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REAUTHORIZATION OF THE NATIONAL SCIENCE FOUNDATION: STRENGTHENING MATH AND SCIENCE EDUCATION RESEARCH AND DEVELOPMENT

HEARING

BEFORE THE

COMMITTEE ON HEALTH, EDUCATION, LABOR, AND PENSIONS UNITED STATES SENATE

ONE HUNDRED SEVENTH CONGRESS

SECOND SESSION

ON

EXAMINING PROPOSED LEGISLATION AUTHORIZING FUNDS FOR THE NATIONAL SCIENCE FOUNDATION, FOCUSING ON MATH AND SCIENCE RESEARCH, DEVELOPMENT, AND EDUCATION

JUNE 19, 2002

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REAUTHORIZATION OF THE NATIONAL SCIENCE FOUNDATION: STRENGTHENING MATH AND SCIENCE EDUCATION RESEARCH AND DEVELOPMENT

WEDNESDAY, JUNE 19, 2002

U.S. SENATE,
COMMITTEE ON HEALTH, EDUCATION, LABOR, AND PENSIONS,
Washington, D.C.

The committee met, pursuant to notice, at 1:45 p.m., in Room SD–430, Dirksen Senate Office Building, Senator Kennedy, (chairman of the committee), presiding.

Present: Senators Kennedy, Jeffords, Mikulski, Clinton, and Bond.

OPENING STATEMENT OF SENATOR KENNEDY

The CHAIRMAN. We will come to order. We are expecting some of our colleagues who will be joining us shortly, but I think we will get started.

I want to thank Dr. Colwell, Dr. Verner and a very special welcome to an old and dear and valued friend, John Glenn, who is a national treasure and a leading authority on math and science education, research and development.

The National Science Foundation has a distinguished history of success and has made a difference in the lives of millions of Americans. It has funded basic research leading to creation of Doppler radar, speech recognition software, and even the World Wide Web browsers many of us rely on today. Its education initiatives in the late 1980s were the forerunner for the standards-based school reform that is now embraced throughout Federal, State, and local education programs.

Today, NSF has two key functions: first, supporting high-end research and development in science, math, engineering and technology; and second, promoting cutting-edge math and science education reform and performance at the elementary, secondary, post-secondary and post-graduate levels. We look forward to hearing about each of those functions today.

Advancements in biological and physical science often depend on each other. Federal research and development funding has grown, especially in the health sciences, over the last several years, which has been very valuable in many areas. The National Institutes of Health's budget has doubled over the last 5 years. But we should also work to grow support for research and development in theoretical mathematics and the physical sciences, not only because

they are valuable in their own right, but also because they support advancements in the health sciences and other fields. In fact, we have an urgent need to begin today to interest young minds in math and science and to recruit tomorrow's mathematicians and engineers.

Over the next 10 years the number of jobs requiring technical schools is projected to grow by 50 percent. Unfortunately, the number of American students studying math and science at the college level has been flat over the last decade. High school student performance on international math and science exams is distressingly low. And at a time that our Nation is growing more diverse, women and minorities continue to shy away from the sciences.

I look forward to hearing from the witnesses today, reviewing the submitted testimony of others and moving forward with this reauthorization. We are honored to have such distinguished witnesses today and look forward to their proposals to address these challenges as we reauthorize the National Science Foundation.

Of our three witnesses today, I would first like to welcome Dr. Rita Colwell, Director of the National Science Foundation. Since she became the director in 1998, Dr. Colwell has emphasized K-through-12 science and math education, graduate science and engineering education and training, and has tried to increase the participation of women and minorities in science and engineering.

Before coming to the NSF, Dr. Colwell was president of the University of Maryland Biotechnology Institute. She was also a member of the National Science Board from 1984 to 1990. Dr. Colwell has received numerous accolades and honorary degrees. In addition, she was born in Beverly, MA. So, I am pleased to have Dr. Colwell here today to update us on what NSF has been doing and on the future plans for the agencies.

And we will have the presentation by our friend Senator John Glenn, who is here with us today to discuss his views on secondary education, the importance of math and science education. Following Senator Glenn's retirement from the United States Senate, he focussed a great deal of his time on math and science education and spearheaded the Glenn Commission report, "Before It's Too Late." I am grateful to have Senator Glenn back in the Senate today to talk about the Commission's report and priorities for math and science education and research. He has already made available to all of us a videotape and report on the Commission work, which I know our colleagues will value. I will ask the staffs to make sure that they give those to the Senators.

Then finally, Keith Verner we are pleased to welcome. Dr. Verner is the chief of Developmental Pediatrics and Learning at Pennsylvania State University College of Medicine. Besides his extensive experience as a professor, he has authored several publications related to health education and science research. I am pleased to have Dr. Verner here today to discuss the importance of both NSF's and the Department of Education's math and science partnerships.

Dr. Colwell, we will start with you.

[The prepared statement of Senator Kennedy follows:]

PREPARED STATEMENT OF SENATOR KENNEDY

Thank You, Dr. Colwell and Dr. Verner, for joining us. We're especially pleased to have with us also Senator Glenn, who is a national treasure and leading authority on math and science education, research, and development.

The National Science Foundation has a distinguished history of success and has made a difference in the lives of millions of Americans. It has funded basic research leading to the creation of doppler radar, speech recognition software, and even the World Wide Web browsers many of us rely on today. Its education initiatives of the late 1980s were the forerunners for the standards-based school reform that is now embraced throughout Federal, State, and local education programs.

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In fact, we have an urgent need to begin today to interest young minds in math and science, and to recruit tomorrow's mathematicians and engineers. Over the next 10 years, the number of jobs requiring technical skills is projected to grow by 50 percent.

Unfortunately, the number of American students studying math and science at the college level has been flat over the last decade. High school student performance on international math and science exams is distressingly low. And at a time that our Nation is growing more diverse, women and minorities continue to shy away from the sciences.

I look forward to hearing from the witnesses here today, reviewing the submitted testimony of others, and moving forward with this reauthorization.

We are honored to have such distinguished witnesses today, and look forward to their proposals to address these challenges as we reauthorize the National Science Foundation.

OPENING STATEMENT OF RITA R. COLWELL, DIRECTOR, NATIONAL SCIENCE FOUNDATION

Ms. COLWELL. Thank you, Mr. Chairman. I would like to thank you and the Committee for the opportunity to discuss the President's budget request for the National Science Foundation. The National Science Foundation's budget request is $5.036 billion for fiscal year 2003, $240 million or 5 percent more than the previous fiscal year. For the United States to stay on the leading edge of discovery and innovation, we cannot do less.

My written testimony contains the specific funding levels for our various initiatives and programs, but the NSF is keenly aware and deeply appreciative of this Committee's strong interest in improving the quality of education in this country, so I wanted to briefly discuss some of the steps that NSF is taking to strengthen our math and science education.

Everyone agrees that we need to improve our preK–12 education system. America's knowledge-based society in the 21st Century puts a premium on the importance of research, innovation, and human capital as our principal strengths. Still, at the dawn of the 21st Century we continue to see depressingly familiar news stories about why Johnny knows little about science and why he lags in math. Information technology, for example, has revolutionized America's businesses, but it also poses new demands. The Com-

merce Department projects that 60 percent of the new jobs in the year 2020 will require skills possessed by only 22 percent of our workers today. The Labor Department projects that new jobs requiring science, engineering and technical training will increase by 51 percent by 2008.

Only about 5 percent of the 24-year-olds in this country have earned degrees in the natural sciences or engineering. By that measure we now trail Japan, Korea and the United Kingdom. A decade ago we were leading.

We are right to be concerned about a seeming mismatch emerging between the skills that workers possess and the skills that employers demand. How can it be that a Nation that spends more than $300 billion on public K–12 education invests less than .1 percent of that amount to determine which educational technologies actually work and how they can be improved?

Well, NSF does not have a magic wand, but we do have an impressive portfolio of research and education programs that are designed to help address these and other challenging problems. One of the most encouraging highlights of our fiscal year 2003 budget request is a second installment of a $200 million program for President Bush's national 5-year, $1 billion math and science partnership program, the MSP, to ensure that no child is left behind. The goal of the MSP program is to link local schools with colleges and universities to improve the preK–12 math and science education, to train teachers, and create innovative ways to reach out to the underserved students and schools.

The NSF and the Department of Education have formed a Tiger Team which meets approximately twice a month to discuss important programs and activities that support our common goals in math and science education. Demonstrating the success of our partnership approach, these Tiger Team discussions resulted in the development of an approach to jointly manage the review and award process for the first math and science partnership competition. The review panels met very recently to examine the appropriate 290 MSP proposals that had been submitted. The Department of Education staff worked closely with NSF's staff in the management of this process and we expect to announce the first set of the MSP awards later this summer.

Now for MSP to succeed we have to first ensure that genuinely productive partnerships are established between schools and colleges. A second distinguishing feature of the MSP is that it will not be an isolated set of local partnerships, but will become part of a national science, technology, engineering and mathematics education portfolio of interconnected sites so that successful methods can be shared to benefit all students.

Through the programs like MSP, our education portfolio is evolving to meet the critical needs of our Nation's future workforce. We must draw on our full talent pool if our work force is to truly reflect the face of America. We must attract more students, especially minorities and women, to pursue careers in science, mathematics, technology and engineering.

In recent years the number of engineers graduating from our universities has decreased by over 20 percent. Over half the doctoral candidates in math and physical sciences in our Nation's uni-

versities are from other countries, with an increasing number returning home after completion of their studies.

Competition from other nations continues to increase. U.S. investment in broad-based fundamental research, which takes place largely in our universities, must not be allowed to slip. President Bush and his administration have recognized that we need to invest more in scientific and technological research across all of the scientific disciplines. The President's science adviser recently testified that the balance in this broad research portfolio recognizes that advances in one field, such as medicine, are often dependent on gains in other disciplines. Diversified investments across the full spectrum maximize our returns, both financial and technical. And this view was echoed by Harold Varmus, the former NIH director, when he noted that "Medical advances may seem like wizardry, but you pull back the curtain and sitting at the lever is a high-energy physicist, a combinational chemist or an engineer."

The National Science Foundation is uniquely positioned to help push forward one of the Nation's highest priorities—improving education for all children. Educational research, the science of education, is a key component. We still do not know how we learn, how we remember, or how we think, yet I believe there is no field in which major advances would have more profound effects for human progress.

Mr. Chairman, I would be pleased to respond to any questions that the Committee may have. Thank you.

[The prepared statement of Ms. Colwell follows:]

PREPARED STATEMENT OF RITA R. COLWELL

Chairman Kennedy, Senator Gregg, and Members of the Committee, thank you for providing this opportunity to discuss the President's budget request for the National Science Foundation.

America's present and future strength, prosperity and global pre-eminence depend directly on fundamental research.

Every year, the Foundation's optimal use of limited public funds has relied on two conditions: number one, ensuring that our research and education investments are aimed—and continuously re-aimed—at the frontiers of understanding.

Number two, certifying that virtually every dollar goes to competitive merit-reviewed, and time-limited awards with clear criteria for success.

Moreover, NSF puts the greatest share of its resources where they will do the most good: in the Nation's colleges and universities where, in addition to generating the truly new ideas that define the future, every dollar invested contributes to developing and training the next generation of researchers and educators.

Moreover, NSF has been proactive in implementing the President's Management Agenda, and we welcome—and apply—input from many sources to continuously improve the way we manage programs at NSF.

When these conditions are met, our Nation gets the most intellectual and economic leverage from its research and education investments.

The National Science Foundation is requesting $5.036 billion for FY2003, $240 million, or 5 percent more than the previous fiscal year. For the United States to stay on the leading edge of discovery and innovation, we cannot do less.

Let me stress that the priority setting process at NSF results from continual consultation with the research community. New programs are added or enhanced only after seeking the combined expertise and experience of the science and engineering community, the Director and Deputy, and the National Science Board.

Programs are initiated or enlarged based on considerations of their intellectual merit, broader impacts of the research, the importance to science and engineering, balance across fields and disciplines, and synergy with research in other agencies and nations. NSF coordinates its research with our sister research agencies both informally—by program officers being actively informed of other agencies' programs—

and formally, through interagency agreements that spell out the various agency roles in research activities.

Partnerships among agencies are proliferating mainly because they offer the best hope for finding answers to some of the most challenging research problems. These partnerships are truly changing the face of science. NSF is the lead agency for two multi-agency administration initiatives in the most promising research fields, information technology and nanotechnology. Knowledge breakthroughs in these two areas alone will fundamentally change the face of research in research areas across the board.

I am keenly aware and deeply appreciative of this Committee's strong interest in improving the quality of education in this country, so I wanted to take a few minutes to discuss some of the steps NSF is taking to strengthen our math and science education.

Everyone agrees that we need to improve our preK-12 education system. America's technology-driven economy demands innovative thinkers to create new industries and fill the ever more demanding jobs these new industries generate.

How can it be, at the dawn of the 21st Century, that we still see news stories about "why Johnny can't read" or "why Johnny can't count?"

How can it be that a Nation that spends more than $300 billion on public K-12 education invests less than one-tenth of 1 percent of that amount to determine "what actually works," and to find ways to improve educational technologies? NSF does not have a magic wand, but we do have an impressive portfolio of research and education programs designed to help address these and other challenging problems.

One of the most encouraging highlights of our FY03 budget request is a second installment of $200 million for President Bush's national 5-year, $1 billion Math and Science Partnership Program (MSP) to ensure that "no child is left behind." The strategic focus of MSP is to link the Nation's higher education institutions with local, regional and State school districts and other partners. MSP calls for a significant commitment by colleges and universities to help improve the quality of science and mathematics instruction in our schools. Additionally, the program calls for greater investment in the recruitment and professional development of highly competent science and math teachers. I would like to note that NSF and the Department of Education are working closely together to effectively manage this joint investment in math and science education. Review panels are currently underway for the first round of MSP proposals, and Department of Education staff is fully involved in this process along with NSF staff.

For MSP to succeed we must first ensure that productive partnerships are established between schools and colleges. A second distinguishing feature of MSP is that it will not be an isolated set of local partnerships, but will become part of a national science, technology, engineering and mathematics (STEM) education portfolio of interconnected sites that will share successful methods so that all students benefit. MSP seeks to improve student achievement in mathematics and science by all students, at all pre-college levels. NSF doesn't have all the answers, but through programs like MSP, our education portfolio is evolving to meet the critical needs of our Nation's future workforce.

That S&T workforce should also reflect the face of America. We must attract more of our youngsters, especially minorities and women, to pursue careers in science, mathematics, technology, and engineering. We must draw upon our full talent pool. One of the steps NSF is taking to attract more of the Nation's most promising students to science and engineering is an investment of approximately $37 million in FY03 to increase annual stipends for graduate fellows to encourage them to pursue technical careers. Other NSF programs geared toward helping this underrepresented segment of our population can hopefully make a difference in their recruitment, retention, and advancement in technical fields.

