Challenges Facing Mathematics in the Twenty-first Century

Congressman George E. Brown Jr.

As many of you know, I have spent a great deal of time in recent years examining the linkages between math and science policy and the political, social, and economic institutions of the broader society. I hope during this next term to double these efforts and help to produce change in the math, science, engineering, and academic community that will enable you to continue to flourish in these challenging times. I also hope to bring some changes to the political institutions and the way that we deal with math and science issues in Congress.

I would like to explore these areas with you today and hope that this is just the start of a continuing dialogue with you as individuals and with the AMS. To start this discussion, I would like to provide some background and context for the situation in which we find ourselves. I will explore the nature of the changes facing us, try to detail the current policy debates in Washington, which are mostly budget debates, and look at ways that you and your colleagues in other scientific professional organizations can deal with this situation. Finally, I would like to issue a set of challenges to your community that will, I hope, stimulate some debate.

During this talk, I will speak about the mathematics, science, engineering, and academic communities as one broad entity and refer to it with a shorthand reference to the "science community". I know that disciplinary boundaries, institutional differences, and a host of other divisions prevent this from being an actual unified entity, but the issues facing all of the parts of your community demand a unified response. So, for convenience's sake, I will speak as if you were part of one broad, interconnected community. I hope that you realize that by your adopting this view you will increase your chances for success in the policy debates taking place.

The science community finds itself in the midst of great challenge and change. You flourished under the new relationship forged between science and government that was born in World War II and continued for the next forty years during the cold war. The weapons labs from the Manhattan Project evolved into a system of many hundreds of government laboratories that employ thousands of scientists and engineers. The GI Bill following World War II was a statement of the value of higher education and our society's desire to establish universal access to higher education as a national goal. Major investments were made in math and science programs following the Soviet launch of *Sputnik*, investments authorized in legislation entitled the National Defense Education Act. Our space program grew out of a competition with the Soviets to be the first to land on the Moon and thus deny them the ultimate high ground. More recently we made major investments in math and physics, seeking to develop a ballistic missile defense system to guard against Soviet attack. Over the last forty years, nearly all of our federal efforts in support of science and engineering were conducted with the shadow of the Soviet Union in the background.

With the fall of the Berlin Wall and the dissolution of the Soviet Union, the easy justifica-

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tions for our national research and development (R&D) investments fell as well. At the same time, the budget deficit, which had tripled during the 1980s due in part to our increased defense spending, became a major political focus.

The loss of a clear political justification for R&D expenditures, coming at a time when budgets are being slashed, has put public outlays in support of the science community at risk. With the exception of funding for the National Institutes of Health (NIH), to which I will return in a moment, federal funding for R&D has been flat to declining over the last three years. And judging from reports on the budget for fiscal year 1998, to be released early next month, this trend will continue.

The moves to balance the budget and the imminent passage of a balanced budget amendment threaten our R&D enterprise. Absent rational reforms to our entitlement programs, the budget cannot be balanced, and programs supporting science and education will be decimated in the process. Let me expand on this statement.

You all probably know that our federal science and education programs are funded out of the discretionary part of the federal budget, the portion of the budget that must be appropriated annually. But these programs make up only about one sixth of total federal spending, so unless we tackle the tough problem of reforming the mandatory spending in federal entitlement programs, payments on the national debt, Medicare outlays, veterans' benefits, and the like we cannot balance the budget and will do irreparable harm to discretionary investment programs like science and education funding.

But even entitlement reform, if poorly done, can end up harming science and education programs. If you look at the recently enacted Welfare Reform Bill, you can see that the so-called "reform" is really a shifting of the fiscal burden to the states. What this does is force higher education, the base upon which academic R&D rests, into a tougher competition for state funds. So we simply shift the burden if we aren't careful and end up hurting our science and education programs in the process.

What I have been discussing is budget policy and its impact upon the science and education programs of importance to all of you. This is what has been happening in Washington for the past few years: budget debates dominate our time, and discussions of science policy become footnotes or afterthoughts. In order to turn this around and put science policy issues first, we must exert considerable effort. And getting mathematics to take its rightful place in these debates will take even more effort.

