Testimony on the Reauthorization of the National Science Foundation

On March 2, 1995, Richard Herman, chair of the Joint Policy Board for Mathematics (JPBM), testified before the House Subcommittee on Basic Research as part of congressional consideration of the reauthorization of the National Science Foundation (NSF). His written statement, reflecting policy adopted by JPBM, is reprinted here.

At the time of this writing, the subcommittee, which is part of the House Science Committee, was expected to mark up NSF reauthorization legislation in late March. Reauthorization bills set policy and approve programs, often for two years, but do not provide funds. (Appropriations bills, written by appropriations subcommittees, allow federal agencies to spend money.)

Herman appeared as part of a panel that included representatives from the American Association of Engineering Societies, the Consortium of Social Science Associations, and the Council of Scientific Society Presidents. The hearing was well attended by the members of the subcommittee, which is chaired by Steven Schiff of New Mexico.

Good morning, Mr. Chairman and Members of the Subcommittee. I'm Richard Herman, chair of the Joint Policy Board for Mathematics, which represents three associations of mathematical scientists whose concerns encompass research, education, and applications. Thank you for this opportunity to talk to the subcommittee about the reauthorization of the National Science Foundation.

Let me start by giving our strong endorsement to NSF's new strategic plan, "NSF in a Changing World". Most importantly, it reaffirms NSF's unique responsibility for maintaining the nation's world leadership in science, mathematics, and engineering and achieving excellence in science, mathematics, engineering, and technology education. The Foundation plays a key role in ensuring the health and vitality of the mathematical sciences in particular. It provides virtually the only federal support for fundamental mathematical research—the study of measurement, forms, patterns, and change—to expand the intellectual frontiers throughout the mathematical sciences and advance our understanding of the universe, often in unpredictable ways. NSF also provides most of the federal funding that enables the mathematical community to work toward the improvement of mathematics education at all levels.

We also support NSF's FY 1996 Budget Request. Even with modest overall growth of 3%, the proposal would allow a 7.6% increase in Research and Related Activities. While we are concerned that the proposed 1% decrease in Education and Human Resources would adversely affect undergraduate programs (on which I will elaborate in a moment), we agree with NSF Director Neal Lane's assessment that, given the rapid growth in other EHR programs, there is now a need to evaluate them carefully and ensure they are on the right track.

It should also be noted that many education programs funded by the research directorates, especially those that connect education to research, would be expanded under the budget proposal. For example, the Division of Mathematical Sciences would emphasize Research Experiences for Undergraduates, postdoctoral fellowships, and regional institutes that bring researchers, schoolteachers, and students together to share in the inquiry and discovery processes that are at the heart of progress in mathematics.

I would like in the remainder of my testimony to address three policy issues that we ask the subcommittee to consider as it writes reauthorization legislation, starting with some thoughts on the nature of the relationship between discipline-oriented research essential to ensuring world leadership and thematic programs designed to address specific national needs.

Research in Areas of National Need

In the correspondence inviting me to testify today, the following question is posed: "Is the balance between curiosity-driven research and strategic research at NSF correct, and what criteria should be used to determine the proper allocation?" I'd like to suggest that the issue be looked at in terms of the two research goals adopted in NSF's strategic plan: maintaining world leadership (mentioned earlier) and promoting the discovery, integration, dissemination, and employment of new knowledge in service to society. It is important to recognize that these goals are tightly interrelated and do not necessarily correspond to a crisp division between curiosity-driven research and strategic research. Curiosity-driven research often leads to contributions toward meeting societal needs; moreover, strategic research, which is more properly labeled research in strategic areas, can enhance the preeminence of the research enterprise.

As a practical matter to facilitate service to society, some federal research activities are organized into thematic programs associated with areas that have been identified as priorities through the confluence of the political and scientific processes. It is appropriate for NSF to have a special responsibility for the fundamental research components of these programs. NSF is really in the best position to engage the academic community in the most promising basic research to address the scientific problems that arise in these and other areas of national need. There is a growing convergence among research driven by scientific opportunities and research likely to advance important areas, and both society and science benefit from NSF's ability to make connections between the two.

We recommend that rather than seeking a balance between thematic and nothematic programs, NSF be held accountable for how its aggregate effort is achieving its goals and addressing societal needs. We are concerned that rigid guidelines for the allocation of the budget between thematic and nonthematic programs would compromise the agility of NSF and diminish the capacity of the research enterprise to respond to as yet unforeseen scientific opportunities and societal needs. The division of dollars in any given year is less important than ensuring that NSF's research portfolio is designed according to its potential to meet its goals and serve society over the long term.

An important corollary of this recommendation is that the proper allocation of funds between categorical and noncategorical programs is not necessarily the same for all disciplines. We are happy to note that the NSF Division of Mathematical Sciences is involved in all of the currently identified areas of national need, providing mathematical scientists with challenging opportunities to investigate the mathematical foundations of complex phenomena and processes associated with critical areas of science and technology. But the ongoing availability of the mathematical sciences as a broad and versatile resource for the nation would be jeopardized if all growth in NSF support for the field continues to come from thematic programs.

