio, Moderator) Richard Bendis, Kansas Technology Enterprise Corporation
4:00 p.m.	**Closing Remarks and Adjournment** Diana Natalicio

SUMMARY

I. NSF Overseas Offices

NSF Europe Office

Schindel gave examples of his functions in the three basic mission objectives of the Europe Office: representation of NSF to all countries and international organizations in Europe; reporting on S&T developments in Europe and disseminating NSF information; and identifying, promoting, and facilitating opportunities for cooperation in Europe. Representation: Schindel served on the delegation to NATO's Science Committee, was an observer at the recent meeting of the European Science Foundation, and participated in the G-8 Working Group. Reporting: unlike science journalism, his reporting is tailored to NSF needs, and he highlights areas of interest to NSF in "real-time" reports of meetings attended. Facilitation: Schindel was involved in discussions about research training and mobility programs; reform of Italian science and its 300 research institutes; and European Union/U.S. cooperation and interactions in materials research.

NSF Tokyo Office

Perrolle noted that, in addition to generic functions similar to those of the Europe Office, the Tokyo Office serves as liaison on a variety of fellowship and exchange programs and assists NSF-funded researchers in Japan. Perrolle summarized the first 20 years of the Tokyo Office (1960-1980), using slides prepared by ***Miyahara.*** The Tokyo Office started after a binational committee designated NSF as lead U.S. agency for a new program, intended to redress the imbalance in the flow of personnel. Although the ratio for long-term student exchanges has changed little over the past 25 years, exchanges of shorter-term duration have become better balanced. The U.S.-Japan Cooperative Science Program continues today and is the longest running bilateral program of NSF; the majority of activities under the program involve exchanges of a few days (e.g. seminars and workshops) to a few weeks (e.g. collaborative research). Participating scientists totaled more than 25,000 from 1961-1998; about 47 percent were from the United States

In a prerecorded videotape, ***Miyahara*** covered the NSF-Japan relationship since 1980. During the 1980s, frictions due to the increasing trade imbalance between the United States and Japan occasioned a review of the overall U.S.-Japan relationship, including S&T. In 1988, the Japanese Government began several initiatives to improve American access to research facilities and institutes in Japan. NSF is the U.S. agency for recruiting and nominating candidates. The initiatives include a summer institute for graduate students, postdoctoral fellowships, and a special fund for senior-level researchers. More than 1300 Americans have participated in these programs to date. Miyahara then described his vision of the Tokyo Office serving a regional function, promoting S&T collaboration with other economies in Asia that are emerging as S&T powers in the 21st century.

II. Role of Office of General Counsel in NSF's International Activities

The Office of the General Counsel (OGC) is the legal adviser and advocate for the NSF. ***Rudolph*** described OGC's role in the U.S. Antarctic Program to illustrate OGC's wide range of involvement in international issues. In the 1980s, OGC helped lay the groundwork for the exemplary environmental practices that now exist at NSF's research stations in the Antarctic. In the process, OGC has also forged a strong partnership with the State Department on matters affecting the Antarctic Treaty. State relies on NSF/OGC to help frame issues and participate as a lead agency in the interagency Antarctic Policy Working Group. OGC has worked closely with the Office of Polar Programs (OPP) to strengthen our Antarctic Conservation Act enforcement program. OGC and OPP together play a pivotal role in international negotiations involving the Protocol on Environmental Protection to the Antarctic Treaty and the ongoing development of a liability Annex that will define each country's financial exposure to environmental harm or damage that occurs in the Antarctic, even if solely as a result of an accident. The State Department relies on NSF's ability to balance sound environmental stewardship with the conduct of scientific activities in the Antarctic, and OGC will continue to define and assert this balance in Treaty discussions on this liability Annex.

