The 1990s

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GAINING STRENGTH, SPEAKING OUT

With the collapse of the Soviet Union, the United States suddenly found itself the world's sole superpower. Yet the Nation's economy remained riddled with problems, including a huge federal deficit, an underskilled workforce, and poor K-12 education. William J. Clinton won election as President in 1992 in part because he called for government to address these issues more actively. Support for research at U.S. universities grew with the decade. Americans saw a dramatic payoff from university research after NSF opened the Internet to public and commercial use in 1991. More than in the 1980s, states helped their local institutions to compete for NSF awards. By FY2000 the Foundation's budget had topped $4 billion.

The Board offered advice within a context that was increasingly global in scope. Issues such as species loss, global climate change, and the Internet's power to distribute information highlighted the international nature of science. The Board tackled national policy issues, such as research priority-setting, now that decisions were no longer to be made under the exigencies of the Cold War. With a report that made the case for environmental research and education as a national and NSF priority, and in other statements on national policy, the Board began finally to fulfill the vision that Vannevar Bush had originally spelled out in Science—The Endless Frontier.

Systemic Change

One of Erich Bloch's last initiatives as director was also among his boldest. In 1990, following his departure, the Board approved the Foundation's program for Statewide Systemic Initiatives (SSI) in Science, Mathematics, and Engineering Education. The era of "systemic reform" began in 1991 as SSI agreements were made with selected states to bring different parts of their education apparatus into alignment with reform. A second version known as Urban Systemic Initiatives funded agreements with large-city school districts that proposed to use Foundation turnkey funds to deliver better teaching to these mostly minority student populations. Rural Systemic Initiatives, which crossed state and school district boundaries, came later.

Bloch's successor, physicist Walter E. Massey, long-time director of Argonne National Laboratory, credits the Board's Education and Human Resources Committee for close work with NSF staff on defining the new initiatives' goals. Board involvement assured that these were cooperative agreements, not grants, with ongoing obligations as well as continuing technical advice.

Though NSF's funding for these and other ambitious K-12 programs remained tiny compared to the Department of Education's portfolio, "the Board was supportive because these could be so important to the country," says James J. Duderstadt, a nuclear engineer and president of the University of Michigan who was Board Chair from 1991 to 1994. Educators widely applauded NSF for "sticking its neck out," in the words of one SSI participant. Nobody, they said, had asked them to "think systemically" before.

1991 First new planets discovered outside Earth's solar system

1992 Presidents Bush and Yeltsin declare end to Cold War

1991 1992

NSB Chair Duderstadt

NSF Acting Director Bernthal | NSF Director Massey

Meanwhile, the Foundation underwent a systemic change of its own when a new Directorate for Social, Behavioral and Economic Sciences was created in 1991. The social sciences were coming into their own, and had bearing on vital national issues. Massey recalls that the Board neither opposed nor championed a separate directorate, though some Board members did warn that social sciences on their own might be more vulnerable to political attack, as they had been in the past.

Beleaguered Industry

The end of the Cold War prompted the question of what priorities should guide U.S. industry in its multibillion-dollar expenditure on R&D. Former NSB Chair Roland Schmitt and TRW, Inc., Vice President Arden Bement, an industrialist on the Board, issued a 1992 report citing "significant gaps in U.S. industrial R&D strength" due to lagging investment and poor distribution of effort. The report said companies were spending too much on defense R&D at the expense of innovation that could invigorate the civilian sector. These ideas foreshadowed the Clinton Administration's 1993 manifesto, *Technology for America's Growth*.

At the same time, the Board was engaged in a more ambitious effort to define how NSF-funded research could better help industry and the Nation. Senator Barbara Mikulski (D-MD), who oversaw NSF's appropriations, had declared that seventy percent of Foundation funds should be allocated for "strategic" research, which alarmed those at the Foundation who took "strategic" to mean "applied." Just as worrisome to some on the Board was that organizing NSF according to strategic directions risked creating institutional rigidities incompatible with the evolutionary, fluid nature of discovery—what is an appropriate strategic goal today might not be tomorrow.

The Board appointed an outside commission co-chaired by Robert Galvin, chairman of Motorola, and William Danforth of Washington University. Duderstadt says the commission was "to interact with the broader scientific community to get a better sense of what the Foundation should be." The Danforth-Galvin report in 1993 argued that NSF-funded basic research could play a larger role in the Nation if it had clearer links to industry and other national needs.

