

APPROVED MINUTES¹
OPEN SESSION
357th MEETING
NATIONAL SCIENCE BOARD

The National Science Foundation
Arlington, Virginia
March 16, 2000

Members Present:

Eamon M. Kelly, Chairman

John A. Armstrong
Mary K. Gaillard
Sanford D. Greenberg
Anita K. Jones
George M. Langford
Jane Lubchenco
Joseph A. Miller, Jr.
Eve L. Menger
Claudia I. Mitchell-Kernan
Robert C. Richardson
Vera S. Rubin
Maxine Savitz
Luis Sequeira
Richard Tapia
Chang-Lin Tien
Warren M. Washington
John A. White, Jr.

Rita R. Colwell, NSF Director

Members Absent:

Diana S. Natalicio, Vice Chair
Pamela A. Ferguson
M.R.C. Greenwood
Stanley V. Jaskolski
Robert M. Solow
Bob H. Suzuki

¹ The minutes of the March 16 meeting were approved by the Board at their 358th meeting, May 4, 2000.

The National Science Board (NSB) convened in Open Session at 1:06 p.m. on Thursday, March 16, 2000, with Dr. Eamon M. Kelly, Chairman of the NSB, presiding (Agenda NSB-00-55). In accordance with the Government in the Sunshine Act, this portion of the meeting was open to the public.

Dr. Kelly began the meeting by congratulating the most recent nominees to the NSB. The President announced his intention to nominate Dr. Nina V. Federoff (The Pennsylvania State University), and to renominate Dr. Diana Natalicio. In addition, the Senate Health, Education, Labor, and Pensions Committee has approved the nominations of Dr. Michael G. Rossmann (Purdue University) and Dr. Daniel Simberloff (University of Tennessee-Knoxville). The latter two nominations await consideration by the full Senate next week.

Dr. Kelly reported on the presentation to the Board the previous evening by Dr. Ernest Moniz, Deputy Secretary of Energy, on the openness of scientific communication.

AGENDA ITEM 6: Minutes, February 2000 Meeting

The Board APPROVED the Open Session minutes of the February 2000 meeting (NSB 00-39, Board Book Tab D).

AGENDA ITEM 7: Closed Session Items for May 2000

The Board APPROVED the Closed Session items for the May 2000 Board Meeting (NSB 00-10, Board Book Tab E).

AGENDA ITEM 8: Chairman's Report

a. Task Force on Polar Issues

Dr. Kelly announced that at the May meeting of the Board the Task Force on Polar Issues, chaired by Dr. Warren Washington, will be established as a standing subcommittee of the Committee on Programs and Plans, recognizing the important and consistent role the task force plays in this area.

b. Awards

The Chairman reported that recipients have been chosen for the Year 2000 Alan T. Waterman Award, the Public Service Award, and the Vannevar Bush Award. The awards will be announced publicly, once the awardees have been notified, and presented at the Board's May dinner.

c. The May Meeting

Dr. Kelly alerted Board members to some annual business that will be completed at the May meeting: elections for Chair, Vice Chair, and two vacancies on the Executive Committee; and consideration of a 2001 meeting calendar. Before the May meeting, Dr. Marta Cehelsky, NSB Executive Officer, will send Board members background materials and instructions on the nomination and election process.

AGENDA ITEM 9: Director's Report

a. Staff Introductions

Dr. Rita Colwell, NSF Director, introduced several recently appointed NSF staff members: Dr. Norman Bradburn, Assistant Director for the Directorate for Social, Behavioral and Economic Sciences; Dr. Lynda Carlson, Director of the Division of Science Resource Studies; Dr. Richards Adrian, Director of the Division of Experimental and Integrative Activities; Dr. Jarvis Moyers, Director of the Division of Atmospheric Sciences; Dr. Herbert Zimmerman, Director of the Division of Earth Sciences; Mr. Michael Sieverts, Acting Director of the Office of Legislative and Public Affairs; Mr. Thomas Cooley, Acting Chief Financial Officer and Acting Director of the Office of Budget, Finance, and Award Management; and Dr. Margaret Cavanaugh, Staff Associate for the Environment in the Office of the Director.

b. Congressional Update

The Director reported on several hearings before the House Science Committee's Basic Research Subcommittee. Dr. Colwell and Dr. Kelly testified on February 16, focusing on the research and related activities and major research equipment portions of NSF's proposed budget for FY 2001. Dr. Judith Sunley, Interim Assistant Director for the Directorate for Education and Human Resources, testified for NSF at a second hearing on February 29 devoted to the education and human resources portion of that budget. Another hearing, presided over by Congressman Nick Smith, took place in Lansing, Michigan, on February 28. Mr. Paul Herer, Staff Associate in the Office of Integrative Activities, testified on behalf of NSF at the field briefing on NSF's FY 2001 budget and the pending reauthorization legislation. Other witnesses at that briefing included officials from the University of Michigan, Michigan State University, and Western Michigan University. Congressman Nick Smith presided. On March 15, the House Science Committee held a third hearing on NSF's FY 2001 budget. All hearings were very positive for NSF.

On March 1, Dr. Colwell testified before the Senate Commerce, Science, and Transportation Committee at a hearing on the status of the Next Generation Internet and Senate Bill 2046, to expand high-bandwidth Internet connections. The hearing, which also included testimony by the President's Science Advisor, Neal Lane, and other Administration officials, was very productive.