Another key domain for OGC is intellectual property rights, an issue that affects all NSF Directorates and the scientific and engineering communities. OGC participated in developing the U.S. position that successfully questioned the soundness of a proposed international treaty on database protection that could have interfered with the open exchange of scientific data among scientists. Among other issues, OGC identified proposed changes to U.S. immigration laws that would impact the availability of visas for foreign scientists; co-sponsored with the Division of International Programs (INT) a State Department symposium on the legal requirements for international agreements; and assisted INT and the Astronomy Division in several aspects relating to GEMINI (involving the construction and operation of twin 8-meter telescopes in Hawaii and Chile): obtaining export licenses from the Commerce Department, helping negotiate and draft the international agreements, and persuading the U.S. Customs Service to allow duty-free entry of the GEMINI telescope mirror into Hawaii. OGC is fully engaged on the difficult and controversial issue of patenting the human genome. Rudolph foresees the Foundation increasingly partnering with more countries on large-scale scientific projects; the increased complexity of these agreements will require OGC involvement.

III. PROGRAMS AND PROJECTS THAT SUPPORT INTERNATIONAL EXCHANGES: VIEWS FROM THE FIELD

1. OCEAN DRILLING PROGRAM (ODP)

Moran described ODP as a research program that is thoroughly international: in funding, governance, and operations. With support from a wide array of countries, regional consortia, and multinational organizations, ODP studies the earth, specifically tectonics and the environment. An international science group staffs the research ship. Funds are given directly to NSF, which contracts with the Joint Oceanographic Institutions (JOI), a non-profit organization. Its annual operating budget is $45-46 million. JOI subcontracts ship operations to Texas A&M University, and to Columbia University for borehole services. A thousand specialists devote time each year to ODP. JOI has a science advisory group; ODP's advisory structure is composed of several panels, all international, that provide advice on all aspects of the program. The Head of the Science Committee is in Germany. Industry is also involved. ODP is a model for international science management.

Huber described the daily routine of the ODP cruises on which he participated. Collaborative teamwork is essential to achieving cruise objectives. Because ODP draws scientific talent from a large number of countries, it can mobilize much deeper expertise in particular research specialties than would be available from a pool limited to one or only a few countries. The close interaction aboard ship among researchers working in one disciplinary area, as well as the interaction among different laboratories on board the vessel, fosters partnerships and friendships. Huber believes his scientific career has been advanced significantly due to ODP and international collaboration.

2. International Long-Term Ecological Research (ILTER)

Gosz cited a need to create opportunities in terms of science in the terrestrial environment and to integrate efforts better: on an individual basis, across disciplines, and across nations. ILTER is a network of researchers at sites around the world that exchange data that adhere to common standards. Although ILTER is only six years old, many countries around the world have adopted the model and joined the network, because ILTER enables countries to gather information that allows them to better manage their resources. ILTER is a research platform; it is not a monitoring effort. Because data gathered for only 1-2 years can be misleading, the need for long-term ILTER sites is clear. Since different cultures can interpret the same set of data differently, an international effort safeguards against parochialism. Gosz then described the generic process by which a site becomes part of the ILTER network. It requires identification of a candidate site, finding a "champion," governmental endorsement, convening of a workshop with other network members, and formation of a national committee.

Peters described her participation in a U.S.-Hungary project involving comparisons of grasslands. The project goals are to sample vegetation at six research sites in two countries. The project involves scientists from both sides at various stages of their careers and has included an exchange of graduate students and training of undergraduates. NSF/INT funded the initial planning grant and has helped tremendously in facilitating project development. The partners bring complementary strengths. The U.S. strength is experimental manipulations; the Hungarians have a very strong background in analyzing pattern. The project's successes include technology transfer from Hungary to the United States (analytical solutions) and from the United States to Hungary (simulation modeling); education and training of students; and scientific productivity and achievements. A major problem, Peters said, is obtaining funding for principal investigator (PI) salaries and graduate student support; these items are normally not provided in INT grants. Doing research with just INT funding is very difficult to accomplish.

IV. New Partnerships for New Opportunities in a New Era

For ***Malone***, the International Geophysical Year (IGY) in 1956 marks the opening of "a new era in the history of the human race," capitalizing on advances in science and technology. He commended to the task force three lessons from the IGY's success: the effective partnership between the governmental and nongovernmental sectors; NSF's leadership in guiding that partnership and in orchestrating Federal interagency cooperation; and the engagement of nongovernmental leadership that recognized the opportunity for new partnerships.