Through a committee chaired by Cornell University president Frank Rhodes, the Board offered assistance to John S. Gibbons, President Clinton's Science Advisor, "in developing a process for scientific priority-setting," Duderstadt says. While this particular effort didn't bear fruit, it provided a foundation for later policy recommendations on the part of the Board that would be more successful.

1992 Clinton elected President

1992 World Wide Web is released (invented at CERN 1988)

1992 Congress cancels Superconducting Supercollider

NSB Chair Duderstadt
NSF Director Massey

How to Measure Performance

Neal Lane, a computational physicist who had been provost of Rice University, succeeded Acting Director Frederick Bernthal in 1993. Popular and effective, he would remain until moving to the White House in 1998 as President Clinton's Science Advisor. While NSF management was in sure hands, the Board had plenty of oversight challenges. The Government Performance and Results Act (GPRA) of 1993 requires federal agencies to account for program results through a system of performance measurements. Progress is noted by OMB and Congress at budget time. But the open-ended nature of discovery-driven research is notoriously resistant to short-term assessment. What's more, grantmakers pressured for close accountability can become too cautious, neglecting emerging fields or risky investigations for those already likely to bear fruit.

The Foundation won approval to use more qualitative measures of performance. Its first GPRA plan was issued in 1995. A report, *NSF in a Changing World*, summarized the NSF strategic plan in which the Board was to watch closely whether Foundation awards and actions matched the new GPRA outcomes. Such outcomes included making "connections between discoveries and their use in service to society," and whether, for example, the Foundation's $700 million education programs were producing a "diverse, globally oriented science and engineering workforce."

The Frontier of Information Technology

By the late 1980's NSF assumed a strong role in computer and information science and engineering, including networking and high performance computing. One initial use of the NSFNet in the late 1980s was to link supercomputer centers, which enable ever-more refined models of galaxies, weather, proteins, and other complex phenomena. These five-year supercomputing center awards were recompeted in 1989 and 1990, sparking lively Board debate. Some members argued that individual grants would advance the field sufficiently, but the case for concentrating funds at centers won out when four of the five centers were renewed. In 1993, when the Clinton Administration made advanced computing a national priority, the NSF supercomputing centers were showcased as the Nation's best civilian facilities.

NSF decommissioned the NSFNet in April 1995 and universities began receiving Internet service from commercial providers. At the same time, NSF with MCI implemented vBNS, a new, high-capacity network for scientific computing. Meanwhile, the five-year awards for the supercomputing centers were coming to an end. In 1995, a Foundation task force cochaired by chemist Edward F. Hayes of Ohio State University,

1992 Proof put forward of 1670 theorem of Pierre de Fermat

1992 Graduate Student Marc Andreesen works on NCSA Mosaic, which will allow point and click web browsing without typing

1992 Very Long Baseline Array, world's largest astronomical instrument, begins operation

recommended that, instead of four or five centers, partnerships among a wide range of institutions having a single super-advanced machine at their apex would best take advantage of recent massive leaps in computing capabilities.

The Board liked the idea and in 1997 approved the Foundation's proposed competition for the new Partners for Advanced Computational Infrastructure (PACI) program. Today, there are two national partnerships: the National Computational Science Alliance, led by the University of Illinois at Urbana-Champaign, and the National Partnership for Advance Computational Infrastructure at University of California, San Diego. When PACI was announced, Board Vice Chair Diana Natalicio said it will push "technological advances that will fuel future economic growth." Students and scientists "at all levels will enjoy a vast resource for education and training."

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A Vision for a National Role

Often in the past, the Board focused more on its NSF oversight responsibilities than on its national policy mandate. But in the 1990s, as the Board passed a mature forty years of age, ecologist and former Board member Shirley S. Malcom of the American Association for the Advancement of Science (AAAS), says the Board became more of a "*National* Science Board."

Stanford University chemist Richard N. Zare, who joined the Board in 1992 and became its chair in 1996, championed a strong vision for how the Board could exercise its legal mandate to "advise the President and Congress, whether on their request or on its own initiative" regarding policy matters related to science and engineering, and on education in these fields.

The group is "a sounding board," he says, "a forum to bring together visions for the future from different federal agencies and stakeholders." The Board should not set a particular President's science policy or respond to near-term exigencies; these duties belong to the President's Science Advisor and to the President's Committee of Advisors on Science and Technology (PCAST). But the National Science Board is uniquely positioned to "engage in long-term planning" of scientific needs and strategies. He notes that members' terms are six years, whereas the President who appoints them serves four. What's more, the Board Chair is elected by the members, not chosen by the President. "This makes [the Board] as nonpolitical a policy group as it can be," while still carrying the authority of a federal body—the only governmental body with a legal mandate to advise the President and Congress on the health of science, engineering, and related education across all fields.