Dr. Colwell, Dr. Lane and Dr. Kelly will testify at an initial hearing on April 4 on NSF's FY 2001 budget request before the House Subcommittee on VA/HUD and Independent Agencies. The committee is considering May 3 as a possible date for the full budget hearing. Dr. Colwell noted that Members and their constituents appear to recognize that the Nation's current economic expansion is directly related to science and technology. Prominent members of the business community have been helpful in communicating to Congress the importance of federally funded university research to the economy, not only in new discoveries but also in the education of young scientists, engineers, and other participants in the workforce.

c. President's National Medal of Science and National Medal of Technology

Dr. Colwell, Dr. Kelly, and NSF Deputy Director Joseph Bordogna attended White House ceremonies on March 14 for the 1999 National Medal of Science and National Medal of Technology awards. Among the 12 recipients of the science medal was Board member Robert Solow, recognized for his analysis of the effects on economic growth of investment and technological progress. The other science awardees were David Baltimore (California Institute of Technology); Jared Diamond (UCLA School of Medicine); Lynn Margulis (University of Massachusetts); Stuart Rice (University of Chicago); John Ross (Stanford University); Susan Solomon (NOAA); Kenneth Stevens (MIT); Ronald Coifman (Yale University); James Kronin (University of Chicago); and Leo Kadanoff (University of Chicago). The technology awardees were Glen Culler (Santa Barbara, California); Raymond Kurtzweil (Kurtzweil Technologies, Inc.); Robert Taylor (Woodside, California); Symbol Technologies (New York); and a posthumous award to Robert Swanson (K&E Management).

AGENDA ITEM 10: Survey of Doctoral Programs in the Sciences

The Director introduced Dr. Geoffrey Davis, a researcher with Microsoft Corporation and a former member of the Mathematics Department at Dartmouth College. Dr. Davis presented the results of an informal online survey he and Dr. Peter Fiske of Lawrence Livermore National Laboratory conducted on graduate science students' experience with their doctoral programs. The survey ran online for 10 weeks in 1999 and allowed doctoral students to respond to questions about such things as mentoring, career guidance, and overall satisfaction.

Dr. Davis noted recent reports critical of doctoral education in science and engineering, most notably the 1995 report from the National Academy of Science's Committee on Science, Engineering, and Public Policy (COSEPUP), that stimulated the survey. The survey sought to determine the extent to which the "best practices" recommended in these reports were being implemented nationwide and to achieve three goals: 1) to stimulate a discussion on graduate education; 2) to prompt institutions to make sure their own practices were strong; and 3) to catalyze implementation of best practices in departments that have not yet implemented them. The Sloan Foundation will fund a second year of the survey, which the researchers hope to make annual. The 2000 survey

will include not just the sciences and engineering, but also the humanities, social sciences, and Canadian universities. Davis said that as the survey matures, it will help prospective students make more informed enrollment choices; help departments, funding agencies, and policymakers better understand the current state of science and engineering education; and increase transparency in the overall graduate education process.

There were about 6500 responses from a broad section of the student population in 264 institutions. Results suggest that, while generally happy with their advisors and education, students thought they needed better pre-enrollment information; better training as teaching assistants; better preparation for employment outside of academia; and a better environment for women and minority students. These and other study results, said Dr. Davis, show that improvements must be made to student decision-making throughout the process of education. This will require that better information be made available to students in the form of: 1) standards for best practices in graduate education; 2) funding to departments for gathering or acquiring outcome data via expanded versions of the Survey of Earned Doctorates and the Survey of Doctorate Recipients; and fund the creation of better information and career choices online. Dr. Davis noted that the survey results will be made public, and that future surveys would include social sciences.

AGENDA ITEM 11: Committee Reports

a. Audit and Oversight Committee (A&O)

Dr. Eve Menger reported for the Committee in the absence of the Chairman, Dr. Stanley Jaskolski. The members were introduced to the new Inspector General, Dr. Christine Boesz, and heard a report from Dr. Lorretta Hopkins, Staff Associate in the Office of Integrative Activities, on the Government Performance and Results Act (GPRA). The committee also received a status report on the FY 1999 financial statement and audit, and the Information Systems Controls audit from Mr. Don McCrory, Acting Chief Financial Officer, Ms. Debbie Cureton, Assistant Inspector General for Audits, and Mr. Fred Wendling, Director of the Division of Information Services. OMB found no material weakness in the FY 1999 NSF audit. Planning for the 2000 audit is underway. The committee held some preliminary discussion of its revised charter; fuller discussion will take place by email with a final recommendation coming to the Board by the May meeting.

In the supervisory session, Ms. Cureton discussed the results of an external quality review of the Office of the Inspector General (OIG) audit organization. The review concluded that NSF conducts its audits in compliance with the Government Audit Standards. Dr. Peggy Fisher, Acting Deputy Inspector General, reported on the OIG's outreach efforts, which was favorably received by the committee. Finally, Dr. Boesz discussed her development of a strategic plan for her office.

b. Committee on Programs and Plans (CCP)

Dr. John Armstrong, Chairman, reviewed three actions recommended to the Board for approval. The committee then considered the best way to follow up on the Board's report on the environment (NSB 00-22). The committee has asked NSF senior management, in particular Dr. Leinen, to report once a year to the full Board on progress made toward the implementation of the report's recommendations, with an update every second meeting of the committee. Dr. Leinen will make the first report to the full Board at the May meeting.

Most of the session was devoted to an ongoing conversation with the senior management on NSF's facilities, infrastructure, and major research equipment in relation to the Foundation's new strategic plan. This discussion will be continued at the Board's May meeting. Finally, with one revision reflecting concern over issues of interest to more than one standing committee, the CPP committee expressed approval of the revised charge.