Mathematics is a wondrous area of study and is unique because it is both a discipline by itself

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and one of a few "gateway" areas of knowledge. By this I mean that a basic understanding of mathematics is required in all other areas of scientific inquiry. In addition, mathematics frequently provides the basis for advances within scientific disciplines. In the past we have observed this with physics, but now we are on the threshold of breakthroughs in biology, chemistry, geology, and materials sciences thanks to new modeling techniques being applied in those fields. While this unique relationship makes math indispensable to science, it also can make it less visible in policy arenas.

With a low level of scientific literacy in Congress and with a lack of familiarity with the process of scientific discovery, mathematics gets lost as we concentrate on the latest advance in physics, biology, or engineering. For example, a breakthrough in new magnetic resonance imaging (MRI) technologies is announced, but lost in the fanfare is the fact that real-time MRIs are not possible without equally important breakthroughs in mathematics that allow the massive data sets being generated to be organized and presented. Time and again, mathematics receives less attention than it deserves.

Unfortunately, this can result in your getting less support than you deserve. By most measures—federal research support, graduate student, research assistantship, and postdoctoral support—mathematics lags behind the sciences in federal support provided. This is a difficult position to be in during good times. It is a very dangerous position to be in during the rough times ahead. What is to be done about this situation?

Earlier I mentioned that NIH has been the exception to the stagnant funding situation for

R&D at the federal level. In constant dollars, overall federal R&D funding has dropped 1.9 percent over the last three fiscal years. Over this same period, NIH funding has increased 10 percent! The reason for this relative success is the political support and education generated by the biomedical research community. Early proposals to cut NIH mobilized the biomedical research centers, the biotechnology industry, and the various disease victims advocacy organizations, all of whom came before Congress to make the case for NIH funding. This allowed strong congressional supporters of NIH, Representative John Porter in the House and Senator Hatfield in the Senate, to press for increases in NIH funding during a period of unprecedented reductions in the federal budget.

What the biomedical research community did stands as a model for the rest of the scientific community. Efforts to educate and contact policymakers have been started by many scientific and academic groups. Work to organize the science community in the field has also been started by science and engineering societies recognizing that contact at the congressional district and state level is most meaningful. I strongly encourage these education efforts because they create a long-overdue link between congressional policymakers and the science community that will, I hope, become an information exchange that transforms the culture on both ends of the exchange.

For Congress this can promote reasoned debate on science policy and provide a perspective on needed social investments that will prevent simplistic budgetary decisions from being made. For the science community this exchange can help transform a culture of isolation into one of awareness and involvement that will allow you to regain control of your future.

That last statement requires some amplification. For most of the last forty years much of the science community has assumed the role of detached, neutral observers who provide society with unbiased information and needed facts. Peer review has provided internal guidance, and intrusions from outside have been viewed as a threat to the neutrality of the scientific process. This detachment from the broader society served the scientific community well, as long as unquestioned public support was forthcoming. And the technological advances of the last forty years, combined with the need to stay ahead of the Soviets in the knowledge race of the cold war, were ample justification for continued support. In today's climate, that detached distance is rapidly proving to be a danger as public confidence in social institutions begins to fail, causing questions to be raised about all public investments. For much of the science community this turnaround has been a shock. Loss of unquestioned budgetary support, caused by increased pressure on public funding sources, as I noted earlier, has forced retrenchment on campus and in federal laboratories. Private sector downsizing has eliminated science and engineering jobs there. Unemployment is rising among recent Ph.D. graduates, who struggle to obtain a series of postdoctoral positions or an adjunct professorship. Yesterday's numerous tenure-track positions are now occupied by senior faculty holding on to their jobs or have been eliminated by cash-strapped universities, with many schools moving to eliminate entire graduate programs or departments. For mathematicians this was demonstrated by the University of Rochester's proposal last year to downsize its mathematics department and phase out the Ph.D. program there. And if these changes weren't enough, state and federal governmental entities have been casting a critical eye on college and university tuition increases, scientific misconduct, indirect cost reimbursement, and a host of other internal issues in the science community.

The only effective response to this changed environment is a change in the culture of the scientific community. And that involves engaging the broader society more directly on a range of issues. This process needs to start with the political communication and education that I have been urging for some time and then needs to be expanded.

At this point I must note that this image of a detached science community is an illustrative one that is largely true but does not hold across the board. Many of you are actively involved in activities of the kind I have been discussing. But as a whole, the scientific community does not have a political presence anywhere near its importance or size, and this needs to be corrected.