The budget also includes funding for six priority areas, including $221 million for nanotechnology research, $286 million for information technology research, and $60 million as part of a new priority area in mathematical and statistical sciences research that will ultimately advance interdisciplinary science and engineering. $185 million is directed toward NSF's Learning for the 21st Century Workforce priority area—including $20 million to fund three to four new multi-disciplinary, multi-institutional Science of Learning Centers to enhance our understanding of how we learn, how the brain stores information, and how we can best use new information technology to promote learning.

We are also requesting $10 million to seed a new priority area in the social, behavioral, and economic sciences to explore the complex interactions between new technology and society so that we can better anticipate and prepare for their consequences.

The budget requests $79 million for research on biocomplexity in the environment. This builds upon past investments to study the remarkable and dynamic web of interrelationships that arise when living things at all levels interact with their environment. Research in two new areas this year—microbial genome sequencing and ecology of infectious diseases—will help develop strategies to assess and manage the risks of infectious diseases, invasive species, and biological weapons.

I should add that as part of the Administration's new multi-agency Climate Change Research Initiative, we will implement a $15 million research program to advance understanding in highly focused areas of climate science, to reduce uncertainty and facilitate policy decisions. Our budget also includes $76 million for programs slated to be transferred to NSF from NOAA, EPA, and the USGS.

Although we did not seek these transfers, we take considerable pride in the fact that of the 26 Federal agencies judged by OMB in five key management areas, only the National Science Foundation received a green light. NSF is noted for its expertise and success in funding competitive research, and this was certainly a factor in this recognition .

In large facilities, we will continue support for the next phase of construction of the Atacama Large Millimeter Array (ALMA). New construction projects in the FY2003 budget include two prototype sites of the National Ecological Observatory Network (NEON) at a cost of $12 million to analyze data to detect abrupt changes or long-term trends in the environment. The budget also requests $35 million for EarthScope to detect and investigate earthquakes, volcanic eruptions, and landslides on the North American continent.

The events following September 11 demonstrated our capacity to engage the research community in ways that are immediately responsive to national needs—ranging from the analysis of a catastrophic structural collapse to the use of robotics in victim location. We owe this flexibility to a highly trained scientific and engineering workforce capable of selecting the most interesting and challenging problems for their research. It is this flexibility, enabled by the merit review system that makes our science and technology enterprise the envy of the world.

The Bush Administration has recognized that we need to invest more in scientific and technological research—across the board. Other nations are building up their R&D commitments. U.S. investment in broad-based fundamental research—which takes place largely in our universities—must not be allowed to slip. I think Harold Varmus said it best when he said, "The NIH does a magnificent job, but it does not hold all the keys to success. The work of several science agencies is required for advances in medical sciences, and the health of some of those agencies is suffering."

The National Science Foundation is the only Federal agency whose primary mission is to advance science, engineering and mathematics across all disciplines. By doing so we support national defense, help our country remain internationally competitive, and provide a better standard of living for our citizens. As we work to develop the finest scientists and engineering for the 21st Century, our human resources policy must move beyond simply the supply and demand of personnel and address the composition of our science and engineering workforce. There is much room for needed improvement and continued policy considerations.

Mr. Chairman, for those who want to examine the NSF budget in detail, it is fully laid out on our website. I would be pleased to respond to any questions that the committee may have.

The CHAIRMAN. Before we move to Senator Glenn, I notice Senator Kit Bond was here earlier and we have been joined by Barbara Mikulski, who I know was looking forward to the testimony of Dr. Colwell and I should have asked John Glenn to lead off first on it, but I note her presence here. If there is anything she wanted to add about Dr. Colwell at this time?

Senator MIKULSKI. Yes, thank you very much, Mr. Chairman.

First of all, Dr. Colwell comes as—we greet everyone, our dear colleague Senator Glenn and, of course, Dr. Verner, but Dr. Colwell comes to us from the State of Maryland where she has been acknowledged in the University——

The CHAIRMAN. I do not correct Senator Mikulski on any matters——

Senator MIKULSKI. Why? Do not tell me——

The CHAIRMAN. She was born in Massachusetts. But I have learned, since she is an appropriator, it is much better to let things go by. There are not many instances where I can——

Senator MIKULSKI. Mr. Chairman, you know as an authorizer, it is not where you start out; it is where you end up.

The CHAIRMAN. That why I am going to keep quiet.

Senator MIKULSKI. Dr. Colwell arrived in Maryland, came to the University of Maryland and to my colleagues, we know that Dr. Colwell is really an outstanding scholar in her own right. She is an award-winning scholar, acknowledged by her peers. She is a talented administrator. Under her stewardship at the National Science Foundation, she has been a leader, she has been effective, and I think she brings to us today a framework for the future on how we can take this great invention of the old century and make it contemporary, fiscally responsible for the new century. I know we will look forward to her testimony.

And I am so pleased that I was joined by my brother appropriator, Senator Bond, because, you know, we are deeply committed to doubling the National Science Foundation's budget and we look forward to working with our authorizers for the right policy framework.

The CHAIRMAN. Senator Bond, we would welcome any comment that you might make.

Senator BOND. Mr. Chairman, if I may impose upon our witnesses, I had a couple of thoughts I wanted to share about the National Science Foundation and I have some other things this afternoon which may preclude my returning, so I am very pleased to join you and my Chairman on the Appropriations Committee for NSF.

Ms. Colwell has been to Missouri many times, if that helps.

Ms. COLWELL. My daughter graduated from Wash. U., sir.

Senator BOND. Wash. U.? Okay, so everybody has a claim.

Senator Mikulski and I do have a very special interest in the NSF and I want to focus on something that Dr. Colwell was talking about on math and science education. Since we have raised these issues, we fought for these issues, I am on the Budget Committee and on Appropriations and we have lots of other things to talk about, but as Senator Mikulski has said, we have been leading a bicameral, bipartisan effort to double the NSF budget and we would like to see the reauthorization bill support this doubling.

We strongly believe that doubling NSF's funding will not only support the strong role that NSF plays in basic science research, but also in the critically important area of education that Dr. Colwell was discussing earlier.

Now when people think of Education they think of the Department of Education, but not enough people understand the critical role that NSF plays in supporting math and science education and developing the Nation's supply of scientists and engineers. As Dr. Colwell has said, they are in short supply. We face a real crisis in this field if we do not improve our production of educated scientists and engineers.

Despite our efforts on the Appropriations Committee, the Federal Government just has not provided adequate support to the NSF and the physical sciences in general. I believe this lack of support

for physical science puts our Nation's capability for scientific innovation at risk and, equally important, as also has been mentioned, at risk of falling behind other nations. Therefore I would strongly urge my colleagues on this Committee to join Senator Mikulski and me.

One other point that I think is vitally important when we talk about doubling the NSF budget, many medical doctors in Missouri and throughout the country tell me that despite the tremendous support we have provided for life sciences in NIH, their research in the biomedical field will stagnate without adequate Government support of the physical sciences that NSF supports. Many medical technologies, such as magnetic resonance imaging, ultrasound, digital mammography, genomic mapping, could not have occurred and cannot improve to the next level of proficiency without NSF-supported work in biology, in physics, chemistry, math, engineering, computer sciences. Simply put, if we want to see medical advances we cannot just double the funding of NIH. We must double the funding of NSF, and NSF is far behind.

Now I think to go back to the education part of it, the high-tech industry is also concerned about NSF funding because they are struggling to find qualified home-grown engineers and scientists and they have to rely more on foreign nationals. Many notable researchers in the high-tech industry have told me that the significant shortage of trained American engineers and scientists have limited the growth potential of the electronics and software industries and allowed foreign competitors to catch up to U.S. industry capabilities.

To address the tech talent in this country, NSF provides a wide array of support to preK–12, undergraduate and graduate level schools. One new important tool is the Math and Science Partnership program jointly administered with DOE. Under this program, NSF is encouraging partnerships with local schools, higher education, and other organizations to improve student outcomes. I hope we can address this in this bill.

The last area I want to mention is math and science education at the undergraduate level. As noted, we are falling behind in the number of students receiving degrees despite the growth in our population and the increase in undergraduate enrollment. In other countries we see the numbers going up and we are having to depend too much on foreign students for the scientists and engineers we need. We love having the resources coming in from other countries, but we cannot depend upon others solely to educate our scientists and engineers.

Demand for engineers and computer scientists is expected to grow by more than 50 percent by 2008 and the high-tech industry is justifiably concerned that it will become increasingly difficult to fill this demand and remain competitive.

In response to this problem my Senator colleagues, Senators Lieberman, Frist, Mikulski and Domenici, and I introduced S. 1549, the Tech Talent Act, to improve undergraduate education in math, science, engineering and technology. In our VA–HUD Independent Agencies Act for this year we jump-started it with $5 million. Sometimes when the authorizers fall behind, we kind of give them a little help in the appropriations process. NSF has already

received 177 applications requesting some $60 million. We have many co-sponsors on the Tech Talent Act. I hope my colleagues will support this in the reauthorization bill.

I look forward to working with you, Mr. Chairman, and the Commerce Committee in developing a strong bipartisan NSF reauthorization. Thank you.

Thank you very much, Senator Bond, for a very important statement. If you had listened to Eliza Sunni, who came here for the leadership in terms of the National Institutes of Health, he spoke very importantly about the same point that you made about the importance of tying in the basic research that is done in the life sciences with the other kinds of research in the more technical fields.

Senator BOND. I told him my favorable vote on confirmation——

The CHAIRMAN. Well, you have done it again. But in all seriousness, I think all of us are impressed by both your statement and the statement of Senator Mikulski about giving additional resources and focus to what is a real national challenge.

Senator Glenn, welcome. We missed you very much and we admire your long-time career of public service in the interest of the country, as one who is at the cutting edge of research and exploration in the atmosphere, a distinguished record here as a Member of the Senate and now awakening the country to the importance of ensuring that the young people and our Nation is going to be well equipped to deal with the challenges of this century and beyond. So we are very grateful for your presence and very grateful for your continued service to the Nation.

OPENING STATEMENT OF JOHN GLENN, CHAIRMAN OF THE BOARD OF DIRECTORS, THE JOHN GLENN INSTITUTE FOR PUBLIC SERVICE AND PUBLIC POLICY

Mr. GLENN. Thank you very much, Mr. Chairman and Members. It is an honor to be asked to come back and to testify. I have a more lengthy statement that I would like to submit for the record.

The CHAIRMAN. Fine.

Mr GLENN. It has a lot more detail in it.

I wanted to acknowledge, too, Linda Rosen, who came with me today, who did a lot of work on this. She formerly was National Council of Teachers of Mathematics as their executive director, was in the Department of Education with Secretary Riley as his principal adviser on math and science matters, and more recently has been senior vice president for education in the National Alliance of Business, and was a teacher of math before that in the public school system.

So I would like to submit that statement from and make some verbal remarks here and then answer any questions.

We all talk about education, but I would like to emphasize today a particular aspect of it, not just education in general, but a specific that I feel is critical that we must deal with, and it has already been addressed here to some extent. Math and science education and particularly in our K–12 system, I think there is a major question, a big question about whether it is adequate to provide U.S. leadership in the future world, and that is not overstated. If we think about all the things that we have—the products, auto-

mobiles, air conditioners, communications, houses, microphones, lights, everything else—they all have some basis in math and science.

Whether you are talking about manufacturing or agriculture, food, transport, or our standard of living, they are all based in what we do in math and science. We have been ahead of the rest of the world because our math and science excellence and the research that came from that in just a short time frame of international history of only a little over 200 years—it has been good enough in the past, yes, but it is not necessarily good enough for the future.

A couple of things have happened. One, it hasn't been too many years since globalization was just a big word, a theory for the future perhaps, but now it is real. The second area is that other nations are emphasizing math and science more than we are in their school systems.

Now globalization, if you think about it in the morning, you turn on your TV set and you see the Wall Street quotes on stocks, closely followed by the Hang Seng Index, the Nikkei Average, the Frankfurt quotes, quotes of the eurodollar, right on around the world, indicating that tens upon tens of billions of dollars are floating around the world all the time looking for places to go where there is good research, where there is entrepreneurship and where there are trained workers, and that is what the other nations are now out-doing in preparing their people for that kind of a world in math and science in particular.

It is not that our kids are getting dumber; they are not going down in their IQ. It is just that other nations are beginning to recognize what the goose was that laid the golden egg for the United States and they are emphasizing their science, particularly math and science, and they are beginning to out-do the United States of America, of all things.

Now this is what concerned Secretary Riley in the last administration. He had seen the Third International Math and Science Study and the National Assessment of Education Progress, NAEP. The TIM Study, as the first was called, was a study done of K–12 education with 41 nations around the world. What it basically found was that our kids, up to about the fourth grade, do fine. We are in the top few nations in the world in math and science up through about the fourth grade. Then things start deteriorating and by the time our kids get out of high school, we are near last in comparison with these 41 nations around the world.

Now when we looked into this, Secretary Riley asked me to chair the National Commission on Math and Science Teaching for the 21st Century, which I did. We had a very notable group we put together for that—educators, legislators, some Members of this Committee; the Chairman was a Member of the Commission. We had leading educators from all over the country come in, particularly in this area of math and science.

Now what we found out was that about one-fourth of our math teachers in this country never had any training in teaching math. They are teaching out of field. They never had any training as either a major or a minor when they were in college. Twenty percent of our science teachers were the same. Thirty percent of both math

and science teachers, on the average, leave the profession within 3 years, and 50 percent are gone within 5 years. Now that is a boiling turnover that we cannot tolerate for the long term.

There are also some differences in the ways of teaching that we saw when Jim Stigler from San Diego, who had done international studies of teaching methods, showed us some of the different things that are used in Japan to teach and how their methods of teaching vary from ours, and also in Germany. Where our kids are taught more in rote and memorization, the Japanese model for their kids is that they teach more problem-solving, thinking about it, are given a problem and then are asked to solve it. Then they get back to trying to determine within the class how they got to their final solutions on this. It is a different approach to education entirely.

Now if we doubt that this is an emergency, the emergency is already here and the Congress itself here has witnessed that because back a number of years when I was still in the Senate here, as a matter of fact, we passed legislation which permitted an immigration waiver of 115,000 people per year over a 3-year period because industry and business was coming in telling us we just cannot get our own people into these high-tech jobs; we do not have the people to fill the jobs.

So we passed that legislation and that did not even solve it. So about 2 years ago the Congress passed again an immigration waiver of 195,000 per year for 3 years of highly technically trained people. As I say, this was done mainly at the request of business and industry and the computer people, who could not get people to fill those good jobs.