Task Force on Polar Issues

Dr. Warren Washington reported that the task force heard an overview of the Office of Polar Programs' budget and was briefed on various logistics and science support plans affecting programs in the Arctic and Antarctic. The committee was also updated on a number of science projects underway at the Poles, including the development of a new workshop to improve weather forecasting and operations in the Antarctic region. Finally, the task force briefly discussed the Arctic Climate Impact Assessment activities.

c. Committee on Education and Human Resources (EHR)

Dr. Robert Richardson reported for the committee in the absence of Chairman, Dr. Bob Suzuki and Acting Chairman, Dr. Richard Tapia. The committee reviewed some of the informal education activities of EHR, including museum exhibitions and mass media projects, and suggested that NSF draw more attention to the supplementary grants that principal investigators can get to communicate their research results to the public. The committee also heard from a representative of the Smithsonian Institution, which is an important partner with NSF in many exhibitions, and who noted the need to reach out to the Asian and Pacific Island populations

The committee heard a report on the framework for the EHR Directorate's decision making from Dr. Sunley. Committee members were impressed by how much is expected in this area from NSF on a small budget. Finally, the committee decided to focus most of its attention in the coming year on K-12 education activities. In discussion of the revised charge, members felt strongly that it should be possible for members to serve concurrently on two of the three standing committees, and suggested consideration of greater reliance by task forces and subcommittees on teleconferencing. Dr. Richardson reported that Dr. Lynda Carlson, the new Director of the Division of Science Resources Studies, met the subcommittee.

Responding to the Committee's suggestion on expanding participation in standing committees to more members, Dr. Kelly noted that as a way to enable members to attend more than one committee meeting the timing of the various committee meetings had been restructured to the extent possible within the current Board meeting structure. Other options will be considered in the future.

Subcommittee on Science and Engineering Indicators (S&EI)

Dr. Mitchell-Kernan reported that the subcommittee was introduced to Dr. Norman Bradburn, the new Assistant Director for Social and Behavioral Sciences, and Dr. Lynda Carlson. Dr. Carlson reported that the Board should receive the two-volume *Science and Engineering Indicators* report (and an accompanying CD) at the May meeting.

Dr. Carlson requested that the subcommittee consider having a substantive discussion at the May meeting on putting the *S&EI* back on its January completion and release schedule. She also presented samples of "data cards" that could serve as models for highlighting specific *S&EI* data, and asked the subcommittee for suggestions on topics that should be included on the cards. Dr. Carlson agreed to provide samples to the subcommittee at the May meeting.

Dr. Daryl Chubin, Senior Policy Officer of the NSB, led a discussion on the draft companion piece for *S&EI 2000*. The subcommittee recommended and approved a resolution calling for the Board to accept the companion piece, with final editorial changes to be made by Dr. Mitchell-Kernan in response to comments from the Board.

Dr. Gaillard noted that the companion piece included a section on "Glimpsing 21st Century S&T." The section discusses biotechnology, information technology, and nanotechnology —NSF initiatives that depend on scientific discoveries made in the more distant past. Dr. Gaillard urged that more mention be made of the fact that some of them grew unexpectedly out of research directed toward something very different. Dr. Mitchell-Kernan agreed this was important. Dr. Kelly encouraged Board members to provide Dr. Mitchell-Kernan with their comments by email. Board members were given until the following week to forward their suggestions, comments, and corrections. The Board then unanimously approved the recommendation of the subcommittee to accept the companion piece to *S&E Indicators 2000*, and authorized Dr. Mitchell-Kernan to make any final editorial changes.

Dr. Mitchell-Kernan reported that Dr. David Stonner, head of Congressional Affairs for NSF's Office of Legislative and Public Affairs, provided the subcommittee with an update on the status of the *S&EI* report. Consistent with the NSB recommendation in November, a discussion was held with the House Science Committee staff on drafting legislation to reinstitute the statutory requirement for S&EI. Dr. Stonner noted the legislation would most likely be attached to some relevant House bill. The Senate could pass the legislation but probably not soon, given its low priority. The subcommittee

expressed its disappointment and urged OLP staff to continue pursuing reinstatement of this mandate. Dr. Colwell assured Dr. Mitchell-Kernan that staff would continue pressing the issue.

Dr. Mitchell-Kernan noted that the *S&EI* has been getting longer over the years, and that there is a need to reassess what should be included on a biennial basis. Dr. Anita Jones suggested that the S&EI subcommittee consider research on transforming *S&EI* into a hyperlinked structure rather than a sequential document.

Dr. Mitchell-Kernan expressed gratitude to everyone involved in the *S&EI* report, especially Ms. Jennifer Bond of the SRS staff, who directed the project.

d. Task Force on the NSB's 50th Anniversary

Dr. Rubin reported that the task force considered the following items. First was a report from Ms. Susan Chase-Mason on the Jumpstart 2000 competition, an elementary/middle school/ senior high science competition in collaboration with *Parade* magazine and REACT. The winners will be announced soon. Ms. Chase-Mason also described activities associated with the NSF 50th celebration, including a document on historical accomplishments this spring, a bimonthly 2-page spread beginning in June in *Discover Magazine* discussing S&E topics, and a Saturday morning 90-second children's program, "Find Out Why" on the Disney Channel beginning in September. Dr. Rubin noted that Dow Chemical Science Service, Dartmouth, will release a White Paper on the future of science and technology to be the subject of a roundtable discussion with the media and Congress. There will be a birthday party at NSF on May 10 and in June a picnic for current and former NSF employees.

