Testimony on Behalf of the Joint Policy Board for Mathematics

The Joint Policy Board for Mathematics regularly arranges for representatives of the AMS, the Mathematical Association of America, and the Society for Industrial and Applied Mathematics to testify before Congress on issues of importance to the mathematical sciences community. What follows is the text of testimony presented by AMS President Arthur Jaffe to the House subcommittee concerned with the budget of the National Science Foundation.

Testimony on the FY 1999 National Science Foundation Budget Request

Subcommittee on Veterans' Affairs, Housing and Urban Development, and Independent Agencies
Committee on Appropriations
United States House of Representatives

April 21, 1998

Good morning, Mr. Chairman and Members of the Subcommittee. I am Arthur Jaffe, president of the American Mathematical Society, chairman of the Joint Policy Board for Mathematics, and Landon T. Clay Professor of Mathematics and Theoretical Science at Harvard University. I speak today on behalf of the Joint Policy Board for Mathematics (JPBM), which is a collaboration of three professional societies: the American Mathematical Society, the Mathematical Association of America, and the Society for Industrial and Applied Mathematics. These organizations have a combined membership of over 57,000 mathematical scientists and educators, whose interests span research on mathematics, both disciplinary and interdisciplinary; applications of mathematics to science, engineering, industry, and business; and mathematics education at all levels.

Thank you for this opportunity to comment on appropriations under the subcommittee's jurisdiction. Let me start, Mr. Chairman, by thanking the subcommittee for the strong support it has shown for the National Science Foundation over the years. We hope for your continued support in FY 1999. The Joint Policy Board for Mathematics wholeheartedly endorses full funding of the FY 1999 budget request for the National Science Foundation, providing a critical 10 percent increase.

We believe that what mathematics, science, and engineering represent is a top priority for investment in the future of our country. However, the NSF budget has seen no real growth since FY 1995 and was part of the almost threefold decline in R&D funding as an overall percent of GDP over the past thirty years. Thus we have been shortchanging the most promising investment in our country's future. Moreover, given the extraordinary importance of the NSF's mission, we believe the need for a full appropriation transcends any particular approach to budgeting.

The importance of the NSF's support for basic research and education has been expressed by a bipartisan group of members both in the House and in the Senate. This budget request is consistent with the authorization bill passed by the House, with the authorization bill moving through Senate committee, and with the Senate's budget resolution, which assumes full funding in FY 1999. The Coalition for National Science Funding (CNSF), a coalition of more than fifty scientific organizations, has endorsed the budget request, and I have attached the CNSF statement to my testimony. Furthermore, an ad hoc coalition of over one hundred presidents of scientific organizations (including the three JPBM presidents) issued a "unified statement" calling for a renewal of science funding over the next decade. These societies have over 3 million members: mathematicians, scientists, and engineers from across the country. I have attached the statement to this testimony.

I believe it is widely understood that:

1. We enjoy unparalleled prosperity today. Much of this is driven by technology growing out of the investment in basic scientific research that we have made over the past thirty years.
2. Tomorrow's new technologies will evolve from today's basic research.
3. Our strength as a world power tomorrow relies on our ability to educate our population in mathematics and science.
4. The NSF bears a prominent share of the responsibility for basic research, and it also contributes to education.

NSF and Mathematics Research—the Enabling Discipline

We are especially supportive of the NSF's proposed budget of $114.1 million for the Division of Mathematical Sciences (DMS), as the Foundation has identified and documented a special need for strong growth in this area. For thirty years we have been in the midst of a golden age of mathematics research. Although American mathematics is the envy of the rest of the world, our leadership is in jeopardy. A panel appointed by the NSF documents this view in a March 1998 study entitled "Report of the Senior Assessment Panel for the International Assessment of U.S. Mathematical Sciences." This study illustrates the inadequate support of twentieth-century mathematics, alongside its increasing role as the enabling discipline for all fields of science and engineering. In FY 1999 the NSF will emphasize a number of interdisciplinary research areas, including furthering the fruitful mathematical ties into physics and opening new dialogues between research mathematicians and their colleagues performing research in biology and medicine. However, interdisciplinary advances rest on disciplinary strength and progress; the nurturing of fundamental disciplines suffers today, and thus progress for tomorrow is threatened.

The interdependence of different scientific disciplines recurs as a theme throughout scientific history; its relevance increases with the growing complexity of modern research. For example, modern medical imaging would be impossible without two hundred years of mathematical development leading to the present-day breakthroughs in applications of wavelets. Life is hard to imagine without the programmable digital computer, an invention that arose from the abstract and seemingly impractical discipline of mathematical logic but whose use depends on the wealth of new algorithms resulting from current research in mathematics. Mathematical research on probability theory contributed to the 1997 Nobel Prize in economics, and the widespread use of this mathematical model has had a profound impact on today's financial markets and on risk analysis. The mathematics behind it arose without any conception that it would ultimately be relevant to economics or business.