Now how do we correct this? In our system, if we can say that it is a system at all, it is very difficult. All of our competitive nations around the world, the major ones, have a national education system through K–12. In this country we do not have an education system as such. What we have are a little over 14,700 independent school boards all getting elected independently and doing their own thing. So we do not have a system and the Federal impact on this, I think, is somewhere around 7 percent of the funding and a lot of that goes to school food programs and lunch programs and things like that.

So it is very difficult. We cannot do like Britain did a few years ago and say we have to upgrade our math and science, so they call about five meetings around the country, they change their curriculum, it goes into effect next fall. We cannot do that here because we are operating with 14,700 school boards, each one doing their own thing, and I might add too many of them getting elected by promising not to raise your taxes as a basis for why they are elected.

So we do not have an education system that we can just plug in and say we are going to change the system and make it more effective.

So what can we do? What our study showed, we approached this in three different areas. We wanted to improve the present teacher force, the ones that are out there right now. Second, we wanted to have greater numbers of teachers in preparation. We wanted to recruit teachers. Then number three, make that work environment one in which we could make teaching attractive and make it as fi-

nancially rewarding as the competition is, the competition being business and industry that hires away too many of our best teachers. So that is something we tried to address with this report.

The report, which we have given to each Member of the Committee—I hope the staff, as you suggested, Mr. Chairman, will take this to your Senator and make sure that they have a chance to see it. Michael Eisner at Disney also volunteered their efforts to put this on tape, videotape, so we gave each one of you a copy of that, also.

To make sure this got to the people that we felt could make the biggest change in the shortest time period, we mailed this to every school board member and superintendent in America, and that was a big job and that was our objective. We think that we actually got about maybe 85 percent. So this report has gone out, so the school board members across the country should have seen this. We hope they take it to heart and do something about it.

Under each one of these three titles, the three goals that we had, we have a number of things that could be done under each one of these and they are listed in that report. We will not have time here today to go through all of these things separately, but under the improvements that can be done right now, in place, are such things as a needs assessment first, having summer institutes, inquiry groups, leadership training, Internet portal access, a coordinating council for math and science teaching, and a rewards program.

Now under the others, we had, number two——

The CHAIRMAN. John, we have about 5 minutes left on this vote. Senator Mikulski will be back in a couple of minutes. She voted early. So she will continue and I will be back in about 6 or 7 minutes for the questions.

Mr. GLENN. Good.

The CHAIRMAN. We will recess just for 2 or 3 minutes.

[Recess.]

Senator MIKULSKI [presiding]. The hearing will reconvene. And while Senator Kennedy is voting, I am going to go to some of my own questions. I also ask unanimous consent that my own statement go into the record because we know that the hearing has been interrupted, but we have read the testimony of both Senator Glenn and, of course, Dr. Verner.

[The prepared statement of Senator Mikulski follows:]

PREPARED STATEMENT OF SENATOR MIKULSKI

Thank you Mr. Chairman.

Doubling NSF's Budget: Two years ago, Senator Bond and I started the call to double NSF funding over five years. Unfortunately, budget constraints prevented us from reaching that goal.

But now we have an opportunity to take a major step forward. By authorizing a doubling of NSF funding, we will be sending a powerful message to OMB. If we can double NIH, we can double NSF.

The only way we can double NSF is through cooperation between the Administration and Congress. It is unfortunate that OMB provided NSF with a just a 3 percent increase for this year. 3 percent increases are just not good enough.

Over the past 10 years, we have had essentially a flat Federal R&D budget. We cannot continue on this path.

Why double NSF? Because of the double value we get for our investment.

Double Value: First, we get cutting edge research in science, unlocking the mysteries of our universe.

Second, we get new technologies that will create new jobs and new markets for our economy.

The future of our economy in science and technology rests on three pillars: Information technology, Biotechnology and, Nanotechnology.

It is critical that we increase funding for these interdisciplinary programs as well as traditional basic scientific research.

Over the past several years, funding for the life sciences has far outstripped funding for the physical sciences. Doubling NSF will help correct this imbalance and increase funding for the core physical sciences.

Over the past 10 years, research in the life sciences has grown from 41 to 47 percent of total Federal research funding, while at the same time, the combined share of physical sciences and engineering in Federal research dropped from 37 to 29 percent.

Education: The only was we can reach our national goals in these disciplines, is if we have a growing corps of math and science students. The Bureau of Labor Statistics predicts that during this decade, hitech occupations will grow by 47 percent, compared to 15 percent for the labor force as a whole.

Improving the quality of math and science education is critical. Each year, the VA/HUD Subcommittee increases funding for math and science education. But we also need to look at new approaches.

That is why I co-sponsored the Tech Talent legislation last year, along with Senator Lieberman, and included $5 million in the VA/HUD bill.

The Tech Talent bill seeks to improve the quality of undergraduate science education through innovative undergraduate programs. We need to increase graduate student stipends to keep attracting more graduate students to research.

Last year, I increased graduate stipends from $18,000 per year to $21,500 per year. But, the real crisis is found at the middle school and high school level, we need to attract more teachers in math and science.

U.S. high school students taking physics lag behind students in Norway, Sweden, Russia, Denmark, Slovenia, Germany, Australia and seven other countries.

According to the Glenn Commission, the nation will need 240,000 middle and high school mathematics and science teachers in the next decade.

A survey of urban school districts, by the Council of the Great City Schools indicated that up to 95 percent of our urban school districts had an immediate demand for high school science and mathematics teachers.

The fact is that this country's future competitiveness rests on our ability to develop a U.S. work force that has the skills necessary to meet the increased competition coming from abroad.

Solving the problem of producing more high-quality, homegrown scientists and engineers—and a well educated workforce—depends upon solving the math and science education problems we have at the elementary and secondary levels of our school system.

Conclusion: We have a big challenge ahead of us as we enter the new millennium. The proposal we have on the table is one that would double the National Science Foundation. That is a goal I have been working towards for the past several years and together with Senator Bond, this Committee and the rest of my colleagues in the Senate, I hope we can make it a reality.

I would like to go right to my questions related to Dr. Colwell.

Ms. Colwell, as you have heard Senator Bond and I say, we would like to double the funding of the National Science Foundation. This is not merely rhetoric but, as you know, we have been working on a bipartisan basis to double the funding of the National Institutes of Health. That national effort has served the Nation well and we believe the NIH. Yet, at the same time, we are deeply concerned that the focus on physics, chemistry, the basic building blocks of science have been underfunded and often overlooked. This also is true of very important research that is needed, as well as developing the next generation of scientists.

So having said that, could you share with us, as we do the march to double the funding for the foundation, what would NSF do that it cannot do now and what do you think should be the most important priorities for doubling? I will just let you, rather than me have

a long question, let me have a short question and you have a long answer.

Ms. COLWELL. Thank you, Senator. Whether the NSF budget is doubled or tripled or even stays the same, our priorities are going to match the Federal Government's three overarching priorities; namely, defeating global terrorism abroad, protecting us at home, and strengthening our economy. Now this goes across all the scientific disciplines. Let me just show you how the NSF is making unique contributions to each of these priorities and that is where we would like to see strength.

That is in basic research, from blue sky to blueprint, it's always going to be the most important to protect our armed forces. If you trace any useful item in our arsenal back to its origins, you will discover that the basic research in physics, chemistry and materials——

Senator MIKULSKI. Doctor, remember I have 5 minutes.

Ms. COLWELL. Yes, I do, Senator. Physics, chemistry and material science are very important. They are a crucial step. We also have been supporting a dozen research areas that impact on defense, like intelligence-gathering and secure systems. This is——

Senator MIKULSKI. You do intelligence-gathering at the National Science Foundation?

Ms. COLWELL. Not intelligence-gathering, but the capacity through information technology, cybersecurity, to enable intelligence-gathering, Senator, I think is really critical.

Also, I think that we must invest in education K–12, education in our undergraduate schools, education at the graduate level, for the scientists and engineers that we need for the workforce. We have to, I think, address the major directions of nanotechnology, the social and behavioral sciences. We have an initiative request in this budget which is critical, and that is understanding risk, risk assessment, understanding the capacity for the computer-human interface, the directions that we——

Senator MIKULSKI. Doctor, I appreciate that, but I was looking for a few more practical things. For example, right now the average grant at NSF is $125,000. Is there a backlog of really solid-sounding research to be funded?

Second, what we are concerned about in the area of education is that foreign students comprise 40 percent of all Ph.Ds in science and engineering. This is not a xenophobic comment on my part. Nor do I have disdain about that. But in 1987 it was 35 percent. Is it that we are not recruiting? Is it that also our grants are spartan and skimpy? You really leaned on me last year to raise the stipend.

Could we have some practical things, in addition to those national priorities that you, the president, and OMB agree upon?

Ms. COLWELL. Senator, thank you for focussing me. You are absolutely right. In fact, I do have some charts of grants that we have not been able to fund that are rated very good or excellent and not able to fund because of insufficient availability of funding.

We also have worked extremely hard to raise graduate student stipends because we know from the studies that we have done that especially minority students, it sometimes takes 7 years to get to a bachelor's degree because they have to work; their families are

unable to support them. They end up with a very hefty debt, so they are not able to go into graduate school. So we need to provide a graduate stipend that is appropriate.

And we have just completed a very interesting study of grant size and duration in which it shows quite clearly that we need to have grants of approximately between $200,000 to $300,000 per year, not $113,000 per year and up to 5 years and not 3 years, as is the present case, for one major reason. We did a survey of about 6,000 people and got a 92 percent return and almost to a person they said that if they had the funds they would invest them in people—in graduate students, in post-docs, and that is exactly what we need in science and engineering for today and for the future.

Senator MIKULSKI. I thought you competed for a grant to do research; you did not compete for a grant to make an investment. Have I missed something?

Ms. COLWELL. No, you have not missed—what I am telling you is that in order to better carry out the research, if the additional funds were available they would hire graduate students and post-docs to help them achieve their objectives and they would get more results faster and they would have the ability to explore ideas that they cannot explore now.

Senator MIKULSKI. I appreciate that.

I am going to turn to my colleague Senator Jeffords, one of the really leading spokesmen here in terms of public education, who I know will go to Senator Glenn and Dr. Verner.

But how many—last two practical questions—about how many grant requests do you get a year and how many of those can you fund at the spartan level of $125,000?

Ms. COLWELL. We are now receiving 32,000. We got up until last year about 30,000. It is up to about 32,000 per year and we are able to fund 9,000. We have about $2.5 billion of grants that are rated very good or excellent that we cannot fund.

Senator MIKULSKI. Even though you would like to double the size of the grant because it actually gives us better research, we also need to help the farm team for graduate students, which gives us more value for the dollar. The people playing single-A ball—I'm an Orioles fan, so bear with me—then go on to really major league research. Am I correct?

Ms. COLWELL. Yes, you are, Senator.

Senator MIKULSKI. Well, thank you. There are so many other questions, but I am going to turn to my dear and esteemed colleague who has really helped keep the focus on public education in the Senate the way it needed to be.

Senator Jeffords.

Senator JEFFORDS. Thank you very much for those very kind words.

Senator Glenn, you were not finished with your testimony, I believe.

Senator MIKULSKI. Oh, I am sorry.

Mr. GLENN. Well, I was very close to it.

Senator MIKULSKI. I thought you all had kept on talking. We would. We would talk to an empty room. John, you are disappointing me. I thought you had even talked to an empty room. I apologize.

Mr. GLENN. I was within a couple of minutes of winding down. I was just going to give some examples to wind up with on my remarks about—this will just take a couple of minutes here—examples of the need for this. You know, we have depended pretty much on our productivity going up and yet if we have a productivity increase of about 2.6 percent per year, we would double our standard of living every 25 years and that is a good objective. We do not do that without math and science.

This is sort of a potpourri here, jumping around a little bit. The Department of Labor says we will have 20 million new high-tech jobs by 2008. And just in health sciences and computers we have 5.6 million new jobs by 2008. They say that in 1950, 80 percent of the jobs in the country were classified as unskilled, and now in the year 2000, 85 percent of the jobs are classified as skilled. You do not address that without math and science.

Training Magazine estimates that business and industry spent $62.5 billion to train the people they needed in 1999. A member of our committee at the National Commission that I headed, one of our commission members was Craig Barrett, who is the head of Intel and I think everyone probably knows that Intel is the biggest computer chip manufacturer in the world. I think they make about 80 percent of them. They spend $160 million a year training their people on things that he said about two-thirds of which is in areas that they should have had coming out of high school. $160 million a year, one company. No wonder they all wanted us to give waivers to let foreigners come in here, immigration waivers so that they could be put into these high-tech jobs.

One of the Midwest think-tanks says the skills required for 60 percent of all new jobs in the 21st Century are possessed now by only 20 percent of the current workforce.

And some of the figures here, Department of Education figures, 1995 to 1996, nonresident aliens in engineering, math and info sciences, 35 percent of the bachelor's degrees, 44 percent of the master's degrees. They are out-competing Americans and then going back home, going to be competitive with us there.

Examples of what is happening are in Ireland. We do not think of Ireland as being a hub of great scientific activity, yet right now 60 percent of all the business application software sold in Europe comes out of Ireland because they have a good background in science and math.

So anyway, those are just some summary remarks here, but just one thing that Dr. Colwell just mentioned in passing here was the military aspect of this thing. If we are really serious about the war that is going to be going on for the next 15 or 20 years and we need whatever we need—we need nuclear deterrence, submarines, B–2 bombers, missiles, vaccinations, night vision, GPS, satellite communications, encryption, you name it right on down the lot—all based in math and science. If we get behind in those areas to any nation in the world or any group that wishes us ill in the world, we are just playing dangerous games with our future.

So I am very much in favor of doubling, tripling, or whatever you can get for NSF. I think it is needed. I hear that one of the previous witnesses said they would triple NSF. If I had my way I would say five times NSF. I will go him two better.

I just think it is that important that we get this back on track again and the difficulty is we do not have an education system where you plug this in and say here is what is going to happen. To repeat what I said a while ago, over 14,700 independent school boards in this country doing their own thing, some of them excited about math, some of them thinking it is a waste of time. If it was good enough for me, it is good enough for my grandkids; that is their attitude and it is just too bad because if we could excite the school boards of this country to do something about it, maybe we would get a lot faster action, but we do not have that kind of a thing.

I know when I was in the Senate if I had made a speech and said we should go to a national education system, I would have been run down the east steps of the Capitol before I could have gotten the words out, but here we have all these school boards that take great pride in their local ability, their local pride in local control, but they are not measuring up in local responsibility to see this danger for the future and do something about it. So thank you very much.

[The prepared statement of Mr. Glenn follows:]

Testimony to the
Senate Education Subcommittee
By
Senator John H. Glenn
June 19, 2002

Let me first express my deep appreciation to Senator Kennedy and the Education Subcommittee for the invitation to testify today. Not only is it a delight to see good friends, but also because mathematics and science teaching and learning have engaged my interest and energies for the past few years.