The task force discussed the external review process for the National Science Board's 50th anniversary commemorative brochure and heard an update on the December 2000 celebratory event. The committee discussed a variety of options, including special awards to individuals long associated with NSF. Board members will be contacted in the next week and asked for recommendations of persons qualified to receive such an award.

e. Task Force on International Issues in Science and Engineering

Reporting for Dr. Natalicio, Dr. Gaillard said that the task force met Dr. Alan Rapoport, the new Executive Secretary, and thanked the previous Executive Secretary, Ms. Francis Li, for her outstanding work. Two guests made presentations: Former White House Science Adviser Dr. Jack Gibbons, now a Special Adviser to the State Department (DOS), discussed steps that it was taking to reverse a decline in science and technical expertise in the department over the last decade. Dr. Gibbons discussed the DOS response to recommendations in a recently issued report from the National Research Council, prepared at the request of Secretary of State Madeleine Albright. Dr. Gibbons expressed optimism about Department changes while conceding that changes were likely to occur slowly. Dr. Gibbons said that scientists and engineers should find ways to spend time at the State Department and help identify scientific and technological developments

of potential importance to foreign policy. Task force members also discussed how NSF might help DOS modernize its information technology systems and how it could interact with other organizations, such as the Agency for International Development, in order to encourage greater science expertise.

The second guest speaker was Dr. Colwell, who discussed how NSF is increasing its global activities across all directorates and often acting as the lead agency in international scientific endeavors. Next, Dr. Cehelsky presented a brief review of the task force's activities to date. Finally, the task force discussed next steps, including identification of key issues, themes, and recommendations both from the literature and from hearings, and preparation of a report. A revised version of the report will be distributed to the task force and discussed in an upcoming conference call.

Dr. Kelly encouraged the task force to aim for a Board-approved draft for distribution at the December meeting.

f. Committee on Communication and Outreach (C&O)

Dr. George Langford reported in the absence of committee chair M.R.C. Greenwood. He stated that the committee was on schedule to deliver a final report to the Board in May on effective strategies to raise public awareness of the importance of science and engineering, especially among policymakers. Toward that end, the committee discussed the NSB Symposium on Communicating Science and Technology in the Public Interest, held in February. The Committee was pleased with the symposium and plans to incorporate into its final report the recommendations that were made by speakers. Also reflected in the final report will be the strong consensus on key issues that came to light in response to the survey Dr. Greenwood distributed to Board members after the symposium.

The committee meeting focused on three broad recommendations: 1) to encourage the creation of a broad-based advocacy group in collaboration with Research!America, run by Dr. Mary Woolley. Dr. Langford said that Dr. Mary Good, Managing Partner, Venture Capitol Investments, Incorporated, of Little Rock, Arkansas, is already active in putting together such a group, which the American Chemical Society has agreed to host; 2) to expand existing NSF programs that focus on communication research and information dissemination. A staff member from the Division of Social, Behavioral, and Economic Sciences briefed the committee on the kinds of research currently supported in this field. Since a fair amount is already underway, the committee feels that NSF's role should be to leverage its investment by boosting support of successful projects. In addition, there should be more research on best practices in the communication of science and engineering. A matrix should be developed for assessing the effectiveness of communications activities; and 3) to work closely with the Office of Legislative and Public Affairs to develop background materials, such as briefing materials and talking points on key issues, to be used for discussions between Board members and Congressional members and staff.

Dr. Langford expressed the committee's appreciation for the input received from the NSF staff. Finally, the committee urged the Board to think of ways to encourage greater public participation in the future, including the earlier release of a draft agenda. Dr. Langford promised to try to formulate suggestions on what to do about participation.

In response to questions from members, Dr. Langford explained that the advocacy would be NSF related only insofar as encouraging its creation; the formation of the group would be independent of NSF and would encompass the physical sciences, mathematics, and engineering. He agreed that there is a parallel need for greater attention to the non-medical life sciences and the social sciences. He noted the suggestion that the Committee report be posted on the Webpage for comment.

g. Ad Hoc Committee for NSB Nominations for the class of 2008

Dr. Jones announced that the committee will begin meeting in May and she encouraged Board members to start thinking about nominees.

h. Committee on Strategic Science and Engineering Policy Issues (SPI)

Dr. Kelly reported that the committee heard presentations from two speakers. The first was Dr. Chuck Larson, president of the Industrial Research Institute. Dr. Larson discussed priority setting in industry and the roles of industry and the Federal government in U.S. research and development. The second speaker, Dr. Jim Duderstadt of the Committee on Science and Engineering and Public Policy of the National Research Council (COSEPUP) discussed his committee's work on the Federal budget and on bench-marking for fields of research. He urged the Board to undertake a leadership role in this regard.

AGENDA ITEM 12: Interim Report, Committee on Strategic S&E Policy Issues

The SPI committee discussed its draft interim report to the Board. The committee will deliver a first draft to the Board in May, after which the report will be revised for consideration by the Board at the August meeting. This schedule allows for workshops and other related meetings in the fall prior to a final report in December and for the completion of the report prior to the installation of the new Administration in January of 2001. Committee members agreed with Dr. Duderstadt's call for the Board to lead on this issue, and also discussed participation of appropriate stakeholders in discussions of the findings and recommendations of the report. The committee asked NSF staff to prepare a timeline, budget, and list of resources required to support its activities through December, and a chart of focus areas and possible organizations and individuals to participate in stakeholder discussions.