A mathematician at UC Berkeley recently developed numerical algorithms and extremely fast computer codes to simulate the manufacture of computer chips. The new methods greatly enhance the ability to model and predict some aspects of semiconductor manufacturing, and the associated mathematical approach has been adopted by leading semiconductor companies. The ultimate goal of these and other such algorithms, models, and simulations is to influence semiconductor manufacturing and design in the same way that computer simulations revolutionized aircraft design.

Today's revolution in communication and encryption is a wonderful mixture of themes. It combines the quite recent realization of the applicability of the most abstract parts of mathematics along with the most powerful computational tools and algorithms made possible by engineers, physicists, computer scientists, and applied mathematicians. As explained at a recent congressional briefing on mathematics, encryption involves large-scale computation and also rests on concrete applications of number theory and algebraic geometry, two central fields of mathematics that forty years ago were believed to have no possible practical applicability. Paradoxically, modern mathematics is both devising new encryption schemes on the one hand and devising new mathematical and computational tools on the other to break apparently secure codes. News comes in surprising ways, and this past week we learned that digital cellular phone encryption, which was believed to be secure, has been broken.

Symmetry in nature plays a central role in the formulation of physical laws. Recently two new kinds of symmetry of these laws have been conjectured in physics; they are given the names mirror symmetry (because this can be thought of like a reflection in a mirror) and duality symmetry (because they are similar to known relations between electric and magnetic forces). The assumption of these conjecture symmetries leads to enormous conceptual as well as computational insights that have been studied extensively over the past five years. This year a justification of mirror symmetry has been found in certain special cases, promising to open new directions in our formulation and understanding of the laws of nature, their reflection as mathematical truths, and their forming the basis of new areas of knowledge.

NSF and Mathematics Education

The NSF also provides most of the federal funding that enables the mathematical community to work toward the improvement of mathematics education at all levels. It is impossible to separate science education from scientific research. The NSF Division of Undergraduate Education (DUE) sponsors programs that link students to the work of research mathematicians and scientists. For example, the Research Experiences for Undergraduates (REUs) have played an important role in exciting undergraduate mathematicians and scientists by making available summer participation in research and thereby fostering the early transition from unharnessed potential to energized creativity.

In a complementary fashion, I underscore the important role of the NSF graduate fellowships. These awards have in the past been central in focusing the talent pool that has resulted in the visionary world leadership of our universities. They play an absolutely crucial role in the vexing problem of providing incentive for young potential research mathematicians, scientists, and engineers to continue in their fields, and they provide concrete recognition of their accomplishments as they progress toward becoming the next generation of first-class American researchers. Likewise the postdoctoral fellowship programs extend the training of mathematicians and scientists at the crucial time when they are making the delicate transition from initial scientific discovery to world scientific leadership. It is through this continued encouragement and development that we instill insight and that we focus our next generation of Fields Medal winners and Nobel Prize laureates, as well as the many other researchers whose contributions provide the depth to make our country great. It is from today's pool of talented mathematicians, scientists, and engineers that the next generation of leaders will emerge whose ideas will hatch the basic discoveries to drive our economy and world competitiveness, and hence our national security.

While U.S. graduate education shines, our schools do not. The results of the Third International Mathematics and Science Study show that U.S. students drop from approximately average in fourth grade to the very bottom by twelfth grade. This is the case not only in averages but even when measuring the top 10 percent of student performance. We must do more to ensure that our school students are learning challenging mathematics, and a strong federal role is essential for our success. We urge the subcommittee to provide the full budget request for the proposed joint mathematics educational initiatives of the NSF, to be undertaken in cooperation with the Department of Education. We hope that both agencies, drawing on their respective strengths, will produce results that raise the content and international performance of U.S. students in mathematics.

Conclusion

Mr. Chairman, there are many other projects I could describe to demonstrate the extraordinary impact NSF programs have on mathematics science, engineering, and education. I don't have time today; however, I would like to invite you, the members of the subcommittee, and your staffs to attend the Fourth Annual CNSF Exhibition and Reception on May 20, at which you can see first-hand a small sample of NSF-funded research projects in all fields and you can talk with some of the mathematicians and scientists whose ideas produced these advances.

Let me emphasize that support for research and education in mathematics, the basic sciences, and engineering ranks among the most productive investments Congress can make in the future of our country. Yet the United States spends less as a percentage of GDP on civilian research than our major international competitors. Working with less than 5 percent of the total federal R&D budget, the NSF assumes major responsibility for many critical components of science and technology and works diligently toward the achievement of excellence in science, mathematics, and engineering education. Moreover, the NSF pursues partnerships and encourages the participation of other federal agencies, of the states, and of industry in its activities, thereby leveraging its comparatively small budget. I again urge you to provide a 10 percent increase in FY 1999 appropriations for the National Science Foundation.

Author Note: I am grateful to A. Odlyzko for drawing my attention to the fact that my assertion of a decline by a factor of three in R&D/GDP over thirty years is too large. According to figures published by the National Science Foundation in "National Patterns of R&D Resources: 1996", we have experienced a decline in federal R&D/GDP from 1.93% in 1964 to 0.89% in 1994, or by a factor of 2.2 over that thirty year period.