Malone noted a recent trend toward renewed emphasis on international S&E. In 1994, an NRC paper prepared for the World Bank challenged the world to make knowledge the organizing principle for society. By 1999, the World Bank had published the results of an international conference on Knowledge for Development. It is now maintaining a website (*www.globalknowledge.org*) to nurture a Global Knowledge Partnership. In September 1999, the Kellogg Commission on the Future of State and Land-Grant Universities published a report on *Returning to Our Roots — A Learning Society*. This kind of a society is now considered by educators to be within our grasp. Clearly, new patterns of interdisciplinary collaboration must be created among the physical, biological, health, social and policy sciences, engineering, and the humanities. There is an opportunity for leadership by the NSB in nurturing these partnerships. Malone mentioned a new initiative, a Western Hemisphere Knowledge Partnership 21 (WHKP 21) to address these issues in the Americas during the 21st century.

V. National and International Trends

Wood said that issues affecting the development and commercialization of science and engineering in the United States and around the world are of great concern to the Industrial Research Institute (IRI). IRI's International Committee fosters IRI-like organizations in other countries, organizes international R&D discussion meetings, and develops information about R&D in other countries. Among recent activities, IRI has hosted R&D roundtable discussions focusing on opportunities with the Czech Republic and Hungary. Increasing global competition is a key agenda item for Chief Executive Officers (CEOs) and Chief Technology Officers (CTOs) in major corporations, as noted in two IRI Position Statements that Wood handed out. Wood then cited some key R&D trends, showing an increase in industry investment in R&D; leveling off of U.S. Government funding of industrial research since 1993; tripling of R&D expenditures in the United States by foreign-owned companies since1987; and close to tripling of R&D spending by U.S. companies in other countries during the same period. More than half of these U.S. investments are in just five countries: Germany, the United Kingdom, Canada, France, and Japan. Wood urged the task force to adopt recommendations and policies that encourage strong academic research and educational programs; enable the effective transfer of technology to industry; and foster the ability of industry to develop and commercialize new technology.

VI. Keynote Address: The Globalization of International Science & Technology

Schmitt discussed Thomas Friedman's view that globalization has produced "fast world" and "slow world" countries, making the concept of First, Second, or Third World no longer appropriate. He believes that technology is driving globalization in governments as well as industry. He then discussed the global availability of human resources and the globalization of research, as supported by NSF data on science and engineering trends in: degree production (United States behind Europe but ahead of Asia); graduate enrollments of U.S. citizens (decreasing since 1994); graduate enrollments of foreign citizens in U.S. universities (increasing since 1994); and numbers of foreign-born engineering students enrolled in U.S. universities who choose to return home (significantly increased this decade compared to last). The United States depends significantly on foreign-born scientists and engineers; they comprise 28 percent of the entire S&E labor force in the United States. Regarding research facilities, in the 1980s, foreign firms established labs in the United States and U.S. firms established labs abroad. In the 1990s, all firms go to where they can get the S&T they need; borders and oceans are no longer significant barriers to these activities. Schmitt articulated strategy recommendations for the U.S. Government, for the Department of State, and for the National Science Foundation, to be prepared for the challenges presented by globalization. He believes the United States must support and strengthen the global S&T capacity in nations moving toward democratically based, market-oriented, and merit-driven systems. For the Department of State, existing international S&T organizations (e.g., ICSU, The International Institute for Applied Systems Analysis (IIASA), and NATO Science) need continuing attention, support, and strengthening. For NSB/NSF, the challenge is to craft imaginative programs to respond to globalization, as NSF has done successfully in the past with other challenges, (i.e., Small Business Innovation Research (SBIR), the Experimental Program to Stimulate Competitive Research (EPSCOR), the Engineering Research Centers (ERC)s, etc).

VII. INDUSTRY PERSPECTIVES

Brunner said that the goal of Procter & Gamble (P&G), to be the lead innovator with superior technology-based products, gives it a vital interest in making sure that public policy is supportive of global innovation. P&G has 19 significant laboratories around the world. 40 percent of P&G's R&D personnel are outside of the United States. The collaboration of P&G technologists from around the world provides insights and connections that are clearly superior to what any single region can provide. This collaboration leads to better product designs, earlier market exposure, and, ultimately, faster global product expansion. Global R&D has been a huge asset not only for P&G but also for the United States. Economic benefits to the United States are in jobs (new opportunities), tax revenues (over $1 billion from P&G in 1998), and shareholder value (P&G stock price increase). Overall, the globalization of R&D is good for U.S. companies, the U.S. economy, and, most importantly, benefits every U.S. citizen.