AGENDA ITEM 13: Program Approvals, Education & Human Resources

Dr. Richardson asked the Board to approve three new programs in the Directorate for Education and Human Resources. Upon this recommendation the Board voted as follows

NSF Graduate Teaching Fellows Program (NSB-00-61):

The National Science Board APPROVED the movement of the NSF Graduate Teaching Fellows in K-12 education (GK - 12) program to the status of a continuing program; and, subject to the availability of funds, authorized the Director to take final action on grants, contracts, and other arrangements except when such actions require Board approval under existing policy guidelines.

Interagency Education Research Initiative (NSB-00-62):

The National Science Board APPROVED the movement of the Inter-agency Education Research Initiative (IERI) to the status of a continuing program; and, subject to the availability of funds, authorized the Director to take final action on grants, contracts, and other arrangements except when such actions require Board approval under existing policy guidelines.

National Science, Mathematics, and Technology Education Digital Library (NSB-00-63):

The National Science Board APPROVED the National Science, Mathematics, Engineering and Technology Education Digital Library (NSDL) as a continuing program of the NSF Directorate for Education and Human Resources; and, subject to the availability of funds, authorized the Director to take final action on grants, contracts, and other arrangements except when such actions require Board approval under existing policy guidelines.

The meeting was recessed briefly until 3 p.m.

AGENDA ITEM 14: Budget and Long-Range Planning

a. Introduction

The Chairman called on the NSF Director to lead the discussion on the NSF Budget and Long-Range Planning. Dr. Colwell explained that the session would first address current thinking and plans, so as to encourage the Board's comments early in the process. Other presentations would look to the future. Dr. Colwell reminded the Board of the timeline

for the FY 2002 planning cycle. At the current session, the Board hears about issues under consideration and offers its guidance in establishing priorities. That leads to a set of issues to be developed for full consideration by the Board at the May meeting. Finally, in June the Executive Committee focuses on the FY 2002 budget that goes to the Office of Management and Budget (OMB). NSF will incorporate discussions from the May and June meetings into the budget and ask for detailed information from the program offices. At the August meeting, the Board will discuss budget development and key directions, which will be incorporated in the final round of budget calls to NSF staff. NSF usually submits the budget request to OMB in September, but OMB is considering asking that 2002 budget submissions be postponed until after the new Administration is in place.

Dr. Colwell said that senior managers are very pleased with the 2001 budget, which provides for a historic \$675 million increase. While this is an important and very welcome development, Dr. Colwell said that the long-term erosion of the Nation's basic research investment will probably take several more years to fix. Momentum is important, she said; it is critical that all elements of the education and research community come out strongly in support of the NSF budget.

Dr. Colwell noted that total national R&D funding—about \$250 billion—has never been higher. However, the Federal share is down to only 27 percent of all R&D funds in 1999, the lowest level since NSF began collecting data. Ten years ago, the Federal share was 46 percent; thirty years ago, it was 60 percent. The mix of sciences receiving Federal support is also changing. In 1970, the life sciences accounted for 29 percent of the Federal spending; by 1997, they had reached 43 percent, significantly outpacing spending in the physical sciences and engineering. While Federal R&D spending share has waned, industry has become increasingly dependent on academic research and other publicly supported frontier research. There is a strong and growing linkage between U.S. patents and peer-reviewed research published in journals, as noted in the Board's recent report, *Industry Trends and Research Support: Links to Public Research*.

Dr. Colwell called attention to NSF's growing leadership role in research and education. NSF has been designated the interagency leader of important initiatives concerning information technology and nanotechnology. Also, excluding biomedical research, NSF's role in supporting basic research at academic institutions has jumped from 43 percent in 1990 to 53 percent in 1999. This means that NSF is becoming the government's main investor for non-medical basic research.

Dr. Colwell suggested that, to fulfill its role as the government's investor for non-medical research, NSF's budget should be in the range of \$12 to \$14 billion. She argued that NSF will need an increase of \$5.1 billion merely to bring the average size and duration of NSF grants up to the National Institutes of Health (NIH) standard. And that doesn't include funds to grow the number of grants under current or new programs.

Dr. Colwell outlined four investment strategies to be discussed in more detail by staff: 1) support for competitive investigator-initiated research along the frontiers of science and engineering, 2) identify and support unmet opportunities that strengthen and cross-

fertilize the S&E disciplines and that promise significant payoffs for the Nation, for example mathematics and the social, behavioral and economic sciences, 3) emphasize areas of emerging opportunities that enable research in education across science and engineering and 4) broaden participation and enhance diversity throughout the research portfolio. She emphasized that these four investment strategies are not separate but rather co-equal, interwoven strategies that support each other in important ways.

b. Non-Initiative Research

Dr. Mary Clutter, Assistant Director, Biological Sciences, led the discussion of NSF's first investment strategy, support for competitive investigator-initiated research along the frontiers of science and engineering. She noted that NSF has long supported the core disciplines. She offered some examples of unexpected payoffs, including the soon-to-be completed first genetic map of a plant (*Arabidopsis*). Turning to the FY 2001 budget request of \$4.57 billion, Dr. Clutter pointed out that most of it will go toward support of the core disciplines. Of this "non-initiative" research funding, \$1.44 billion is available for completely new activities. In addition to the increase in funding, NSF would like to increase the awards' size (similar to NIH's standard grant of \$283,000) and duration (from three to five years), as well as the funding success rate. Currently only about a quarter of all proposed projects are funded, although program officers estimate that at least half are worthy. NSF's goal is to increase the success rate to 35 percent.