I want to take the opportunity today to discuss with you the following paradox: While the United States maintains a profound superiority and leadership in technology and innovation in every field, we lag behind the rest of the world significantly in our commitment to prepare the coming generations of American school children in the areas of math and science.

The evidence of this troubling phenomenon comes from a variety of respected and independent sources. Let me briefly cite some of the evidence. The Third International Mathematics and Science Study—known as TIMSS (1995) and TIMSS-R (1999)—found that US students did not excel in those fields as most Americans might suspect they would. Fourth graders scored only slightly above the international average in math and admirably near the top in science; eighth graders were only slightly above the international average in science and below the average in math. And, by the twelfth grade, our students score at the very bottom of the rating scale by international measures. In other words, **the longer American students stayed in school and studied these disciplines, the less favorably they compare with students in other countries**.

It's not that our children have become less intelligent. The fact is that other nations have seen the extremely rapid rise of the American economy and way of life, and have recognized the key role that math and science have played in that phenomenon. As a result, they are putting far more emphasis on math and science education than we are, and their children are becoming better prepared for the future where 'globalization' and increasing international competitiveness will be the norm. **There is no guarantee that the United States will always be the world leader if this imbalance of educational emphasis is permitted to continue.**

Thankfully, there are a few bright spots. The TIMSS-R analysis found that our top-performing school districts, such as Naperville School District #203, IL or the First in the World Consortium, also in Illinois, already keep pace with the top-performing nations. A different kind of bright spot was demonstrated by some states and districts with the courage to participate in the assessment, despite inevitably poor results. These districts are much better prepared to make progress armed with hard data that show how their students perform against their international peers.

Nonetheless, news from international comparisons remains grim. Results in 2000 from the first administration of the Program for International Student Assessment —known as PISA—show that the mathematics and science literacy of American 15-year-olds (usually 10th grade) is only average in comparison to 28 participating countries in the Organization for Economic Cooperation and Development (OECD).[1] In comparison to the US average, eight countries[2] have higher average scores in mathematical literacy and five countries have lower scores[3]. In science literacy, seven countries[4] have higher average scores and four[5] have lower average scores. In each category, the remaining countries[6] had average scores similar to the US.

Similarly, in the most recent administration of another important study, the National Assessment of Educational Progress (NAEP), to a representative sample of all US students, 74% of the fourth graders, 72% of the eighth graders, and 83% of the twelfth graders scored at 'basic' or 'below basic' in mathematics. In science, 71% of the fourth graders, 68% of the eighth graders, and 81% of the twelfth graders scored 'basic' or 'below basic.' [See the Appendix for this data and other relevant information for this testimony.] Such levels of understanding are certainly insufficient to achieve success in the next higher math or science course. And, for vast numbers of graduating high school seniors, postsecondary education or employment in any area which requires facility in math and science is not an option. State tests in every part of the country reflect the same disturbing picture.

Let me note that, unfortunately, this is not a new trend. The NAEP studies from earlier years show that, while there have been marginal improvements in scores over the past thirty years, US students have been performing at disappointing levels since the 1970's. And, the relative position of US students in international comparisons has stayed disappointingly average or below average since the 1960's.

And yet, to again cite the paradox, look what has happened in our nation and indeed throughout the world in the last thirty years. We have led and helped usher in a revolution in learning and discovery that affects every corner of the globe. The advent of the information age—the proliferation of computers, access to the internet, the globalization of our economy and culture—all these forces have combined to present tremendous opportunities and demands on every aspect of our society. Our education system remains the gateway to the opportunities that result from this information revolution.

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[1] OECD is an intergovernmental organization of 30 industrialized nations that serves as a forum for member countries to cooperate in research and policy development on social and economic topics of common interest. [From the National Center for Education Statistics, US Department of Education]
[2] They are Japan, the Republic of Korea, New Zealand, Finland, Australia, Canada, Switzerland, and the United Kingdom.
[3] They are Italy, Portugal, Greece, Luxembourg, and Mexico.
[4] They are the Republic of Korea, Japan, Finland, the United Kingdom, Canada, New Zealand, and Australia.
[5] They are Greece, Portugal, Luxembourg, and Mexico.
[illegible] France, Austria, Sweden, the Czech Republic, Spain, Germany, Norway,

Yet sadly, we are not now keeping up, not even coming to grips, with the momentous requirements of our changing world. Other nations, seeing the advantages we have gained through education, are pursuing an aggressive course of action to improve the educational attainment of their students. Most important, we are not coming to grips with the need for all students to acquire a solid background in math and science. A small cadre of highly capable mathematicians, scientists, and engineers will no longer be sufficient to meet workforce demand and the challenge of innovation. Neither would a general populace unable to make accurate observations, develop conjectures, and test hypotheses—in short, unable to apply a scientific approach to the decisions of daily life and informed citizenry.

As you might imagine, I am not unfamiliar with the rigors of math and science. I could not have aspired to being a pilot or an astronaut if my interests in learning were not in these fields. I started out as a chemistry major at Muskingum College, a small liberal arts school in my hometown of New Concord, Ohio. I had ambitions then of becoming a doctor or doing medical research. That is, until I saw a notice on the Physics Department bulletin board in 1941 describing something called the Civilian Pilot Training Program.

This federal program offered to train pilots not only in the skill of flying, but in the sciences of aerodynamics, and I signed up immediately—despite some concern on the part of my parents who worried that no airplane was really safe. This was at the beginning of World War II—and I was proud to serve at this ominous time, knowing as we all did that the nation was headed into the uncharted territory of a World War that threatened our very annihilation. After the Korean War, I knew that I would continue to fly; but I could not envision then the great adventures I would later be so fortunate to take part in as an astronaut. Like many of my generation, we were swept up by the adventure of a world discovering new frontiers in science.

We had the opportunities to make our contribution to this wonderful nation—a country that was then, as it is now, rich in the gifts of democracy. We knew also that the price of admission to enlightened citizenship was a good education—and that we could best help others and ourselves by our own individual quest for knowledge. In other words, that learning was a form of our patriotism. I do not believe, despite the passage of time, that this simple truth has changed.

Against this backdrop, I welcomed the invitation in 1999 of Former Education Secretary Richard W. Riley to chair a National Commission that would be convened to study the roots and consequences of the persistent national trend of low student achievement in math and science. As Dick knew, the empirical evidence had been mounting that showed children in the US did worse than their counterparts in other countries and that there was no end in sight unless we took dramatic steps to close this critical achievement gap. In his travels as Education Secretary, he had also heard the concerns of the business and higher education communities about students poorly prepared for the opportunities awaiting them after high school. He asked us not only to

analyze the problem, but more importantly, to recommend a series of aggressive and comprehensive action steps.

The distinguished panel of education, civic, government, and business leaders who made up the Secretary's Commission [A list of the members is included in the Appendix] became increasingly impressed with the urgency of our task. We reached out to teachers and students, to employers and elected officials and education professionals at all levels. We found a collective concern about the depth of the problem, and about the consequences to the broader society if it were not solved. We also found unanimity about where we must start if our nation were to change the trajectory of this unacceptable state of affairs.

The unanimous answer? **The most direct route toward improving math and science learning for all students in this country is to improve the quality of teaching.**[7] That may sound simplistic, but the solution is far more complicated for several reasons. First, there is a teacher shortage in the United States, especially in math and science.

A study released just last month by the National Center for Education Statistics (NCES)—*Qualifications of the Public School Teacher Workforce: Prevalence of Out-of-Field Teaching 1987-88 to 1999-2000*—reports that 69% of middle school students enrolled in mathematics are taught by teachers who neither majored in math in college nor are certified to teach math at that level. About 60% of middle school students enrolled in biology or life sciences find themselves taught by teachers who are similarly 'out-of-field.' Worse yet, 93% of the middle school students enrolled in physical science are taught by 'out-of-field' teachers. These numbers are clearly unacceptable, especially when we consider the need in middle school to provide a sophisticated understanding of math and science as a basis for more advanced courses in high school.

This situation is better in high school, according to the study, but utterly unacceptable, nonetheless. A minimum of 60% of high school students enrolled in physical science—including chemistry, geology/earth/space science, and physics—had teachers without a major or certification in the subject taught. Forty-five percent of high school students enrolled in biology or life science and about 30% of those enrolled in math have 'out-of-field' teachers.

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[7] There is a growing body of research supporting the relationship between teaching quality and higher levels of student performance. Studies that focus on math and science, include, but are not limited to, Darling-Hammond, L. (1999). Supply, Demand, and Quality in Mathematics and Science Teaching. Prepared for the National Commission on Mathematics and Science Teaching in the 21st Century; Goldhaber, D.D. and Brewer, D.J. (1997). Why Don't Schools and Teachers Seem to Matter? Assessing the Impact of Unobservables on Education. *Journal of Human Resources,* 32: 505-523; Goldhaber, D.D. and Brewer, D.J. (2000). Does Teacher Certification Matter? High School Certification State and Student Achievement. *Educational Evaluation and Policy Analysis,* 22(2): 129-145; Monk, D.H. (1994). Subject Area Preparation of Secondary Mathematics and Science Teachers and Student Achievement. *Economics of Education Review,* 13(2): 125-145.

When the data is disaggregated for urban schools, the situation is likely worse. The study cited above is one of the first analyses to emerge from the 1999-2000 administration of NCES' Schools and Staffing Survey. Our Commission did not have the benefit of this data set, but we learned, for example, that among 40 large urban schools, more than 90% of them had an immediate need for a certified math or science teacher.[8] Indeed, Richard M. Ingersoll, a professor at the University of Pennsylvania, prepared a paper for the Commission demonstrating that retention was even more of a challenge among middle and high school math and science teachers than recruitment. No self-respecting principal opens school in the fall without an adult assigned to each classroom; whether the adult has the necessary credentials or the size of the class is optimal for learning may not factor prominently into the decision.

Students who fail to reach proficiency in these disciplines cannot be blamed because they are taught by someone who is only vaguely familiar with the subject matter, let alone the ever-growing body of new knowledge in the field. In studies of the condition of American education, the findings are unequivocal that the two most consistent and powerful predictors of high student achievement are (1) that the teacher is fully certified by the standards set in each state and (2) that subject matter assignments are made to match the teacher's college major.

Let's explore this particular dilemma in more detail. The analysis of TIMSS made clear that US students are not taught what they need to know, especially at the high school level. Teacher knowledge of subject matter is one explanation; a rigorous course is difficult to convey if the teacher is but one chapter ahead of students in learning the material. But, other issues are just as critical. From TIMSS, we found "...that mathematics and science curricula in US high schools lack coherence, depth, and continuity; they cover too many topics in a superficial way."[9] Also from TIMSS came the widely-used expression that our mathematics curricula, in comparison to other countries, is "a mile wide and an inch deep." That is, the rigor and pace of US courses is suspect. Even well-qualified teachers need high quality curriculum if significant learning is to occur. "Topics on the general knowledge (TIMSS) 12th grade mathematics assessment were covered by the 9th grade in the US, but by 7th grade in most other countries. In the general (TIMSS) science assessment, topics in the US were covered by the 11th grade, but by 9th grade in other countries."[10] With additional time available, students in other countries are apparently graduating from high school with deeper math and science subject matter knowledge than US students, subject matter that was not even included on the international assessment.

Even if US courses were rigorous enough, we need to ensure that students are actually enrolled in them. Four years of math and science are often not required to

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[8] Urban Teacher Collaborative (2000). *The Urban Teacher Challenge: Teacher Demand and Supply in the Great City Schools.* Council of Great City Schools.

[9] National Science Board (1999). *Preparing Our Children: Math and Science Education in the National Interest.* National Science Foundation. 15

earn a high school diploma. According to TIMSS data, "among college-bound students, half had not taken physics or trigonometry; three in four had not taken calculus, while one in three had taken less than four years of mathematics."[11] Disaggregated data heightens concern: by twelfth grade, over 34% of female high school seniors report that they have been advised not to take senior mathematics.[12] Moreover, access to rigorous courses has to be widespread. A recent report from the National Research Council found that "...the availability of AP (Advanced Placement) in a school decreases as the percentage of minority or low-income students increases, and this trend is starkest in mathematics and science. Even where such courses are available, students from underrepresented and low-income groups take them less frequently than students from other groups and may be discouraged from doing so."[13]

Just as important is the alignment of subject matter between elementary, middle, high school and postsecondary learning opportunities. Evidence is increasing that many students who earn a high school diploma are not necessarily well positioned to perform well on college entrance exams or in high performing jobs.[14] That is, students earning good grades in high school sometimes find themselves unable to qualify for the sequential credit-bearing course a few short months later as college freshmen. The business community is equally concerned about the costs of training new employees in skills that should have been acquired at school.[15] Our young people are shortchanged by not receiving a high quality secondary school education that can serve as a springboard for their future.

The root of the difficulties can sometimes be found much earlier, however. Elementary school teachers are 'teachers of math and science.' That is, part of their regular teaching responsibility includes these subjects. Yet, many of them have as little as three credit hours of undergraduate education in either field. And, anecdotal information suggests that some elementary school teachers avoid teaching these subjects in any depth because of their own lack of comfort in the discipline, thus denying their students the necessary foundation for more rigorous study in middle and high school.

A second complication is the 56 million young people enrolled in elementary and secondary schools in this country, the most ever. There are simply not enough qualified teachers around who want to teach. Moreover, the trend will not abate at any time soon. Experts predict that by 2020, there will be 55 million American schoolchildren, and by the end of the 21st century, there will be 94 million American

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[1] *Ibid.*
[2] National Science Foundation (1994). *Women, Minorities, and People with Disabilities in Science and Engineering 1994.* 94-333.
[3] National Research Council (2002). *Learning and Understanding: Improving Advanced Study of Mathematics and Science in US High Schools.* National Academy Press, 4.
[4] *Ticket to Nowhere: The Gap Between Leaving High School and Entering College and High-Performance Jobs* (Fall 1999). The Education Trust.
[5] *Training Magazine* (1999). Annual Report, Minneapolis: Bil Communications, Vol. 36, No. 10.
Downloaded from www.trainingsupersite.com

schoolchildren.[16] Congress faced this thorny issue in the recent reauthorization of the Elementary and Secondary Education Act, calling for all teachers in major subject areas to be certified by 2006. But, where are these teachers to come from, especially in math and science?