The foundation plays a key role in the health and vitality of the mathematical sciences in particular.

Undergraduate Education

The second issue I would like to discuss is undergraduate education. I know that members of the subcommittee have expressed concerns about the quality of education at our universities. The mathematical community believes in the paramount importance of undergraduate education and has been working consistently to improve it. While NSF's Education and Human Resources programs have been growing rapidly in recent years, most of the new funding has been devoted to K–12 activities, and deservedly so. But we suggest that the NSF Division of Undergraduate Education (DUE) is underfunded relative to its importance to education reform at all levels. We urge the subcommittee to encourage and expand the DUE curriculum development and faculty enhancement programs as the most effective way for NSF to help strengthen undergraduate education.

For over a decade, the mathematical sciences community has been working to revitalize a key ingredient in undergraduate education: the calculus course. NSF's leadership and support for this effort have been absolutely crucial to its success. We simply could not have taken a comprehensive, systemic approach to reform without a concentrated NSF initiative in the area. Between 1988 and 1994, NSF provided \$3 million a year to fund about ten major curriculum and text development projects (in the early years), dozens of smaller curriculum reform and faculty enhancement projects, and (in the later years) dozens of dissemination and large-scale implementation projects to adapt the new curricula and teaching methods for widespread use.

A recent assessment conducted by the Mathematical Association of America describes the overall success of calculus reform efforts and testifies to the essential role played by NSF. By 1994, materials developed with funds from the NSF calculus initiative were in use at over 800 colleges and universities as well as 300 high schools, and nearly one-third of all calculus enrollments were in reformed courses. Evaluations of these new courses show that students believe they are learning more, getting higher grades on standardized tests, and more frequently continuing their study of mathematics.

The movement to improve the teaching and learning of calculus is still fragile and requires support to sustain momentum. Moreover, the success of the program has prompted educators to identify other courses and disciplines where NSF's involvement could leverage significant change for the better. DUE is now supporting curriculum initiatives in introductory chemistry and interdisciplinary mathematics, for instance. So we strongly recommend that the division's budget be allowed to grow at least modestly, not decline as proposed, while calculus reform is still in the critical implementation phase and new efforts in other areas are just getting under way.

It should also be noted that strengthening undergraduate education is a prerequisite to true reform at the K–12 level, because prospective science and mathematics teachers learn subject content and are influenced by teaching styles in their undergraduate courses. It is therefore critical that the education we offer more properly captures the image of society.

NSF and High Performance Computing

Finally, let me make a few comments on NSF's role in the High Performance Computing and Communications (HPCC) program. I would like to emphasize for the subcommittee that high performance computing technologies are revolutionizing research in many areas of basic science, mathematics, and engineering. This potential was actually identified in the early 1980s, long before the federal government established a multiagency program in this area. Since that time, NSF has taken the lead in providing academic researchers with access to advanced computing technologies and investing in the mathematical and computational research that enables their use in solving highly complex scientific problems. NSF continues to help the research community through the cost and technical barriers that prevent bringing the full advantages of HPCC technologies to bear on key problems on the edges of the intellectual frontier. We urge the subcommittee to champion NSF's involvement in high performance computing as an essential component of the nation's basic research infrastructure.

Many of NSF's research divisions support work characterized as part of the HPCC program. In the mathematical sciences, basic research carried out under the HPCC banner has led and continues to lead to new mathematical methods, algorithms, and conceptual models motivated by the multitude of issues that arise in the development and use of more powerful and interconnected computing environments. Making use of these environments also requires the invention of sophisticated software tools by interdisciplinary teams of mathematical, computational, physical, and biological scientists and engineers.

These interactions are stimulating new creativity and progress in many fields as researchers chip away at the so-called "Grand Challenge" problems, like atmosphere and ocean modeling, molecular design, and improved understanding of physiological processes. NSF is truly inventing the future of basic research, when computational and numerical "laboratories" are able to replace expensive physical facilities and time-consuming processes, much as mathematical models simulate wind tunnels so that aircraft designs can be tested before prototypes are built.

In conclusion, Mr. Chairman, let me thank you and the members of your subcommittee for the supportive comments you've made on behalf of the National Science Foundation. I hope you will agree that it is a valuable national resource for meeting our research and education needs in a comprehensive and coordinated fashion—the advancement of knowledge across the spectrum of science and the development of human resources from students to educators and researchers. NSF has also been working diligently to ensure that its programs meet the highest standards of quality and contribute to the objectives identified by Congress and the Administration. The agency is clearly poised to lead the mathematics, science, and engineering enterprise toward an ever more active role in securing the nation's health and prosperity.

Thank you very much for your consideration of my remarks. I would be pleased to answer any questions you might have.