To achieve these goals across all the disciplines, however, would require a budget at least twice that of FY 2001. At current funding levels, increasing the size of the median award of \$78,000 a year by 10 percent to \$86,000 would mean that NSF would have to make 800 fewer grants, reducing the success rate. Four years after increasing the duration of the average grant by one year (from three to four years), NSF would need a budget increase of more than 30 percent. Finally, increasing the success rate would necessitate decreasing the median award size. All of that, said Dr. Clutter, would be spreading the new money too thin and would fail to reach the desired results. She explained that with the increased budget, program officers would be asked to enhance investments selectively in areas of opportunity.

c. Unmet Opportunities

Dr. Karl Erb, Director, Office of Polar Programs (OPP) noted that unmet opportunities are those for which the ideas, people, and infrastructure are essentially already in place which require funding to make the extra push toward results. Dr. Robert Eisenstein, Assistant Director, Mathematical and Physical Sciences, discussed one of the areas of unmet needs, mathematics, which plays an important role in three NSF initiatives: information technology, biocomplexity and the environment, and the 21st century workforce. Dr. Eisenstein concluded his remarks by noting that mathematics has long been underfunded in the U.S., especially compared to the emphasis given to mathematics in other countries. Increasing the funding for mathematical sciences is the first priority of the Division of Mathematical Sciences (DMS), which is slated for a 22.5 percent increase in FY 2001, with the longer-term goal of doubling the DMS budget over five years.

Additional funding would be allocated to increase grant sizes, grant duration, student support, and mathematics related to other disciplines. Achieving this goal will require an extensively coordinated effort across NSF, which is already underway. In response to a question Dr. Eisenstein reported that the mathematics budget is \$105 million, the smallest in MPS. The mathematics budget will grow by \$24 million to about \$130 million, a rise of 22 percent while the average increase in MPS as a whole is 16.3 percent. Dr. Eisenstein agreed that this is a relatively modest emphasis on mathematics compared to the total MPS portfolio.

Dr. Bradburn, Assistant Director for the Social, Behavioral and Economic Sciences (SBE), began his discussion of unmet opportunities by describing his vision for the directorate. He noted that the social and behavioral sciences are severely underfunded. Progress in the social and behavioral sciences draws heavily on mathematics, and Bradburn therefore supports the mathematics thrust in the FY 2001 budget.

Referring to the social, behavioral, and economic sciences as the human sciences, Dr. Bradburn noted a number of areas with enormous implications for the Nation. For example, research on the rules of language and speech have applications in computerized speech recognition. A major initiative supporting work in the human sciences will repay the investment many times over. He will aim to double the SBE budget in three years starting with the development of a strategic plan over the next few months with the assistance of a planning team of senior social scientists and others from the academic, government, and private sectors.

d. Current Initiatives

Information Technology Research: Dr. Ruzena Bajcsy, AD, Computer and Information Science and Engineering, described some of the most exciting areas of information technology research (ITR) and reported that NSF's recently launched Information Technology Initiative received a tremendous number of excellent first-round pre-proposals. Only 10 to 12 percent of these may be funded. In an effort to extend resources, NSF is working with other agencies such as NIH to share funding of certain proposals. Many requests come in for funding in support of infrastructure needs. Dr. Bajcsy asked for the Board's help in thinking about what "infrastructure" should mean in the context of distributed systems. For example, NSF has supported network infrastructure; should the agency also support the development of large-scale data repositories?

The FY 2001 budget provides a \$225 million increase for ITR, \$100 million of which is for basic IT research, \$80 million for IT applications, and \$45 million for a second terascale computing system. In conclusion, Dr. Bajcsy said that she and others at NSF are working hard to coordinate cross-directorate management of ITR projects.

Responding to questions from Dr. Armstrong on the difficulty of finding enough qualified reviewers with no conflicts of interest to review the large number of proposals and proposal success rate, Dr. Bajcsy explained that the number of potential proposal

writers was constrained by limiting the number of times a person could be listed as a principal investigator to three and by permitting only research faculty to apply. Staff then compiled a database of potential reviewers who did not submit proposals, including computer and computational scientists from industry, laboratories, and research institutions, and from outside the U.S. Mr. Lawrence Rudolph, NSF General Counsel, explained that proposals could be separated by size and reviewers who had submitted small proposals could review the large proposals, and vice versa, without being in conflict. With regard to the success rate for proposals, Dr. Bajcsy estimated that for the large proposals, the success rate would be around three percent of the 950 initial submissions. Awards are targeted for mid September.

Dr. Jones noted the need to position NSF as the leader in ITR and asked whether there was a guideline that makes it clear to applicants that progress will be made not just in new applications but in the way information technology is employed. Dr. Bajcsy and Dr. Colwell assured Dr. Jones that this was the case.

Nanotechnology: Dr. Eugene Wong, Assistant Director for Engineering, reported on the status of the nanotechnology initiative, which is the culmination of a four-year effort among six Federal agencies, including NSF, the Department of Defense, the Department of Energy, National Aeronautics and Space Administration (NASA), National Institutes of Health, and National Institute for Standards and Technology (NIST). While NSF's mission is one of fundamental research, Dr. Wong called attention to how quickly fundamental investigations are already leading to important commercial applications. The budget for this initiative in FY 2001 is a total of \$495 million among the six agencies, an amount he described as fairly modest. For NSF, the budget is \$217 million, of which about \$120 million represents an increase from FY 2000. Dr. Wong emphasized that only about \$70 million of that increase is new money. The rest is spread among existing programs across many NSF directorates. He noted that EHR and SBE will have roles in specific programs within the initiative.