Strauss discussed the current international controversy over issues of food safety and genetically modified organisms. The precautionary principle, as defined by the EU, is an approach to risk management that is applied in circumstances of scientific uncertainty, reflecting the need to take action in the face of a potentially serious risk without awaiting the results of scientific research. The G-8 has charged OECD to look at biotechnology and report back in June 2000 on how the OECD and the G-8 should be studying the issues regarding food safety and related matters. Strauss described the debate within that forum as over whether science should be the fundamental basis or whether the precautionary principle or other factors should be included in the decision. Strauss opined that countries have the right to manage risk however they wish within the framework, but when one totally decouples risk assessment from risk management, one loses much of the knowledge and the scientific underpinning. Strauss then described another forum, the Codex Alimentarius, which is a governmental organization, funded by the Food and Agricultural Organization (FAO) and the World Health Organization (WHO), to develop standards, guidelines, and codes of practice to protect the health of consumers and ensure fair practices in food trade. The General Principles Committee of Codex is currently dealing with the precautionary principle and factors other than science that are relevant in food safety standards. Strauss believes that the primacy of science and what that means to risk assessment and risk management is very important for the United States, as well as for industry in general. Equally important is how scientific research and understanding is interpreted by WHO, FAO, and the World Trade Organization.

VIII. HUMAN RESOURCES

Vaz described the Global Perspective Program at Worcester Polytechnic Institute (WPI) as an innovative, project based, outcome-oriented approach to undergraduate education. Under this program, all WPI students must complete three project degree requirements in order to graduate. One of these, the Interactive Qualifying Project, requires the student to research and report on a problem that examines how science or technology interacts with societal structures and values. An increasing number of WPI students are completing the project requirements abroad. Students and faculty travel together to various WPI Project Centers around the world to work on real-world problems, typically for government agencies, or NGOs and non-profits, and sometimes for corporations. The students receive academic credit. A typical project involves a two-month sojourn in the host country, coinciding with one instructional term. The cost to the student is a negligible amount higher than on-campus. The program has proven to be an effective recruiting tool for potential incoming freshmen. Vaz described in detail one such international project that was based in Thailand. Following Vaz, ***Mello*** described the more traditional type of exchange program that WPI also offers. She also described WPI international initiatives for eliminating cost barriers, re-entry programming, and faculty development.

Grathwol described the Alexander von Humboldt Foundation (AvH) in terms of its guiding principles, its programs, and its particular strategy of follow-up. A guiding principle of AvH is the creation of a life-long partnership and worldwide network; it tries to maintain contact with all former re-search fellows and research awardees. Thus there is a network of more than 20,000 researchers in more than 120 countries. The follow-up program supports a variety of activities, such as subsequent research stays in Germany; fellowships to support German post-docs to collaborate with Humboldt "alumni" at their institutions outside Germany; and colloquia and regional meetings of Humboldtians, held both outside Germany and in Germany. In addition, there are 85 Humboldt clubs and Humboldt associations in 50 countries around the world. The follow up program is the major link between one time sponsorship and a life long relationship. Grathwol expressed interest in exploring possible cooperation between AvH and NSF.

IX. STATE PERSPECTIVE

Bendis recounted the origin and achievements of the Kansas Technology Enterprise Corporation (KTEC). KTEC was a response to a slump in the mid-1980s of the three primary Kansas industries, aviation, agriculture, and petroleum. The ensuing recession prompted a move to diversify and strengthen the economy. KTEC was created as the single entity responsible for all S&T programs in Kansas. It is a holding company that manages a portfolio of programs, investments, subsidiaries and affiliates that operate as for-profit and not-for-profit entities. Although created by the state government, KTEC has the powers and functions of a private corporation, with the ability to own equity and make investments. The KTEC mission is to create, grow, and expand Kansas's enterprises through technological innovation. Bendis views technology as the engine of economic growth, and science as the fuel for technology's engine. Internationally, KTEC has relations with Africa, Asia, Europe, and Latin America. A number of European companies have a presence in Kansas, and Kansas is an exporter to Europe. Bendis mentioned KTEC support for SBIR and noted that KTEC finances both academic and industrial research that leads to new or improved products.