Nor does the scientific community have as broad a perspective as it needs. For example, simply working to defend your favored agency's budget or even working to increase support for R&D funding across the board is not enough. As I discussed earlier, funding for your programs is tied to a complex set of issues involving the entire federal budget. You need to understand those other issues and address them as well.

After spending the last two years fighting to maintain R&D funding in the agencies under the Committee's jurisdiction, I realized the need for a more comprehensive approach to this problem. So I set out to develop a budget plan that results in a balanced budget *and* allows for an increase in R&D funding. In September I released such a budget plan in order to move an R&D investment strategy into the center of the budget debates. While I do not seek your endorsement of this

plan, although I would welcome it, I am offering it as an example of the broader thinking that must take place in the science community if we are to meet all of the challenges facing us today. You cannot simply say, "Don't touch my programs." You must also provide a means by which your needs can be met while addressing the larger pressures for a balanced budget.[1]

This broader focus needs to be cultivated within the scientific community on a number of fronts. The AMS is already moving ahead with this, as shown by your plans for Math Awareness Week in April and the other activities that you have undertaken. You should feel proud of the work you have under way and look for more things that could be done.

As you are well aware, a study was recently released on math and science education that showed United States students were not performing as well as their peers in other nations. This study has prompted reviews of math and science teaching methodology and has again raised concerns about our nation's ability to keep pace in an increasingly technological world. I know that you are involved in the follow-on to this report and that the National Council of Teachers of Mathematics has been in the center of this issue for some time. You should view this study as an opportunity for mathematicians to raise their profile on an issue of current social concern.

I know that the issue of curriculum reform is not without controversy within your membership: what one person calls making math more accessible is what another calls "dumbing down" mathematics. But this is an opportunity for you to get involved, as individuals and as a professional society, in an important issue and to raise the profile of mathematics. National Science Foundation director Neal Lane has been calling for scientists and engineers to get involved in education and other important community activities. The AMS has proposed a Working Group on Public Awareness, and this work needs to be emphasized so that there is wider participation and broad development of a "citizen-scientist" or a "citizen-mathematician" ethic within the AMS.

Improved mathematics education is essential in our society. Just as it is a "gateway" to success in the sciences, basic mathematical understanding is a gateway skill to success in today's world. As we make advances and move the boundaries of human knowledge further out, we leave behind those who are merely standing still. Every advance in science and technology has consequences, both good and bad, and we owe it to ourselves to minimize the adverse consequences. This does not mean that every one of you has to solve every problem in society, but you should be aware of the dislocations that progress causes and the new knowledge that is required to keep pace with the progress you create.

Without equity across society in knowledge skills, we cannot have equity in the benefits that social progress brings. This inequity can cause social disruption that threatens the peace and stability that scientific inquiry requires. To find immediate proof of that you need look no further than the current state budget in California, where, for the first time, the cost of the state corrections system exceeds the combined budgets for the University of California and California State College System. Yearly graduate tuition at Stanford is less than the average yearly cost of incarceration in California. These are startling facts that urge broader social involvement by the science community for reasons of enlightened self-interest. That broader involvement can bring greater support for mathematics at a time when you most need it.

I know that this is a great deal to have loaded upon you in such a short period of time, but as I stated earlier, this is just the start of a longer dialogue. I am aware that the AMS has begun to take action in many of these areas, and you are to be complimented. And on an individual level, I know that much of the change that I have discussed is not easy. After all that is required to earn a living and have a personal life, where do you find the time to get involved with math curriculum reform, or student mentoring, or helping with in-service training for high school mathematics teachers, or meeting with local politicians, or doing any of a hundred other things that these changes involve?

But these are challenging times, for you as individuals and as a society. Who, just a few years ago, would have predicted the situations we face in the science community? Who would have foreseen proposals to close entire graduate programs? Who would have predicted that we would be on a steady course to cut science funding? And obviously no one predicted unemployment figures among recent math Ph.D.s in double digits. But all of these things are part of the new reality facing us and are all signs that we must try new ideas and new approaches, and this will require new efforts on all of our parts.

I am willing to help you in these efforts and look forward to working with you as we approach the twenty-first century.

[1] *A summary of the budget proposal can be found on the Democratic WWW Home Page at* `http://www.house.gov/science_democrats/gebinvst.htm`.