Dr. Wong cited the initiative's principal areas of research, primarily biotechnology but also nanostructure by design, devices, nanoscale processes, modeling and simulation, and education and the social impact of nanotechnology. In conclusion, Dr. Wong noted that for the first year of the initiative there will be a single announcement encompassing several different modes of funding support. A large part will be for individuals and small groups, but proposals will also be encouraged in response to "grand challenges" or preset goals achievable by concerted action.

Biocomplexity and the Environment: Dr. Leinen, Assistant Director for Geosciences (GEO), discussed the initiative for biocomplexity and the environment. She placed her status report in the context of NSF's entire environmental portfolio and GEO's initial response to the NSB environment report (NSB 00-22). That report focused on three areas relevant to the biocomplexity initiative: NSF's organization and management of this very broad, cross-disciplinary, cross-directorate activity; the resources that would be necessary; and the setting of priorities. One step taken so far has been the establishment of a high-visibility, NSF-wide organizational focus. This was accomplished with two

new appointments: Dr. Leinen herself who was charged with responsibility for managing the entire cross-NSF environmental portfolio, and Dr. Margaret Cavanaugh as special staff associate for the environment in the NSF Office of the Director. A second step has been to work with the NSF Working Group on Biocomplexity and the Environment. Initially tasked with guidance on the biocomplexity initiative, the group now has added responsibility for advice on the entire environmental portfolio. Dr. Leinen reported also that steps had been taken to establish a formal Federal Advisory Committee for Environmental Research.

Resources have improved as well, said Dr. Leinen. In FY 1999, \$12 million was spent on a Biocomplexity in the Environment competition. In FY 2000, that competition is funded at \$50 million and next year a multicomponent \$136 million competition is being proposed. On the core disciplines side, FY 1999 saw \$600 million spent on programs across NSF that are inherently environmental in nature. In FY 2000, there was a modest increase to \$609 million. But proposed for FY 2001 is \$800 million, a 30 percent increase. Some of the themes emphasized by program officers and directorates for core support include genomics; ocean observatories; bio/geo/chemical cycles; knowledge management (data and information management), and environmental education.

Dr. Leinen reported that the biocomplexity in the environment initiative includes three thematic areas: microscale systems, including genomics, molecular level studies, and geo/microbiology; ecosystems, including interactions among human, biological, geological, and physical systems; and finally, planetary systems such as the water and carbon cycles. The latter also includes new initiatives in the deep biosphere and in bio/geo/chemical dynamics.

Dr. Leinen said her staff is in the process of defining priorities for the biocomplexity initiative and for the environmental portfolio. Doing so has raised important issues, such as how to review responsibly complicated, multidisciplinary proposals. To address that challenge, Dr. Leinen's staff is reviewing best practices within NSF as well as at sister agencies with large, multidisciplinary programs. Another step toward setting priorities will be to take a multi-year perspective on activities and to identify opportunities in broad, interdisciplinary areas outside of the biocomplexity initiative itself. Dr. Leinen concluded by noting collaborations underway with Federal partners, such as developing quantitative mathematical models of cell function in conjunction with the Department of Energy.

21st Century Workforce: Dr. Judith Sunley, Interim Assistant Director, EHR, discussed the 21st century workforce initiative. The initiative's areas of emphasis include idea-oriented activities, such as research into the science of learning. People-oriented activities are aimed at particular issues, such as enhancing science, math, engineering, and technology education performance and getting a broader base of participation in the science and engineering workforce. Finally, there are tools activities, such as the National Science, Mathematics, Engineering, and Technology Education Digital Library project.

Some strategic issues include the need to develop a critical mass of research in the science of learning; to enhance the connections between K-12 education and higher education; to improve teaching at all levels, consistent with the Department of Education's Glenn Commission on Math and Science Teaching for the 21st Century; to address certain key immediate workforce needs, such as the lack of a sufficiently skilled technical workforce in the U.S.; to work in concert with the other three initiatives described today; and to broaden the participation of underrepresented groups in science and engineering.

Concerning the latter, Dr. Sunley noted three key ideas brought forth in NSF's Strategic Plan: embed diversity in all activities; develop targeted programs as needed; and continue to identify barriers to participation as well as possible solutions. NSF's approach to diversity changes depending on the population addressed, from K-12 through postdoctoral.

Broadening Participation: Dr. Nathaniel Pitts, Director, Office of Integrative Activities (OIA), addressed broadening institutional participation in NSF programs. He urged NSF to focus on three issues: how Congress and NSF have been interacting recently on this question; NSF's rich history on the topic; and Innovation Partnerships: a vision.

Dr. Pitts discussed NSF's response to a 1999 Congressional request to study and report on mechanisms that would increase funding for Doctoral I and Doctoral II institutions, using the Carnegie Classification system, which number about 111. NSF has committed to four mechanisms: 1) expanding NSF's existing knowledge and programs; 2) undertaking an extensive and aggressive outreach effort; 3) developing an organizational framework for Innovation Partnerships; and 4) establishing an office, including EPSCoR (the Experimental Program to Stimulate Competitive Research), that would answer directly to the Director. In its 2000 report, Congress provided NSF with \$10 million (later reduced to \$8.5 million) to establish an Office of Innovation Partnerships within EHR. The current budget submission for FY 2001 includes a placeholder, but no money, for this activity.