Agenda
Global Science and Engineering: Foreign Perspectives, Multicultural and International Organizations

Tuesday, November 16, 1999—Room 1235

9:00 a.m.	**Welcome and Introduction** Diana Natalicio, Chair, NSB Task Force on International Issues in Science and Engineering
9:10 a.m.	**Third Annual Competitiveness Survey: How the U.S. measures up** (Stanley Jaskolski, Moderator) Charles Evans, Council on Competitiveness
9:30 a.m.	**Panel: U.S. Organizations Involved in International S&E Cooperation** Craig Dorman, Office of Naval Research (teleconference from London) Richard Getzinger, American Association for the Advancement of Science
10:15 a.m.	**Break**
10:30 a.m.	**Panel: Partnership Programs** (Mary K. Gaillard, Moderator) Robert Eisenstein, NSF Mathematics and Physical Sciences Directorate; U.S.-Israel Binational Science Foundation (BSF); OECD Global Science Forum Gerson Sher, Civilian R&D Foundation (for the Independent States of the Former Soviet Union) John Hardie, International Development Research Centre (Canada) Erick Chiang, NSF Office of Polar Programs, U.S. Antarctic Program
12:30 p.m.	**Lunch**
1:00 p.m.	**Panel: Foreign Models and Perspectives of International Science and Engineering Cooperation** (Pamela Ferguson, Moderator) Dominique Martin-Rovet, Attaché for Science and Technology, Embassy of France Takao Kuramochi, Science Counselor, Embassy of Japan Jorge Litvak, International University Exchange, Chile
2:30 p.m.	**Introduction of Keynote Speaker** Diana Natalicio **Keynote Address: Globalization of the Science and Technology Workforce in the United States** Mary Good, Venture Capital Investors, Inc.

3:15 p.m.	**Break**
3:30 p.m.	**Panel: Development Assistance and International Organizations** (Luis Sequeira, Moderator) Ray Kirkland, Agency for International Development Michael Crawford, World Bank Laurence Wolff, Inter-American Development Bank
5:30 p.m.	**Adjourn**

SUMMARY

I. Third Annual Competitiveness Survey

Evans discussed the Changing U.S. Competitiveness Agenda and the role of the Council on Competitiveness, which looks at how the sources of competitive advantage are shifting, international competition is growing, and the leadership role of the United States is changing. The insufficient investment of the United States in the development of the nation's talent pool is resulting in an outlook for U.S. innovation that is not as strong. Evans noted three factors contributing to the creation of competitive advantage – Internet connectivity, innovation clusters, and collaboration to leverage costs, risk, and resources. An initiative to ramp up U.S. productivity and growth has three compelling priorities. These priorities are: shoring up weaknesses preventing the U.S. economy from realizing its innovation potential; building on strengths differentiating the U.S. innovation platform from that of other countries; and expanding global opportunities to capture the benefits of technological leadership.

II. Panel: U.S. Organizations Involved in International S&E Cooperation

Dorman, in a teleconference from London, emphasized the importance of international issues in the coalition operations in which the Department of Defense is involved. One concern discussed was technology movement, particularly the possibility that the United States could end up working against countries with whom it has previously collaborated. The Department of Defense has put forth international cooperation programs related to the development of hardware, software, and operational capability and the development of actual systems and capabilities. The Navy runs basic programs to identify information in which it is interested, including visitor programs to provide interaction at the bench level, conference promotion, and collaborative R&D programs.

Getzinger presented an overview of selected activities of the American Association for the Advancement of Science (AAAS), as well as comments on two components of the charge to the task force, related to the Federal institutional framework for educational research and NSF's leadership role in the 21st century. AAAS activities include publication of the premier Science magazine, a number of programs including science education, science policy, and international programs, and affiliate relationships with worldwide organizations, providing a huge research base. Getzinger expressed the opinion that the task force should closely examine NSF playing a stronger role in institutional relationships dealing with research and education as well as NSF having an expanded role in the human impacts on the global environment.