Further exacerbating the situation is the competition from the business community for math and science professionals. It has been said that we are eating our own seed corn. The demand for math and science skills is unprecedented, and unlikely to lessen despite current economic challenges. Yet, those with an affinity for and knowledge of math and science can practically double their salaries if they leave their classroom for corporate America. [And, when they do leave the classroom, the next generation of math- and science-able young people suffer.] The NCES reports that, on average, teachers earn 29% less than other employees with a baccalaureate degree. Is it any wonder that our Commission wrote: "**One powerful litmus test of how serious we are about providing high-quality mathematics and science teaching is what we are willing to pay good mathematics and science teachers. That is not really so much a financial test as it is a policy one, not so much a matter of the pocketbook as one of political will.**"[16]

Of course, many teachers—I would argue most teachers—do what they do because of the psychic rewards inherent in the profession; the satisfaction of watching young people learn, the contributions to their communities and the nation. Few professions can provide such magnificent personal rewards. But all of us, whether we have children in school or not, have an obligation to recognize the contribution teachers make to society by also paying teachers what they are worth. Unfortunately, we are a long way from that goal.

I firmly believe that our nation has become the leader of the free world and an example to others not because we have conquered other nations, but because we have expanded knowledge beyond that of any other nation. The United States has led the world in the technological revolution, in every branch of science and mathematics, in inventions, and discoveries and innovations in every field. We have made this leap despite the middling performance of our math and science teaching and learning efforts largely because inventive minds always flourish here, because the number of new ideas has been commensurate with the growth in knowledge; and because our society has invested more in these enterprises—we are home to the intellectual leaders in those disciplines.

But, if we are not careful, that may be changing, especially with the explosive growth of knowledge and opportunity. Consider, for example, some irrefutable realities of our rapidly changing world economy:

- Singapore reputedly has the most technologically intensive workforce in the world
- Israel produces more technology-based startups than anywhere outside Silicon

[5] National Center for Education Statistics (2000). *The Baby Boom Echo.* US Department of Education.
[6] National Commission on Mathematics and Science Teaching for the 21 Century (2000). *Before It's*

Valley; it has 135 engineers per 10,000 citizens—twice the US ratio.

- Ireland produces 60% of all PC-business application software sold in Europe.[17]
- US jobs in the health sciences and computer industries requiring science and math skills will increase by 5.6 million by 2008, which, in turn, requires four times as many graduates in computer science as are currently available.[18]
- In 1995-96, nonresident aliens received 34.6% of all bachelor's and 44% of all master's degrees in engineering, mathematics, and information science. These young people are returning to their native lands after graduation to work in industries competitive with the US.[19]
- The technology-driven economy will likely add 20 million jobs to the American economy in this decade, many of them requiring sophisticated training. In fact, high tech and other white-collar jobs—jobs that require advanced training—are the fastest growing occupations by far in this country, rapidly replacing blue-collar and manual labor jobs. But, we may not have the workforce to fill them.[20]

Perhaps the most dramatic development of all is that our major industries in which math and science education are fundamental necessities—finance, trade, communications, stewardship of the environment, defense, and production—are increasingly global enterprises. That means that in all those areas, fields in which the US has always been a dominant power, we now face competition that will likely threaten our preeminence as the strongest, most stable democracy in the world.

Even before September 11th, the Commission on National Security for the 21st *Century, in Roadmap for National Security: Imperative for Change* (February 2001) asserted that:

> Americans are living off the economic and security benefits of the last three generations' investment in science and education, but now we are consuming capital. Our systems of basic scientific research and education are in serious crisis, while other countries are redoubling their efforts...The quality of the US education system has fallen behind those of scores of other nations. This has occurred at a time when vastly more Americans will have to understand and work competently with science and math on a daily basis...In this commission's view, the inadequacies of our systems of research and education pose a greater threat to US national security over the next quarter century than any potential conventional war that we might imagine. American national leadership must understand these deficiencies as threats to national security. If we do not invest heavily and wisely in rebuilding these two core strengths, American will be incapable of maintaining its global position long into the 21st century.

Is this a crisis? Yes. But, let me share some of my optimism that we can resolve it

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[17] *Workforce Economics* (2000), National Alliance of Business, Occasional Report, Vol. 6, No. 1. 9-11.
[18] US Department of Labor (2000). "20 Million Jobs: January 1993-November 1999," A Report by the Council of Economic Advisers and the Chief Economist. Downloaded from www.dol.gov/_sec/public/media/reports/20mill/main.htm.
[19] *Workforce Economics* (2000), National Alliance of Business, Occasional Report, Vol. 6, No. 1. 10

effectively. First of all, we have the resources to do so. Despite current challenges, the information age has given rise to economic opportunity that only a decade ago was unfathomable. If we have the will, we can find the resources in government and in the private sector to invest what it takes in math and science education reform.

Second, there is new and sustained political will to reform education, as Capitol Hill demonstrated during reauthorization of ESEA. It was inevitable, I think, that the central issue that emerged in the last presidential election was education. Indeed, candidates in upcoming state and local elections throughout the country will likely all promise investments and improvements in our schools, regardless of political affiliation. One reason may be that in public opinion poll after public opinion poll[21], the majority of Americans say that education should be our first priority. That was not always the case. Not so long ago, education reform was an afterthought—not a priority.

Third, the timing for massive reform is right. Just as the school population will steadily expand in the 21st century, the demographics of our education system will shift as well. The current generation of teachers—many of them the baby boomers who are the sons and daughters of my generation—will retire over the next decade, as they watch their grandchildren go off to school. In the meantime, we must make sure that the teachers currently in the system receive the additional professional development they need.

But the attrition must also be looked at as an opportunity to instill new energies into math and science teaching. We need new, stronger partnerships between teacher preparation programs in higher education and K-12 school systems. Teacher preparation programs cannot continue to produce young people ill equipped for the important challenges and responsibilities that they will face. And, programs are needed for alternative certification—ways to bring mid-career math and science professionals into the teaching profession with a newly gained knowledge of teaching methods and learning theories. Aggressive recruitment and retention strategies must be put in place and perhaps most importantly in my view, greater rewards, including higher pay for good teachers with high achieving students, are needed.

In our months of work, the National Commission on Mathematics and Science Teaching for the 21st Century came to agreement on three goals[22] and corresponding strategies that will go a long way toward resolving this problem now and for future generations. We described our recommendations in a report entitled *Before It's Too Late*. The title conveys the sense of urgency felt by the Commission members, but the blueprint that follows conveys deliberate plans to make long-lasting improvements nationwide.

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[21] For example: Haselkorn, D. and Harris, L. (2001). *The Essential Profession: American Education at the Crossroads.* A National Survey of Public Attitudes Toward Teaching, Educational Opportunity and

Goal One: We must first improve the quality of math and science education in today's classroom by providing the current work force with the additional learning opportunities they need.

- The Commission called for a 'Needs Assessment' so that a system of learning opportunities for teachers can be designed to target those areas where help is most needed.
- To jumpstart the process, we also devised a series of summer institutes over five years to reach the 1.7 million teachers of mathematics (1.4 million elementary school teachers and 300,000 middle and high school math and science teachers).
- To sustain the system of professional development, we want to identify and train leaders in each school who have special responsibility to bring the latest research to the attention of the teachers, especially the resources available on the Internet.
- Communities of learning, or Inquiry groups, in the Commission's jargon, were envisioned as structures and time for ongoing contact with colleagues, higher education faculty, and experts to improve day-to-day teaching. Although rarely available now to teachers, in-depth opportunities for continued learning is a hallmark of professionalism. Ongoing, high quality professional development for teachers, in the Commission's words, must be considered sacrosanct.
- All professionals, including teachers, must be held accountable for results. The Commission called for a system of rewards and recognition for schools with exemplary professional development programs and with improvement on rigorous assessments of student achievement in mathematics and science.

Goal Two: We must also expand the pool of potential math and science teachers by recruiting teachers from traditional and non-traditional sources and ensure that they are well-prepared to enter the classroom.

- Exemplary models of teacher preparation must be identified, according to the Commission. These higher education institutions would be responsible for collaborating with colleagues at other institutions to improve preparation nationwide. Moreover, these model programs should receive federal funds to provide scholarships to talented high school students to encourage them to enter the teaching profession.
- The Commission also envisioned a prestigious one-year fellowship program—called Math and Science Teaching Academies—to help mid-career professionals with solid math or science content knowledge become teachers. Rather than creating new brick and mortar structures, each Academy was seen as a consortium of existing higher education institutions, neighboring school districts, business partners, and perhaps others. To ease the math and science teacher shortage and to acknowledge the special needs of new teachers, the Commission recommended that $10,000 of federal funds be available to each district hiring a Fellow, with two provisos: the district must match the funds and must create a district-wide induction program for new math and science teachers.

students who can demonstrate need and who agree to teach math or science for five years in districts with shortages of teachers.

Goal Three: Finally, we must vastly improve the working environment to make the profession more attractive and financially secure. There are already some wonderful examples of business partnerships with school districts for mutual benefit that meet this goal.

- The Commission sought induction programs for all new teachers of math and science as means of imparting the school's culture and acknowledging the leadership and excellence of seasoned veterans.
- Widespread use of technology, especially in pursuit of rigorous math and science learning, is an important component of this Goal. Partnerships with higher education and business can help provide districts with facilities, materials, equipment, and other much-needed resources.
- Paid summer internships for teachers can help expand their knowledge base of content, especially in the applications of math and science.
- Higher education faculty and business leaders can act as mentors to math and science teachers or assist them in other ways.
- Pay increases to be competitive with industry.

In 1959, when I was privileged to be selected to be one of the first seven astronauts in the US space program, I remember that all of us who took part were struck by the fact that we were at a dramatic and wonderful intersection of history. But for all the preparation and training and hard work back then, none of us knew what the outcome of those early journeys would be. We only knew that we had to make them.

In my subsequent years in public life, as a Senator for 24 years representing the State of Ohio, I have watched the sea changes in the space program. And, when I was fortunate enough to return to space in 1998, I was overwhelmed by the advances in everything from the progress in space travel to the facilities and food that are now routine. Frankly, I didn't feel so much like a pioneer, as a relic. The one immutable lesson I take from that adventure as it has endured with me over the years is that all we do may be borne from our dreams, but it must be grounded in our never-ending quest for, and commitment to, nurturing a nation of learners.

We must not delay the needed investment in improving our education system generally, and in the areas of mathematics and science in particular. The information age is the new next frontier, and we cannot hesitate to embrace that challenge any more than we had the option, over four decades ago, to turn away from the vast and unknown opportunities that awaited us in space.

It is time—past time—to commit as a nation to the high purpose of education reform in math and science teaching and learning and to meet head-on the future. With the Commission's report, we have merely put forth a blueprint for what improvements are possible. Now, it is up to all of us—elected officials, business leaders, community activists, average citizens—to become the architects of that dream.

Let us all embrace this effort and begin this century with the promise to restore the US to its place as the world leader of learning as well as the guardian of democracy and the defender of the world's stability and military strength. Americans will always look to the stars, but we must do so with our feet firmly planted in the realities of what we are capable of accomplishing and what we must do to achieve our goals.

In that light, we must first believe that every student can master a rigorous course of study in math and science when given the opportunity to do so, and we must call on the enduring American spirit to make it happen now. There is no more important mission that we can undertake together in the next decade and beyond. And, it is not too soon to enlist our energies and commit our resources. We must, in fact, begin ***Before It's Too Late***.

Thank You.

The National Commission on
Mathematics and Science Teaching
for the 21st Century

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Deborah Ball, University of Michigan
Craig Barrett, INTEL Corporation
Diane Briars, Pittsburgh Public Schools
Rep. Cynthia Chestnut, Florida State Legis.
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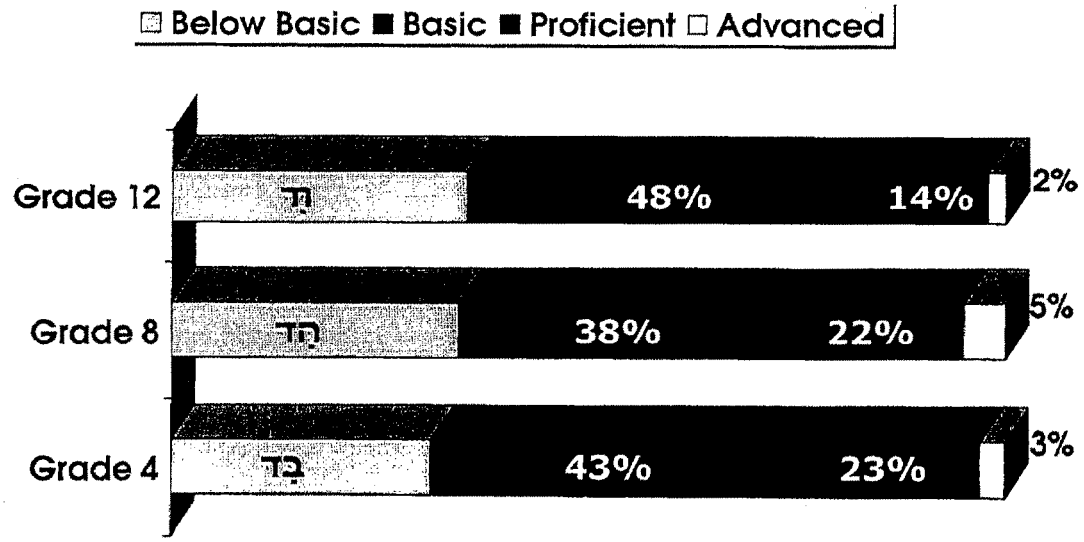
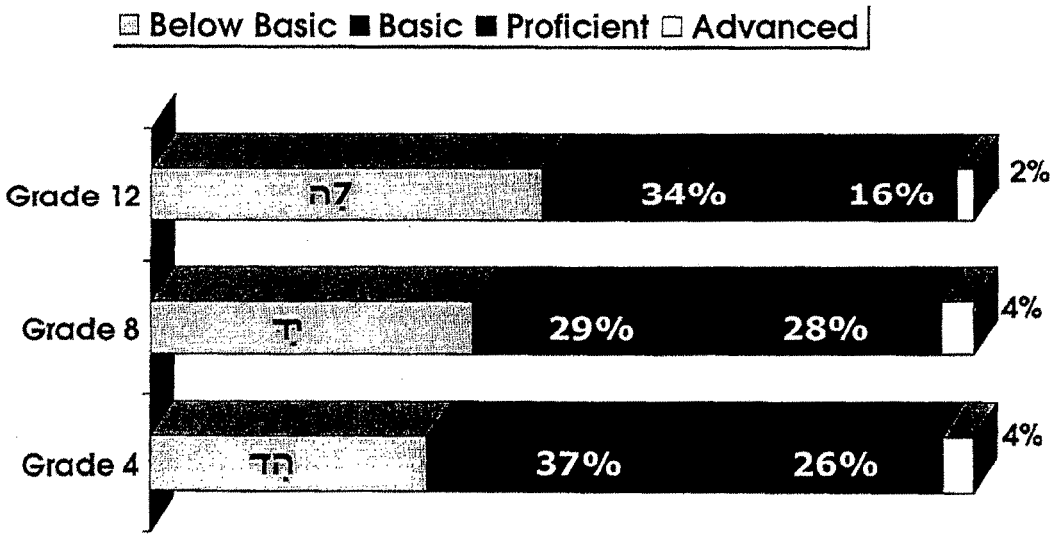
Chang-Lin Tien, UC Berkeley
Dennis Van Roekel, NEA

Percentage of Students Within Each Math Achievement Level by Grade Main NAEP 2000



Source: U.S. Department of Education, Office of Educational Research and Improvement. NAEP 1996 Mathematics Report Card. April 2001.