1993 Carolyn and Gene Shoemaker and David Levy discover the comet subsequently observed crashing into Jupiter

1993 1994

NSB Chair Duderstadt | NSB Chair Rhodes

NSF Acting Director Bernthal | NSF Director Lane

"Vannevar Bush's vision was that the Board would do it all," Zare notes. "But there was not a big National Institutes of Health in 1945; there was no White House Science Advisor. I'm not trying to roll back time. I'm pointing out there's a need to do something now, in addition to what the White House does."

As Chair, Zare waded into the key national science policy question of the day: how the government should set federal research priorities in light of inevitable limits on spending and the growing expense and scale of basic research. Former Board members and chairmen James Duderstadt and Frank Rhodes had initiated the Board's consideration of the issue in the early 1990s. Now Zare and other Board members went a step further and met with past presidential Science Advisors and research directors from other federal agencies to discuss their basic research programs and needs, and how the Board could be useful to them. In 1997, the Board issued its report. *Government Funding of Scientific Research* argued that given the wholly new, global context for research, and the dramatic breakthroughs in so many fields at once, "one must also ask what is the appropriate scale of the investment to meet the needs of the greatest economic power in the world."

Strategic Directions for Education, Scientific Freedom, and the Environment

Having offered to work with other agencies and stakeholders while overseeing the Foundation (which was growing in accord with its 1995 NSF strategic plan), the Board spelled out its own priorities and work plan. The *National Science Board Strategic Plan* was produced in 1998 during the chairmanship of economist Eamon M. Kelly, president emeritus of Tulane University.

Eventually, the NSB plan and earlier NSF plans would serve as the basis of a new NSF strategic plan in 2000. The new NSF strategic plan was intended to guide the Foundation in meeting its goals of upholding U.S. "world leadership in all aspects of science and engineering," in "promoting discovery, integration, dissemination and employment of new knowledge in service to society," and in achieving "excellence in U.S. scientific, mathematics, engineering and technical education."

Kelly, the first social scientist to be elected as NSB chair, shared Zare's vision of an active national policy board and drew up an ambitious set of objectives. Beyond oversight for the Foundation, the Board's own strategic plan called for the Board to "provide advice to the President and Congress on major issues" (especially in federal research priorities, education, and public understanding and enrichment). The Board will also take into account the globalization of scientific issues. At the heart of the plan was the idea that the Board could best influence national policy by fostering "cooperation with other stakeholders," including other federal agencies, universities, industries, and public groups.

1995 NSFNet decommissioned; Internet fully public and growing rapidly; by 1996 it will have 12.8 million hosts

1995 Genes that switch on flowering in plants found, using *Arabidopsis* data; some 600 mutant genes of *Arabidopsis* have been discovered and mapped

1995

NSB Chair Rhodes

NSF Director Lane

"If in the twentieth century, science and technology moved to the center of the stage, in the twenty-first century they will command it. Quality of life will depend in large measure on the generation of new wealth, on safeguarding the health of our planet, and on opportunities for enlightenment and individual development. The contributions of research [will] make possible advances in all these areas."

1998 NSB Strategic Plan

After the strategic plan was released, the Board became more active in policy matters. In 1998 the Board responded to TIMSS, the Third International Math and Science Study, which showed U.S. fourth-grade students near the top internationally but middle and high-school students faring progressively worse: U.S. twelfth-graders ranked nineteenth of twenty-one industrial nations. In a statement, "Failing Our Children," the Board declared its "special responsibility to enlist the science and engineering community as a precious resource" to support and improve "local programs."

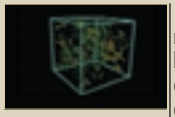
The need for national education standards—a "common core of mathematics and science knowledge"—was pounded home the next year in *Preparing Our Children*. The report, prepared by a Board task force chaired by Mary K. Gaillard of the University of California at Berkeley, suggested that a core science and mathematics curriculum could counter the disadvantages faced by children who frequently change schools.

In 1999, when the Kansas State Board of Education decided evolution would no longer be required in courses and tests, the Board called the move "a retreat from responsibility." The Board condemned the removal from school curricula of such a key piece of scientific knowledge "at a time of already profound concern about the quality of mathematics and science education in our Nation's schools."

In September 2000, the National Commission on Mathematics and Science Teaching for the 21st Century released its report, *Before It's Too Late*, which reinforced the recommendation made by the Board in 1998. The Commission, chaired by Senator John Glenn (D-OH), stated that "the future well-being of our Nation and people depends not just on how well we educate our children generally, but on how well we educate them in mathematics and science specifically."