III. Panel: Partnership Programs

Eisenstein described the establishment and subsequent operation of the U.S./Israel Binational Science Foundation (BSF). The BSF is funded from the interest, currently about $13 million per year, on an endowment jointly established by the United States and Israel. It makes grants primarily in the areas of health and life sciences, physics, chemistry, and mathematics, for binational cooperative projects. Efforts are presently underway to expand the program to include researchers from other parts of the Middle East region. The original endowment for the BSF used Israeli residual foreign aid money and a matching contribution through a State Department appropriation. This endowment frees the BSF from dependence on budgetary allocations from the sponsoring agencies or from the legislatures. The binational Board of Governors of the BSF meets annually to oversee the policy and programs; their oversight helps assure that the BSF criteria of scientific excellence, mutual benefit, and equitable balance are maintained.

Sher discussed the makeup of the Civilian R&D Foundation for the Independent States of the Former Soviet Union (CRDF) and its four basic cooperative programs, all of which require a minimum level of cost sharing. The principal program, the Competitive Grants Program, adapts the NSF system and philosophy of merit review to the making of cooperative research grants. Sher underscored the importance of continued NSF funding for CRDF, to strengthen the regional infrastructure. Achievements of the CRDF include funding human resources infrastructure; developing a model for industrial R&D collaborations; building institutions; and empowering U.S. programs. Sher pointed out that because CRDF is a private organization, it has more flexibility in decision making, responding to opportunities, and program design. He believes that the CRDF model should be replicable as long as there is commitment to the general goals of bridging categories of cooperation and assistance.

Hardie described the creation of the Canadian International Development Research Centre (IDRC) in 1970 to encourage and support research into the problems of developing regions and to assist the regions in building up research capabilities. The IDRC is funded so as to enable a degree of independence from the Canadian political system. Hardie noted that the focus is placed on production and knowledge sharing of all kinds, as well as the application of scientific and technical knowledge to the social and economic advancement of developing regions. The IDRC has emphasized social and technological innovation rather than science and technology, and has shifted toward more partnerships and joint ventures with other donors in order to expand the quality and quantity of resources devoted to mobilizing and enhancing research capability.

Chiang provided a historical background of the U.S. Antarctic Program that traces its origin to collaboration regarding the International Geophysical Year. Chiang described how the Antarctic Treaty provisions establish cooperation amongst nations operating on the continent, resulting in the creation of an environment rich in opportunity for multilateral partnerships. While the State Department represents the United States in policy issues, it does not take an active role in activity coordination amongst the cooperating nations. NSF's stewardship for U.S. interests and environmental protection in the Antarctic has led to the evolution of the NSF Office of Polar Programs. Chiang expressed the opinion that the success of the treaty system with respect to international cooperation is attributed to the scientific objectives, the mutual benefit provided by the collaboration among international organizations, and the direct involvement of program directors and managers enabling the establishment of boundary conditions and the subsequent commission of resources for project implementation.

IV. Panel: Foreign Models and Perspectives of International Science and Engineering Cooperation

Martin-Rovet described the shift of French educational focus from dissemination of the French language/culture to the aim of training scientists and engineers. Because the few students who travel from the United States to France do so to study humanities, not science, and the French students who travel to the United States generally do so to study science, Martin-Rovet emphasized the need to balance the exchange of French and U.S. students, as well as the need to make better mutual use of the capabilities of both countries. Martin-

Rovet discussed the objectives of the Centre National de la Recherche Scientifique (CNRS) in the United States–to represent French science, facilitate contacts between French and American scientists, and provide enhancement and fund cooperation–and the manner in which the CNRS evaluates programs and provides peer review for the political bodies. Efforts are currently underway to integrate academic research with industry, provide education in the handling of technology transfer, and increase visibility of French science. Martin-Rovet discussed the availability of fellowships for U.S. post-doctoral students to travel to France, noting the lack of interest in these fellowships, and discussed negotiated agreements between the CNRS and universities such as the University of Illinois as well as the attempted integration with industry.