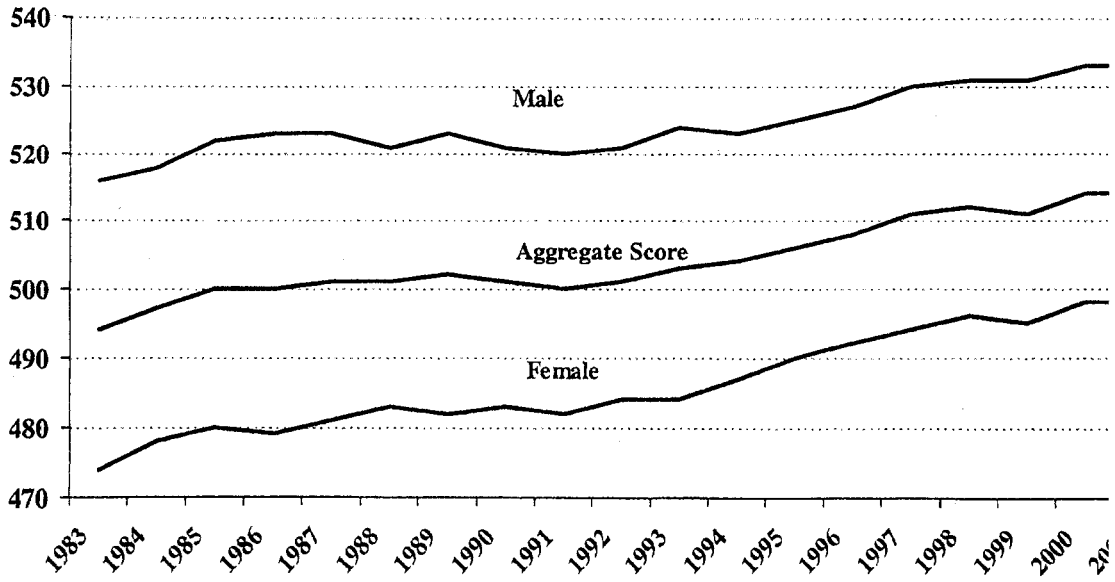
Percentage of Students Within Each Science Achievement Level by Grade Main NAEP 2000



Source: U.S. Department of Education, Office of Educational Research and Improvement. Student Work and Teacher Practice in Science. July 1999.

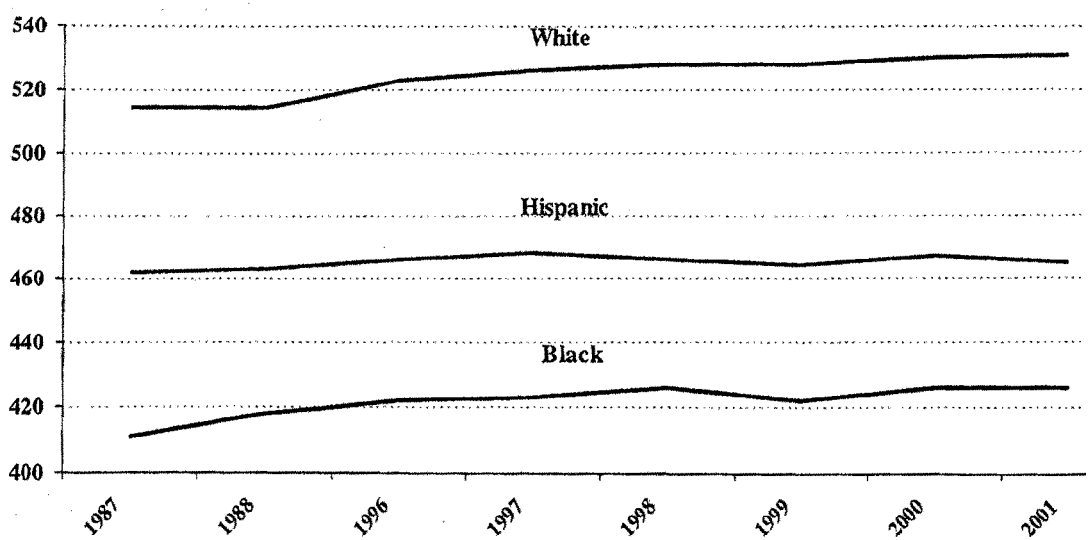
Average Math SAT Scores by Gender, 1983-2001
Percent of High School Graduates Taking Test

1983: 33%
2001: 49%



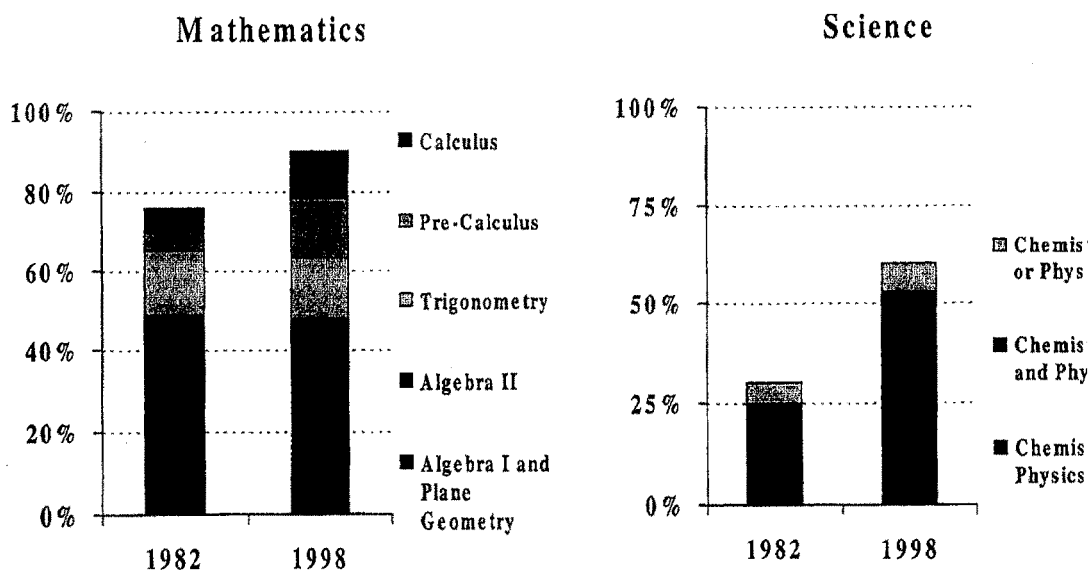
Source: The College Board. "Profile of 2001 College-Bound Seniors."

Average Math SAT Scores by Race/Ethnicity, 1987-200



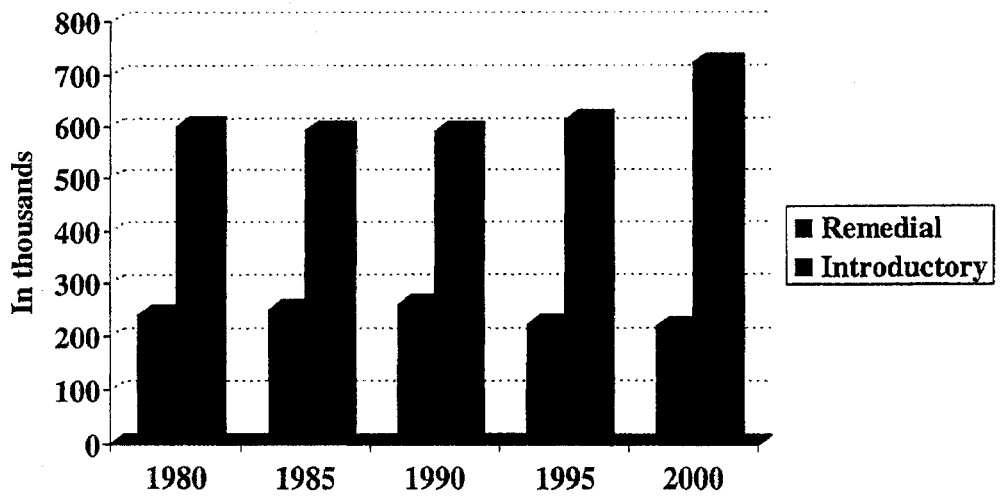
Source: The College Board.

Highest Levels of Math and Science Taken
High School Graduates 1982 and 1998



Source: National Center for Education Statistics. *Monitoring School Quality: An Indicators Report.* U.S. Department Education, December 2000.

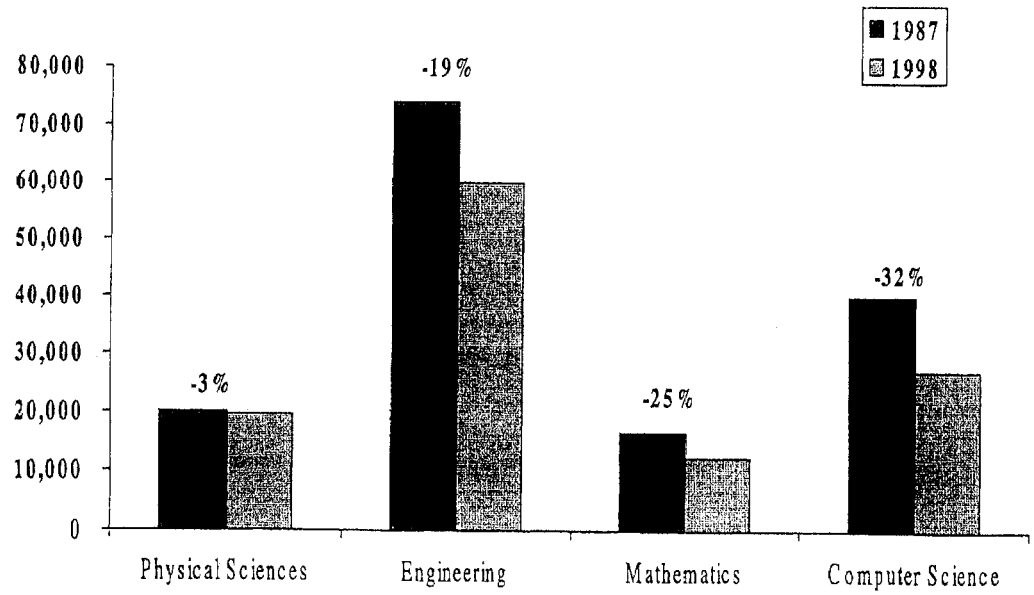
Enrollments in Introductory & Remedial Math at 4-Year Postsecondary Institutions, 1980 to 2000



Source: Unpublished data from the 2001 Conference Board of Mathematical Sciences survey

Change in The Number of Bachelor's Degrees Awarded in I and Science Related Majors, 1987 and 98

Total Bachelor's Degrees Awarded: + 19%



Source: U.S. Department of Education, National Center for Education Statistics.

Bachelor's Degrees Awarded in Selected Disciplines by Gender, 1998

Distribution, 4-Year Undergrad Enrollment			Number of Degrees		Distribution	
Men	Women		Men	Women	Men	Women
45%	55%	Computer Science	19,686	7,166	73%	27%
		Engineering	[illegible]	[illegible]	[illegible]	[illegible]
		Mathematics	6,596	5,732	54%	46%
		Physical Sciences	[illegible]	[illegible]	[illegible]	[illegible]
		All Other Fields	420,261	631,621	40%	60%

Source: National Center for Education Statistics, *Digest of Education Statistics 2000.* U.S. Department of Education, March 2001.

Senator JEFFORDS. Thank you and you are right-on. I will be back to you.

Dr. Verner, please proceed.

OPENING STATEMENT OF KEITH VERNER, CHIEF OF DEVELOPMENTAL PEDIATRICS AND LEARNING, PENNSYLVANIA STATE UNIVERSITY COLLEGE OF MEDICINE

Mr. VERNER. Thank you very much. I guess before I start I would just like to say to Senator Glenn that I notice the same problem with school boards so I actually ran and got elected to be on one.

Mr. GLENN. Good for you.

Mr. VERNER. I am pleased to be here to discuss with you really the crucial challenge of improving basic science education. I do not need to cite how poorly our students have done on international tests in math and science because that has already come up here today, and I do not think I have to accentuate how important it is for our students to be able to think scientifically in an increasingly technological economy and society. So basically I am not here to point out the problem, but to suggest ways in which I believe that the scientific community can help address this problem.

As a scientist who is dedicated to the mission of improving basic science education what I will do is just begin by describing a couple of our programs at the Penn State College of Medicine as a means of showing you an example of how the scientific community can address this problem.

Now both educational experience and cognitive science suggest that science is best taught with a hands-on approach that blends the cognitive appeal of experimental activity with comprehensive, standards-based science instruction. But the ability to deliver meaningful hands-on science while making sure that there are no gaps in the conceptual basis of the curriculum requires that the curriculum directors have a very deep and comprehensive understanding of science and this is not an easy task.

I therefore suggest that this challenge is best approached through collaborations, direct collaborations between practicing scientists and basic educators. What better way to interweave deep content expertise with practical classroom experience?

This was essentially the vision that guided us to employ teams of scientists and public school educators at the College of Medicine to create what we ended up calling the LabLion Program for elementary school science. Its features include a dual emphasis: first, on promoting interest in science and conveying knowledge, and also in developing concise, complete and grade-appropriate inquiry-based lesson plans. This program is currently employed in many schools across Pennsylvania and, in fact, there are over 25,000 Pennsylvania elementary school children that are in this program at this time. This is just an example of the types of programs that can be derived from these interactions between scientists and educators.

For science teachers, thinking in terms of scientific concepts and principles that, in the end, give meaning and context to scientific facts and formula is essential. And scientists can help in this regard by organizing content-rich educational experiences for teachers.

To this end, as another example, we have designed and implemented the Governor's Institute for Life Science Educators in Pennsylvania over the past several summers. The Life Science Institute is an intensive in-residence program at the College of Medicine for 100 teachers per summer, and summer is a wonderful time at a medical school to bring in teachers like this, because we have the student housing available to us. Mornings are spent in activity-based group lessons that begin on Monday morning right after breakfast with the dissection of a human cadaver and gradually become more molecular as the week progresses, with strong integration of biochemistry and biophysics. Afternoon and evening sessions are devoted to grade level-specific scientific content and lesson plans, as well as different approaches to teaching strategies.