Also in 2000, a Board Committee on Communication and Outreach, chaired by M.R.C. Greenwood, Chancellor of the University of California at Santa Cruz, urged the science and engineering communities to establish a broad-based public information group to increase public appreciation of science and engineering and urged Board members to increase their activities as "personal ambassadors" for science, engineering, and NSF. Such efforts would further the Board's strategic goal of helping the general public understand "the joy and fascination of science as well as its utility."

The Board reaffirmed its role as a defender of open scientific communications by protesting ill-conceived and restrictive policies in connection with espionage charges against a scientist, a naturalized U.S. citizen, at Los Alamos National Laboratory. "Discouraging scientists and engineers from working in world-class facilities for reasons of national origin, ethnicity, or citizenship...could undermine our long-term security interests," the Board said, and "deny American science and engineering the benefits of openness and excellence."



1995 Physicists create a new form of matter, the long-sought Bose-Einstein condensate, allowing easier exploration of quantum mechanics

1996

NSB Chair Rhodes

NSB Chair Zare

NSF Director Lane

By 1998, private groups were lobbying for a new institute for environmental research, possibly to be housed with its own board at NSF. Many at the Foundation feared that adding a separate vertical structure would cripple the agency's ability to sponsor work across disciplines, one of its strengths. Kelly appointed a Board Task Force on the Environment under Jane Lubchenco of Oregon State University, an authority on sustainable ecology and past president of the AAAS. The goal was to define a future-oriented environmental research portfolio for the agency.

The task force took inventory of NSF's current efforts and interviewed other agencies about their environmental projects. The survey uncovered "enormous gaps," says Lubchenco, in the research, education, and scientific assessment that should be done and the technologies that should be deployed. In 2000, the Board unanimously approved a new vision for NSF contained in its report, *Environmental Science and Engineering for the 21st Century: The Role of the National Science Foundation*. The report recommends that Foundation support for environmental research should grow by $1 billion over the next five years—a hefty jump from the $600 million the agency was currently spending. The report also recommends that NSF create new mechanisms for enabling environmental activities.

PCAST warmly welcomed the report and endorsed the plan for NSF to become a leader of federally funded basic research in the environmental sciences. Rita R. Colwell, who became the first woman to head the Foundation in August 1998, has since established a major initiative in the area of Biocomplexity in the Environment.

2000 and Beyond

The Board's agenda and the Foundation's under the leadership of NSF Director Rita Colwell meshed with that of the Clinton White House. For FY2001, the President requested, and Congress approved, the largest budget increase in Foundation history—13.6 percent. In addition to support of core areas, other priorities included information technology research, where NSF already had a primary role. Another is nanoscale science and engineering. NSF leads other federal agencies in efforts to understand phenomena on the scale of one billionth of a meter. A third area of emphasis is biocomplexity, kicking off the Foundation's growth in the environmental realm.

Another critical objective is building the twenty-first century workforce. NSF is continuing to develop human resources at all levels of education—formal and informal, in schools, homes and communities. The Foundation will give priority to research on learning, systemic reform, teacher preparation, rigorous instruction, and accountability. "From here on," Kelly says, "it will be a question of public understanding and political will" to improve U.S. student achievement.

1998 NSF begins work on a new U.S. research station at the South Pole

1998 Neal Lane becomes President's Science Advisor

1998

NSB Chair Kelly
NSF Director Colwell

"We are inspired by all that our predecessors have accomplished. I hope that in another fifty years, those who follow us will find similar reasons to celebrate."

Eamon M. Kelly, Board Chair, (1998-2002)

While the Foundation's budget is likely to grow, basic research—which is now primarily funded by the federal government—is just 0.002 percent of the total U.S. economy. This alarms Kelly. "We know as a result of the past fifty years that basic research is the only investment that pays off with such high returns," he says. "Applied research and development work do not have anywhere near the same impact."

In coming years, Kelly says the Board will push hard to "stimulate the political environment and the public's understanding" to realize the importance of a higher level of investment in basic research. The Foundation, he says, "is responsible for the health of the scientific enterprise, and the only agency responsible for the general well-being of the entire spectrum of the natural and social sciences."

In this sense, the National Science Foundation is a national treasure. For 50 years, it has enabled scientists and engineers to advance an endless frontier. What would Vannevar Bush think if he could see the National Science Board today? Kelly's ready answer is: "He would see the fulfillment of a vision in which the Board has moved science policy to center stage in the service of the Nation."