Kuramochi described the 1995 enaction, in response to economic difficulties, of the Japanese Science and Technology Law, the Law's purpose in promoting the research development environment and aiming Japan for a leadership position in science and technology, and the resulting development of the five-year Science and Technology Plan, aimed at improving educational opportunities in national labs and universities, improving the environment in R&D sites, and opening labs to the world. As Kuramochi noted, a review of the performance of the five-year plan has shown that it has helped bring science and technology to national policy levels. Special coordination funds have been provided to promote interagency science and technology, recognizing the importance of having joint programs among agencies. Kuramochi described collaborative U.S./Japan agreements, including the Science and Technology Agreement negotiated under President Reagan and Prime Minister Takeshita and the Common Agenda, a cooperative partnership program created in 1993 to tackle global issues bilaterally. As an example of a very specific project, Kuramochi described the International Cooperative Research Project of 1989 which provided five years of international joint research funded in-kind by Japan and its partner, the research to be performed at the best-suited research institutes. Fellowship programs were established in 1988 to correct imbalances in the number of scientists performing research in Japan. Kuramochi discussed the recent kick-off of the Millennium Project targeted toward information, Japanese societal issues, and the environment.

Litvak discussed the comparatively high Chilean investment in science and technology in relation to other Latin American countries, noting the low level of investment in comparison to the United States The Millennium Science Initiative has been negotiated with the World Bank to create high-quality research units and has resulted in a subsequent controversy in a country where research has traditionally been university based. The University of Chile has an initiative aimed at promoting international research collaboration by stimulating international interest in the university's programs and projects and by mobilizing external resources through collaborative activities. The promotion of research alliances has proven the most winning strategy by providing grants for development, awards from foundations and other grantors, and major in-kind collaborators such as Lucent Technologies. Litvak indicated that there is a need for private sector investment in science and technology, noting that increased funding for research by international collaboration provides the best strategy.

V. Keynote Address: Globalization of the Science and Technology Workforce in the United States

Good presented NSF-generated data regarding the drop in U.S. investment in R&D in relation to the Gross Domestic Product (GDP), noting that U.S. institutions lack the understanding of the significance of these changes. There has also been a dramatic shift in funding sources for U.S. research as private sector funding has increased in relation to government funding. Workforce data indicate an increasing percentage of foreign-born doctoral students in science and technology. The dependence on foreign nationals in the U.S. science and technology enterprise has caused issues of concern in terms of unemployment and depressed wages, particularly wages paid to graduate students and university post-doctoral students. Good indicated an uncertainty regarding whether the availability of foreign students discourages U.S. native talent from pursuing scientific careers. Good indicated that while the United States has created revenue by its edge in the sale of intellectual property, the availability of intellectual property around the world will simply make the playing field more even. In R&D expenditures, the United States is neglecting important educational opportunities by not creating new engineers outside of the health sciences. Good expressed the opinion that the United States must refocus its research funding at the Federal level to create the best quality people in the world. The free flow of scientists must be allowed since the majority of science is done outside of the United States, creating the need to know what is happening elsewhere so as to enable global capitalization.

VI. PANEL: DEVELOPMENT ASSISTANCE AND INTERNATIONAL ORGANIZATIONS

Kirkland described the mandates of the U.S. Agency for International Development (USAID) as the promotion of sustainable development and the provision of humanitarian assistance. It has established as its goals broad-based economic growth, building sustainable democracies, human capacity building through education and training, population stabilization/human health protection, environment protection, and humanitarian assistance in crises and transitions. USAID established a policy in 1997 laying out the standards and criteria for determining research priorities. Among the areas which USAID has identified as not fitting its criteria is research for training scientific or technical personnel. Due to economic considerations and the incidences of students failing to return to their home countries, USAID has shifted its capacity building endeavors from bringing overseas students to the United States for training to providing in-country and on-the-job training in conjunction with applied research activities. Kirkland discussed the channeling of the budget to the areas of population, health, nutrition, and agriculture, indicating that much of the research is programmatically oriented.

Crawford discussed the evolution of the World Bank's science and technology funding, noting the Bank's attempts to increase the size of grants to top people and the remaining problems resulting from researchers working in isolation. A new approach has been adopted by the Bank which is discussed in the Knowledge for Development Report, the Bank's flagship statement on development. One conclusion made in the report is that for advanced countries, knowledge may be the most important factor in determining the standard of living. The Bank has made a large commitment to support science and technology and is working on the development of a science and technology strategy covering all sectors and raising the profile of support for science and technology. The Bank will attempt to cooperate with partners in international, national, and nongovernmental organizations and will seek to use its convening power and resources to invigorate science in the developing world.