Now such professional development programs, I believe, are a direct and very important way that the scientific community can help improve basic science education. Based on analysis of student NAPE scores and teacher professional development programs, Wenglinsky concluded, and I quote: "In science, students whose teachers have received professional development in laboratory skills outperform their peers by more than 40 percent of a grade level." That is very important.

Now Title II, Part B of No Child Left Behind gives guidance and funding for preparing science teachers to meet this challenge of improving student performance. It is also, I must say, entirely consistent with what we have learned over the years in our K–12 science and health outreach efforts. Perhaps the most important, No Child Left Behind is very results-based. For the evaluation of professional development programs, for example, it prescribes that States measure the effectiveness of its professional development programs through increases in teacher subject mastery and student academic gains, and this is very important.

I believe that this new law provides great promise for improving science and further, I believe that the National Science Foundation can and must play a major role in implementing these desperately needed changes.

The National Science Foundation is an ideal champion for K–12 science education because of its broad scientific expertise, and we have just talked about NIH. With all of the quality research it does, it very much leans toward the life sciences and yet we also know the very important contribution that physical sciences and mathematics make to fields like medicine itself.

So the NSF is in an ideal position to take a leadership role in this. Over the years NSF supported important research and it has very much helped in maintaining America's leadership in the state that it is and it has demonstrated a growing dedication to improving basic science education.

I believe that the recent involvement of the NSF in collaboration with the Department of Education specifically on the Math and Science Partnership Program offers, in my opinion, one of the greatest steps forward in this area in a decade or more. The NSF program directly addresses some of the best parts of the Title II of the No Child Left Behind Act and provides funding to make meaningful impacts. The program inspires interactions between university science departments—and I think that is important—science

departments and basic science educators. It mandates approaches to education that are based on research and verifiable analysis of student performance. Importantly, it values teacher professional development and it puts the scientific community in a much more proactive position.

Therefore, as a scientist and as a strong supporter for basic science education reform, I emphatically recommend doubling, tripling the program for the NSF.

In my written report I have some specific recommendations that I would like to submit. I would be happy to answer any questions. Thank you.

[The prepared statement of Mr. Verner follows:]

PREPARED STATEMENT OF KEITH VERNER

Mr. Chairman, and Members of the Committee: I am pleased to be here to discuss with you the crucial challenge of improving basic science education. I will not cite references pointing out poor U.S. student performance in international tests in math and science or the importance of being able to think "scientifically" in an increasingly technological economy and society. It is clear from recent legislation, from the involvement of the Department of Education and the National Science Foundation, and from this very hearing today, that we as a Nation are adequately aware of the urgent need to improve science education. Therefore, I am here today not to point out the problem, but to suggest ways in which the scientific community must help to solve it. I will begin by describing two of our science education outreach programs as examples.

ROLE OF THE SCIENTIFIC COMMUNITY IN K-12 SCIENCE EDUCATION

Both educational experience and cognitive science tell us that science is best taught with a "hands-on" approach that blends the cognitive appeal of experiential activity with comprehensive, standards-based science instruction. But the ability to enable meaningful hands-on science while making sure there are no gaps in the curriculum requires that the curriculum developers themselves have a deep and comprehensive understanding of science (Verner, K., 2002). I suggest that this challenge is best approached through collaborations between practicing scientists and basic educators—What better way to interweave deep content expertise and real-life classroom practice? This was the vision that guided us to employ teams of scientists and public school educators at the College of Medicine at Penn State University, over the past several years, to create the LabLion elementary school science program. Its features include a dual emphasis on promoting interest in science and conveying knowledge; concise, complete, and grade appropriate inquiry-based lesson plans (Ruiz-Primo, M.A., et al, 2002; Wenglinsky, H., 2000); readily available supplies; very low maintenance costs following installation (Levitt, K., 2001); and a strong professional development component (van Driel, J. H., et al, 2001; Haney, J. J., et al, 1996; Levitt, K., 2000; Monk, D. H., 1994) among others. This program is currently employed in many schools across Pennsylvania, reaching more than 25,000 elementary school students, and we continually work with the educational community to improve it. Such blends of theory and classroom activity are needed for every level and sub-discipline of science education.

For science teachers, thinking in terms of scientific concepts and principles that give meaning and context to scientific facts and formulae, is essential. Helping students to build scientific concepts requires an understanding of the relationships among their components. Teachers must see these relationships and understand the logic and organization of the relationships in order to teach the concepts to their students (National Academy of Sciences, 1999). Scientists can help by organizing content-rich educational experiences for teachers. To this end, we designed and implemented the Governor's Institute for Life Science Educators over the past several summers for K-12 teachers. The Life Science Institute is an intensive in-residence program at the College of Medicine for 100 teachers per summer. Mornings are spent in activity-based, scientific content-rich group lessons that begin on Monday morning with the dissection of a human cadaver and gradually become more molecular as the week progresses, with strong integration of biochemistry and biophysics (Appendix A). Afternoon and evening sessions are devoted to grade-level specific scientific content and lesson plans, as well as effective teaching strategies.

Such professional development programs are a direct and very important way for the scientific community to help improve basic science education. Based on an analysis of student NAEP (National Assessment of Educational Progress) scores and teacher professional development programs, Wenglinsky concluded, "In science, students whose teachers have received professional development in laboratory skills outperform their peers by more than 40% of a grade level." (Wenglinsky, H., 2000).

NO CHILD LEFT BEHIND

Title II, Part B, Section 2002 of the No Child Left Behind Act gives guidance (and funding) for preparing science teachers to meet the challenge of improving student performance in science and is entirely consistent with what we have learned over the years in our K-12 science and health education outreach efforts. Perhaps most important, No Child Left Behind is results-based. For the evaluation of professional development programs, for example, it prescribes (section 2113 (c) (7)) that states measure the effectiveness of professional development programs through increases in teacher subject mastery and student academic gains.

I believe that this new law provides great promise for improving science education. Further, I believe that the National Science Foundation can and should play a major role in implementing this desperately needed change.

THE NATIONAL SCIENCE FOUNDATION

The NSF is an ideal champion for K-12 science education because of its broad base of scientific expertise in a variety of disciplines, from molecular biology to oceanography and space exploration. Over the years NSF has supported important research that has been crucial to maintaining America's scientific leadership and demonstrated its growing dedication to improving basic science education.

The recent involvement of the NSF, in collaboration with the Department of Education, in the Math and Science Partnership (MSP) program, offers the single most encouraging development in a decade. The MSP program directly addresses the best ideas put forth in Title II of the No Child Left Behind Act and provides funding to begin making a meaningful impact. The MSP program inspires interactions between university science departments and basic science educators. It mandates approaches to science education that are based on research and verifiable analysis of student performance. It values teacher professional development and puts the scientific community in a more direct and proactive position. As a scientist and a strong supporter of basic science education reform, I most emphatically recommend developing the MSP program further.

SUMMARY RECOMMENDATIONS

Schools should offer hands-on, inquiry-based science curricula at all levels. These curricula should cover a range of "concepts" providing context for factual knowledge that is essential for the scientific literacy American citizens need.

Teachers should train students, from elementary school on, to develop a conceptual framework of scientific principles. Each new concept should be linked to previous concepts within the framework so that its inclusion is logical and relevant to preexisting student knowledge.

Teacher preparation and professional development are key. Without adequate scientific experience and a scientific factual knowledge base, teachers are left to rely on science textbooks and have difficulty facilitating the building of conceptual frameworks by their students.

The scientific community can and should have a significant impact on improving K-12 science education. This involvement is now mandated by the No Child Left Behind Act. The scientific community should be proactive, and its contributions may include: Developing K-12 science curricula with basic science educators; Providing "scientific" experiences for teachers at university laboratories so that they can develop a feel for scientific thinking; Developing summer institutes on university and medical school campuses to immerse basic science educators in the latest trends in scientific thinking; Collaborating with experienced, practicing educators to translate primary scientific research results from disciplines such as cognitive neuroscience and functional neuroimaging into innovative methodologies of classroom practice (Verner, K., 2001); Directing the scientific training of pre-service teachers in schools and colleges of education to ensure that their training has a direct grounding in science; Integrating directly into the system of basic science education, in both instructional and administrative capacities, and supporting alternative teacher and administrative certification programs that facilitate such career transitions; and establishing deep intellectual collaborations with basic educators built upon mutual

respect and guided by a shared commitment to improving student performance in, and enjoyment of, science.

The CHAIRMAN. That is fine. Thank you and I thank all of you very much.

I know that we had some response to Senator Mikulski on how we deal with the future with an expanded NSF budget and I know Senator Glenn talked a little bit about why this is important in terms of national security and national defense. I might try to come back to that, about how the role and importance of education and our defense and national security, which I think is enormously important. I do not know if you have said everything, John, that you wanted to say on that, but I will look forward to reading it in the record.

Information technology, Dr. Colwell. One of the areas that I think we have a great need is using IT in terms of getting a handle on the costs in terms of health care. Five years ago, it cost $23 for a piece of paper to be filed in terms of the Mass General Hospital and Fidelity, and today Fidelity is 3 cents and going down to less than a third of a cent, and Mass General has gone up to $25.

Health and defense are the two areas where IT has not really been used and used effectively. I am wondering if you could give us any sort of ideas about how we could follow up on that, how it could be used more effectively in terms of the control on health care.

First of all, I think you do a great deal more in terms of quality of care because you would be able to monitor various kinds of outcomes. You would do better in terms of dealing with the problems of fraud in the health care area. In an industry that is $1,400 billion and spends close to $400 billion on administrative, I cannot believe you could not save a couple of hundred billion dollars.

Ms. COLWELL. There are a number of areas. One I would emphasize is cybersecurity, the ability to protect patient records and to be able to keep secure the information that is put into the database. That is one aspect.

Another is manipulating very large databases. We are doing a lot of research and investing in the capacity to handle huge——

The CHAIRMAN. Just before, on cyber issues and cybersecurity, of course, defense is spending a good deal of funds on that.

Ms. COLWELL. Yes.

The CHAIRMAN. And I am just trying to think as we look at it say, for example, in health, you have the cybersecurity from defense. How do we benefit from that research? How do we benefit from your research? How do we sort of begin to bring some of this into being attractive to the private sector to be able to develop systems which would be able to do this?

Ms. COLWELL. Actually, the National Science Foundation and DARPA, the research projects agency, and the intelligence agencies have been collaborating especially since September 11, but we had already introduced a major program September 11 on cybersecurity because it is very important for industry, as well as the health care industry, so to speak.

It is a theme that goes through the entire information technology world. I am told that we can expect next year a hacker break or virus every 10 minutes in our systems. That means that we have

got to find ways now to be able to protect our databases, our information transfer systems, and we have to do it in a way that provides us with the security that we need domestically, as well as for defense.

You asked about cost-cutting. Let me just give an example of DNA sequencing. It used to cost about a dollar a base pair and it is down to pennies and that is because we are able to do the kind of analysis of the huge volumes of data in a very much shorter period of time. What took us a month to calculate we can now do in hours or a day. That alone is a major cost-effective approach to take and this depends on our being able to develop software and we are committed to investment in IT software for the next 2 years of the 5-year initiative and probably beyond because we have to sort of keep ahead constantly.

That is one of the frustrating things about science. We scientists always tell you that here is the answer, but we still have to do more research, but that is the dynamics of being human beings and thinking beings.

The CHAIRMAN. Could you talk a little bit about the nanotechnology? I asked two or three people about it who did not know and then I asked my son and he knew. At least he started off with a description that he'd been learning about. I would be very interested in what you are doing and how you see the technology.

Ms. COLWELL. Let me explain it as a microbiologist, if you will. A bacterium is about 1/25, 400th of an inch and a typical bacterium has a little whip-like appendage that propels it through an aqueous medium and that is driven by a tiny motor within the cell, which is probably a hundredth the size of the cell. So you are beginning to get the dimension of where we are working. We now have the capacity to make electromechanical motors about the size of a red blood cell, which means that we now can actually implant a motor on the wall of an artery or a vessel that will allow us to monitor blood pressure, perhaps even to monitor iron concentration if you tend to be anemic, on a continuous basis.

And we are able to build materials from the atom on up so we can custom develop materials now in a way we never could before—stronger metals, stronger materials.

So we have an entirely exciting future ahead at the nano scale. As Richard Fineman, a very famous scientist, physicist once said, "At the very, very small level you can do very great things." I am paraphrasing him.

So I think that it portends even greater wealth accretion, accumulation and development and job creation than information technology, and we already know what that has done for us in terms of being able to do the kinds of things we never could do before. With making things smaller and more effective and working from the atomic level up, we are able to, I think, create in a fantastic way in the future.

So that is what we are working on and that is what we are investing in and we have in the budget about $280 million, I believe, of requests to keep us in the forefront, but I remind you in a visit to Japan a month ago the Japanese are investing $900 million for

that country alone in nanotechnology because they do understand that that is the future.

The CHAIRMAN. Getting a well-qualified teacher in every classroom, having that teacher competent in terms of math and science, giving teacher quality a priority in funding—you have outlined these recommendations. What is really necessary? I think you would find that the American people, of all the issues on education, the one that is at the top—there are a number that are very, very close to the top, but at the top is having a well-qualified teacher in the classroom.

Now you list here the kinds of steps which are necessary to get there, but what is your sense, knowing the institution that you served nobly in and understanding what is happening out in the grassroots and having heard and having a series of hearings, what is the national will?

Mr. GLENN. Part of it is resources, but I think we addressed our report—we made sure the report got in the hands of every school board member in America—we think we got about 85 percent of them—because we thought that is where the changes could be made more rapidly than anywhere else. And we have had some good responses back from some school board members, too, that are taking the issue to heart.

The first thing we stressed, though, was improving the present status of math and science teaching in the classrooms right now. How do we take an existing bad situation where 25 percent of the people teaching math never took that as a major or a minor, never were trained to teach math? I can see why up to the fourth grade I could probably teach math up to the fourth grade, but beyond that, when you get into algebra, advanced algebra, and so on, then you need special training to do that kind of teaching, and that is the reason why things fall off. Twenty percent of our science teachers, the same way.

In the more lengthy report here this translates into greater numbers. It is up in the 60 percentile of our students that are not getting adequate training in math and science in the schools, particularly in the urban schools and some of the ones that have the least facilities, the least ability to get good teachers into those particular areas.

To get good teachers right now and train the ones in place right now, we think you have to do a needs assessment. We had summer institutes, inquiry groups, leadership training, Internet portal access, coordinating councils, reward programs. They are all listed in the back of our report there as to what we think need to be done to upgrade people where they are right now.

Number two, how do we get more people in? How do we recruit good people and improve their preparation? And we make some suggestions in that area of exemplary models that can be followed, some things to do on recruitment, math and science teaching academics, not brick and mortar, but reorganizing some of our teacher training areas, and improving the work environment, not the least of which is pay. We just refuse across the country to pay teachers what teachers are worth, so it is no wonder that the good math and science people are hired off by industry at probably double the sal-

ary that they are able to make as teachers. Business district partnerships are another area that we talk about, also.