In working toward a vision for the Innovation Partnerships project, critical issues include strengthening the capabilities and competitiveness of institutions, groups, and regions; enabling the movement of knowledge and people in the private sector; and boosting regional capacity in education, technology, and local economic development. Underlying the vision are two basic tenets: 1) innovation occurs on a local basis, strengthened by the connectivity of the Internet, requiring partnerships with state and local government, a variety of schools and industrial partners; and 2) innovation depends on new knowledge and therefore on institutions that educate the knowledge workforce.

Administration and Management

Dr. Colwell noted that the proposed 2001 budget is nearly 14 percent higher than it was for FY 2000. To support the efforts described today it is essential that NSF as a whole function smoothly in the years to come. One of the improvements underway is a team of

staff members dedicated to making sure that FastLane works well; another task will be to make sure that computer networking throughout NSF is optimum.

Board Discussion

Dr. Jones suggested that NSF would increase its chance of increasing grant size and duration among mathematicians by identifying at a relatively young age those with the most promise of making significant contributions, given that most mathematics accomplishments in the U.S. can be traced to a few stellar individuals. Dr. Menger agreed with the comment by Dr. Jones and suggested that it could be a very powerful argument for Congress. It might be beneficial, for example, if such stellar researchers could spend less time preparing proposals. She further requested more data on the effects of inflation on NSF grants that might be used to support an argument for increasing grant size on the basis of sustaining the buying power of grants, rather than reaching the size of NIH grants. Dr. Richardson agreed that efficiency was an issue when 1,000 researchers, many of them highly qualified, apply for grants that only two percent receive.

Dr. Rubin observed that NSF's diversity programs do not seem to be having the desired impact and wondered whether there wasn't something more NSF should be doing. She argued that graduate students were continuing to be discouraged by faculty from pursuing science or engineering paths. Faculty are responsible for creating an unwelcoming environment for a diverse student body and until programs take that into account, the problem will persist. NSF should use its leverage as a major supporter of science faculty to make a change.

Dr. Colwell responded that the budget for the Integrative Graduate Education and Research Training Program (IGERT) had been increased from \$34 million to about \$54 million, that more programs were being introduced that enable researchers to pull undergraduate students onto their research grants, and that NSF is insisting that centers have a connection with minority students. She further pointed to programs that place graduate science students in K-12 classrooms, efforts at better enforcement of merit review criterion 2, and the establishment of centers for teaching and learning. These centers will bring together representatives from industry, academia, and the community with the same commitment that exists in the Engineering Research Centers. Improving diversity in science and engineering will also be a focus of an upcoming retreat of senior staff. The goal is to make this the responsibility not just of EHR, but of the entire agency.

Dr. Langford noted that the number of women and minorities majoring in science at the undergraduate level is going up, even while the number at the graduate level is dropping, and it is at the graduate level that NSF has the most leverage. Dr. Langford complimented Dr. Sunley on EHR's research into the barriers that confront women, minorities, and persons with disabilities, and also suggested that it would help to increase the number of diverse students on training grants. Dr. Sunley agreed that NSF has not taken a strategic enough approach to graduate education with regard to diversity. However, she pointed to the IGERT program as a model for how to embed diversity in

every NSF activity. Science and Technology Centers or in the Engineering Research Centers are another area where this issue can be addressed.

Dr. Menger recommended that in addition to research on barriers, NSF should support research on successful minorities and women in science and engineering to see what made them successful. Dr. Kelly wondered whether there is a mechanism for getting a more systematic and quantified picture of what the Foundation was doing to increase diversity in programs across the agency. Dr. Colwell said that some data exist but that no external review has been conducted. Dr. Gaillard said that her impression is that over the last 30 years, departmental support for diversity has improved; that while attitudes have improved, the pool of potential hires has not increased enough. Dr. Lubchenco added that studies have shown that the dual-career issue is another problem for women.

Dr. Kelly raised the question of what issues should be discussed at the May Board meeting. He especially encouraged ideas for long-range planning. In response, Dr. Richardson, noting that not much had been said about tools, said he was interested in learning more about the long-range planning concerning equipment and infrastructure. Dr. Savitz asked whether, given that six different federal agencies are involved in the new initiatives, there was a lead agency to ensure that efforts would not be duplicated. Dr. Colwell noted that NSF had been designated the lead agency in both the IT and nanotechnology initiatives and Dr. Wong briefly described the coordination effort for the nanotechnology program.

Dr. Lubchenco commented on the need to look ahead to the FY 2002 budget to begin formulating the plans for the Biocomplexity and the Environment Initiative. She asked why SBE was not mentioned in connection with any of the four areas highlighted for the initiative in 2001. Dr. Leinen responded that the May meeting would provide more thinking with regard to the environmental portfolio. Dr. Colwell added that NSF's incubation grants will get small groups of people together to address this issue so that all of the movement would not be top-down. Dr. Leinen noted that while currently the initiative's funding is in the biosciences budget, the nature of the proposals are very interdisciplinary and included many SBE researchers.

Dr. Kelly said that the May meeting should address the issue of how priorities are determined and tradeoffs in the allocation of resources are made between and within directorates. Dr. Langford reiterated his point that grant size had to be increased; small grants are not only inefficient but they actually hamper research by not allowing the formation of the expert teams needed in the modern laboratory. Dr. Sequeira asked for an evaluation of the use of pre-proposals with respect to such question as: Do they provide enough information for reliable reviews? And: Do they leave room for investigator initiative?

Dr. Cehelsky drew the Board members' attention to two National Academy of Sciences reports that had been distributed to them relating to topics to be considered in the future.

Dr. Kelly thanked everyone who worked to prepare for the Board meeting and adjourned the Open Session at 6:00 p.m.

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