Wolff addressed the current science and technology situation in the region, critical regional needs, the Inter-American Development Bank's (IDB) previous role, the IDB's new strategy, and the IDB's instruments for supporting science and technology. The critical needs in the region are to incorporate new technologies into processes through better international cooperation as well as a need to increase the amounts and effectiveness of science and technology investment and investment in primary through higher education. In its previous role, the IDB focused on institutional strengthening of science research and funding institutions but those reviews concluded that the payoffs were inadequate with respect to changes in the productive sector and utilization by industry of new technologies. The new strategy focuses on ensuring that technological development can take place by encouraging innovation, supporting technology development rather than simply supporting research, being more selective in supporting science research and training while encouraging links with the productive sector, increasing the overall investment in education and training, and increasing support for developing countries.

Appendix C

List of Contributors to the Report

The task force held hearings and consultations with experts and stakeholders representing a wide range of perspectives; convened an international symposium on models for S&T budget coordination and priority setting, cosponsored with the NSB Committee on Strategic Science & Engineering Policy Issues; received briefings from key representatives of a number of Federal agencies; and received comments on a draft of the final report from many of these participants. The name and affiliation of those who participated in this process are listed below.

Name	Organizational Affiliation at Time of Initial Participation
Experts and Panelists	
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Getzinger, Richard	American Association for the Advancement of Science
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Kuramochi, Takao	Embassy of Japan
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Appendix D

Acronyms and Abbreviations

AAAS	American Association for the Advancement of Science
AIDS	Acquired Immune Deficiency Syndrome
AvH	Alexander von Humboldt Foundation
BSF	U.S.-Israel Binational Science Foundation
CISET	Committee on International Science, Engineering, and Technology
CNRS	Centre National de la Recherche Scientifique
CRDF	Civilian R&D Foundation for the Independent States of the Former Soviet Union
DARPA	Defense Advanced Research Projects Agency
DAS	Deputy Assistant Secretary
DOC	Department of Commerce
DOD	Department of Defense
DOE	Department of Energy
DOS	Department of State
EPA	Environmental Protection Agency
EPSCOR	Experimental Program to Stimulate Competitive Research
ERC	Engineering Research Center
EST	Environment, Science, and Technology
EU	European Union
FAO	Food and Agricultural Organization
FAS	Foreign Agricultural Service
FCS	Foreign Commercial Service
FSO	Foreign Service Officer
GAO	General Accounting Office
GDP	gross domestic product
GNP	gross national product
HHS	Department of Health and Human Services
ICSU	International Council for Science
IIASA	International Institute for Applied Systems Analysis
IDB	Inter-American Development Bank
IDRC	International Development Research Centre
IGY	International Geophysical Year
ILTER	International Long-Term Ecological Research
INT	Division of International Programs
IRI	Industrial Research Institute
ITER	International Thermonuclear Experimental Reactor
JOI	Joint Oceanographic Institutions
KTEC	Kansas Technology Enterprise Corporation
LHC	large hadron collider
MNC	multinational company
NAS	National Academy of Sciences
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NGO	non governmental organization

NIH	National Institutes of Health
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
NSB	National Science Board
NSF	National Science Foundation
NSTC	National Science and Technology Council
ODP	Ocean Drilling Program
OECD	Organization for Economic Cooperation and Development
OES	Bureau of Oceans and International Environmental and Scientific Affairs
OGC	Office of the General Counsel
ONR	Office of Naval Research
OSTP	Office of Science and Technology Policy
P&G	Procter & Gamble
PI	principal investigator
R&D	research and development
S&EI	*Science & Engineering Indicators*
S&E	science and engineering
S&T	science and technology
SBIR	Small Business Innovation Research
SSC	Superconducting Super Collider
STH	science, technology, and health
U.K.	United Kingdom
UNESCO	United Nations Education, Scientific, and Cultural Organization
U.S.	United States
USAID	United States Agency for International Development
USDA	U.S. Department of Agriculture
WHO	World Health Organization
WPI	Worcester Polytechnic Institute