Also, in high school quite a different area, Mr. Chairman, has been mentioned here today, though I think we should be challenging our kids to a more rigorous course in school. I think that is a very important thing. You go to Japan or Germany or some of these other places around the world. You visit a classroom and the kids are generally about 2 years ahead of our kids in math and science in what they are studying. What our seniors in high school would be studying, they are studying as freshmen or sophomores in high school because they have a far more rigorous system that leads up to it.

All that means that at the farther level down in the school system we need teachers better trained at a lower level if we are going to alter that, so that our kids come out of high school with the same level of education and do not need remedial education before they have to go on to even consider entering college.

So it is a very tough one and particularly when we have our main support for education still the local school board, the local school district and what little equalizing funds that the States may be able to provide to certain districts. But it is a tough one and you have put your finger on the real part of the problem.

The CHAIRMAN. My time has expired, but I was wondering if we could ask Linda Rosen if she would visit with our staffs some morning or afternoon and invite all of our Republican and Democratic staffs and on this and have a working session, as well. If she would be good enough to do that at some time that would be convenient, I think it would be very valuable.

Ms. ROSEN. I would be happy to.

The CHAIRMAN. And what recommendations they have for us.

Senator Jeffords.

Senator JEFFORDS. Thank you. I am so pleased to be here with you today, because I think this is probably the most important hearing we could have for the future of this Nation.

I am convinced that actually some of the problems are very simple. Like if you do not pay your teachers enough to stay in the job, you do not get the kids to learn too much.

I talked to Rick Mills, head of the New York school system, and he says, "Jim, you are absolutely right. Eighty-eight percent of my math teachers that are still there are over 55 because they are locked into their pension program and I do not know what I am going to do when they all get to be the age to retire."

When I look over at what the rest of the world does and see how we handle our school systems relative to pay for teachers, I am shameful, shameful.

Also, I would just point out that the H1B, we are now up to 1 million certificates of H1Bs for kids to come in from foreign countries, young people coming from foreign countries to take the jobs that our young people should have. That is shameful that we are in that kind of a situation.

But to me, you also analyze how—I need some studies done here and I hope you take note. How do we compare, for instance, with European and Asian nations on just how we pay our teachers? If you take a look at the amount of money that goes from the Federal

Government around the world as compared to ours, about 30, 40, 50 percent of the money at the local school district comes from the Government. In our country, it is 7 percent and you cannot compete with having to depend upon the local resources and the local property tax to pay the teachers.

So unless we do something about getting the money to the areas that it is needed to hire the teachers, we are not going to attract the teachers or anything else. I hope maybe you can do a study for me and really outline as to what every other country does with respect to paying their teachers. Japan is the best example. They make sure that their teaching level of pay is within the top 10 percent of wage-earners in Japan, it is my understanding. These come from some of the work that the AFT did some years back. So I hope we can get some real credible information so that we can get to the core of this.

Incidentally, the United States Government pays just 1 percent of our total Federal budget toward education, elementary and secondary anyway, and I think post-secondary, as well. So it is a small amount and it is shameful that we do not put more into it.

The only time we really did take notice was back after World War II when we had a similar situation. Right now we have no adequate number of math teachers. Back in World War II we had millions of GIs that came back that had nothing more than a high school education and many of them did not even have that. So what did we do? We passed the GI bill and that moved us from 1 percent of the Federal budget up to 7 percent of the Federal budget and that brought about an incredible educational opportunity for all of our GIs. They motivated themselves and lobbied and got it done.

So what I want to end up with is hopefully I can get the NSF to verify what I am saying because there is not anything else that really puts it together in a form that we can go back to Congress and say look, here is what everybody else in the world does and here is what we do and guess what? These are the results of us not doing that.

So I would like maybe a comment or something, but I get so energized on this that I sometimes lose track of the time. John, do you have any comments you might make?

Mr. GLENN. Yes, I do. Out of our report on page 36, if you happen to have it right in front of you there, down in the lower left-hand corner, "The National Center for Education Statistics reports that on average, teachers earn 29 percent less than other workers with a baccalaureate degree." That is just general, across the board baccalaureate, whatever they are going into. They earn 29 percent less—$35,048 per year compared to $49,362 per year. That was in 1997, a differential that has nearly quadrupled during the economic expansion of the 1990s. It is getting worse instead of better. You would think that we would have learned enough that we are going to have to pay teachers to keep them in the job. And the demands of the economy and workplace are widening this gap. Given that the national average starting salary for teachers is $25,735, the teaching profession is nowhere near being a financially competitive option for most young people who leave college with back-

grounds in math and science. And we have to change it; you are absolutely right.

Senator JEFFORDS. Dr. Colwell, can you do some studies for me?

Ms. COLWELL. Yes, we can certainly provide the comparative data. I would add that this is an interesting phenomenon of the decline in performance of students that is beginning to appear in other countries, as well, including Japan. At the moment the Japanese students are performing better, but when I was talking to my colleagues in Japan a few weeks ago the science minister said yes, but once they get to university, they are not going into math and science majors.

So it is a curious phenomenon. The performance in England of students in the elementary, middle and high schools is declining and the interest in science and mathematics is declining. And there is the immigration of students who are the scientists and engineers coming from countries like Turkey, Pakistan and India.

So it is something that I think we have got to address in an international arena, as well. It is certainly very, very serious for us because we find that just as your own data quoted, Senator, that the majority of the students who are, let us say, doing a Ph.D. in electrical engineering will be—not even a majority, but almost all of them will be from other countries. We could depend on them to stay, but that is no longer something we can be sure of because they are beginning to return because of the opportunities back home.

So it is something that we can look into for you, sir, but I do think that this is a kind of global phenomenon that we may want to have some sort of a summit study on.

Senator JEFFORDS. Thank you. I just get so upset when I see what we could be doing and what we should be doing, but what we are not doing and we seem to think it is simple to get the local school boards to get on the stick or to spend more money, but I do not know how it is in—I know our State, the property taxes are so high now, trying to take care of the educational needs, if you want to get unelected, just try and raise the property taxes. And the only answer is the Federal Government has to do it and I am going to try to make sure they do, but we will see how that goes, but I would like to increase the amount that we pay each year, from 1 percent per year, increase the amount of money we put into the local schools and after about 10 years we would be up to somewhere around where the Europeans are.

I thank you very much.

Senator Glenn.

Mr. GLENN. Just on the cost of this thing, in our study with this, in the back of this thing we put what we thought was necessary and broken down between the Federal, the State and local and what business might contribute and public-private back here. We came out with an estimate of a little over $5 billion a year that is needed right now to do the teacher training and get it going now and do teacher training and recruitment training, and so on. It is in the back, the blue page, page 42 if you want to check out what our figures are.

Senator JEFFORDS. Thank you.

The CHAIRMAN. Senator Clinton.

Senator CLINTON. Thank you very much, Mr. Chairman. I am delighted that Senator Glenn is here with us testifying about these really important matters. And thank you, Dr. Colwell and Dr. Verner. I am just sitting here in great admiration listening to Chairman Kennedy and Senator Jeffords and Senator Glenn talk about this really important issue. I wish that more people had heeded their warnings in the past years because the three of them have certainly sounded the alarm and it is not getting any better. In fact, it is much worse in our poorer districts where we have concentrations of children of poverty whose first language is not English, who for all we know have tremendous math and science capability, but it is not being given an opportunity to flourish. I mean, they are basically off the track before they get started.

So it is a double disgrace, Senator Jeffords, overall it is, because of our failure to make these investments, and then in particular, because of the people that it falls most heavily on.

So I certainly hope that we will heed the recommendations of Senator Glenn's fine report and I hope that a lot of those school board members watch the video and read the report and I hope our colleagues will, as well, and perhaps we can, with your guidance, come up with some suggestions about how to turn this around.

I support very strongly the increased funding for NSF. I think it is clear to all of us that we have to make these investments. Then, though, we have to act on what we learn. All too often, Washington—or at least this body—seems to be existing in an evidence-free zone and we have to figure out how to take the results of the work that NSF, the scientists whom you fund, the kinds of reports that Senator Glenn has championed, and actually use it as the basis for policy.

So I think the first step is to make sure we provide the funding. The second step is actually to heed what you recommend to us and not continue to just proceed merrily along while the situation worsens.

I had a couple of very specific questions, because certainly I am very proud of the fact that New York is a recipient of quite a bit of National Science Foundation funding and there were a couple of projects that I think hold great promise for our Nation, and indeed, the world that I wanted to inquire about, Dr. Colwell.

About 5 years ago, scientists at Brookhaven National Lab, in collaboration with Stony Brook University, NYU, Syracuse and about a dozen others, submitted a proposal for exploring rare particle physics techniques called the rare violating processes or the RSV project. I have been told—I am certainly not an expert in this, but people whom I respect and trust have told me that if funded and the work is undertaken, RVP could potentially change our understanding of nuclear physics and nature. I know that the project passed the rigor of NSF peer review; it was placed on the to-do list. The scientists involved were assured that if their project did not make it into the fiscal year 2002 budget it would almost certainly be in the fiscal year 2003 presidential request. However, it was not included in either.

As a result, it is kind of languishing in—I guess you could say "the black hole of approved MRE proposals." There is more than $15 million in foreign contributions waiting to be expended, which

is now on the verge of literally disappearing since the collaborators' international partners are losing faith in the selection process. And if I have one question and slight criticism of the process, because I think overall the NSF has done by far the best job of any federally-funded agency, it is that when scientists work as hard as these have to put into motion this kind of project, have literally global interest, and then it does not come through, it sets it back and it sets back the collaborative enterprise.

So first, could you give me an update on the status of the RVP proposal and when you anticipate it would be funded? And second, is there a lesson that we should learn from this particular proposal, which is not unique, but is the one that I know the most about, that even after MRE projects have been approved in the competitive peer review process, we do not have any prioritized list and it is hard to know whether somebody should continue to wait, whether they should change direction even if it is a very worthy undertaking.

So how would you help me understand where we are with that specific project and then more generally, what we can do to avoid these kinds of hang-ups in the future?

Ms. COLWELL. Well, the status of the RSVP is that it is in a small set of the National Science Board-approved projects that are waiting for inclusion in an NSF budget request and it is strictly a matter of at this point funds that are available.

We have a very careful prioritizing process whereby these projects go through very intense screening and review within the foundation. They are then presented to the Science Board for additional evaluation and approval, but then, of course, must negotiate which projects get funded and we have a priority that those that are on-going will be funded because it would not be cost-effective to stop and start. Then those that have been approved and have gone through Science Board approval then will be in line to be submitted for budget request.

A project becomes a candidate, is determined by a very systematic planning and review process, which involves scientific merit, feasibility and readiness. In the case of RSVP, it will depend on funds being available and we would hope that in the coming budget years we would be able to fund the project.

I have to point out that quite rightly, and through no one's fault, there were no new starts in the fiscal year 2001–2002 budget process, which created even more of a bottleneck, so now we do have several projects which we need to get through the budget process.

Senator CLINTON. And I guess the President's budget has a decrease. Is that right?

Ms. COLWELL. The decrease is——

Senator CLINTON. In MRE funds.

Ms. COLWELL. Yes.

Senator CLINTON. That reduces it by about 9 percent, right?

Ms. COLWELL. Part of that is due to one of the projects nearing completion, so it is not necessarily a decrease in the funding.

Senator CLINTON. Well, do you think we should increase MRE funding specifically in this reauthorization?

Ms. COLWELL. I think that the answer to the question is that scientists need tools and what we need to understand is that we fund

people who have very good ideas. We fund their ideas, but they have to have tools to work with and tools mean telescopes, investment in platforms for research, like the earthquake engineering platform, the nanotech manufacturing initiative, and so forth. So scientists do need tools.

Senator CLINTON. Related to that is that, and this is, I think, a very hard decision, but one of the very few criticisms that I have heard is that the current NSF budget is rather heavily tilted toward the life sciences at the present time and that there are other sources for life science research, as compared to research in physics, chemistry, et cetera, which often lays the groundwork for future life science breakthroughs or at least in conjunction with life science research create the synergy that is needed for the kind of advances. Do you think we should address that in the reauthorization?

Ms. COLWELL. Let me answer that very directly. Actually, we do not have an imbalance within the NSF budget toward the biosciences and life sciences. In fact, the funding that we provide is funding for projects that would not be funded by NIH—fundamental ecology, fundamental developmental biology, study of organisms other than the human or closely related organisms.

We fund within the life sciences some very, very important research. For example, the capacity for bioinfomatics really comes from the NSF funding of mathematics and biology. The genomics that we do, plant genomics, very critical. Senator Bond has been very, very supportive of that area. NIH would not be funding the Erabidopsis genome, for example. This is critical and very important funding.

Indeed, the balance is important and we tried very hard to address that. And I think it is critical to point out that we also address very carefully the core disciplinary programs because it is very important to address the opportunities in interdisciplinary science, like nanotechnology, which involves biology, chemistry, engineering, mathematics, and you cannot have excellent nanotechnology if you do not have excellent engineering, chemistry, mathematics and physics. So clearly we have to continue investing in those core areas.

And another aspect of it is that we have to tie that more and more to the social and behavioral sciences and we do have in our budget request $10 million to get established an initiative in the social behavioral sciences and the economic sciences. Those are very critical because we need to look at the computer-human interface. We must not make the mistake of making huge advances without bringing along an understanding of how humans interact with these new tools, with these new ideas.

So yes, a balanced portfolio is really important.

Senator CLINTON. Well, certainly we hope that we can increase your funding so that a lot of these hard choices do not have to be made.

Ms. COLWELL. Thank you.

Senator CLINTON. I think we are at a point now where we have a tremendous opportunity to make advances along a range of scientific enterprises and endeavors that I hope that we will make the

investments in and we need the pipeline that Senator Glenn has talked about so that we have scientists we can fund in the future.

I just want to end with referring to the point that Senator Jeffords made with the visa issue because I think that we have to figure out a way to incentivize more of our own students and citizens because I think that we are going to have some continuing issues around the visas and we have to figure out a way to—it is something I have talked to Senator Jeffords about; he has a real passion about it and any ideas any of you have.

I mean, it is not that we want to eliminate that process, but the process needs to recognize that right now all we have done is used it in many ways to fill positions that we should be taking a long-term approach toward filling ourselves. It is a short-cut way to try to provide some of the additional math-science personnel that we need, but it is not a long-term solution.

Ms. COLWELL. May I offer a comment? I think both of you are extremely strong on a very important point, and that is we are now looking at the sources of the talent that we need in the future and community colleges do represent one very important one. Let me share my recent visit to Mercy College, which is in Tarrytown, New York.

Senator CLINTON. I know, right.

Ms. COLWELL. I gave a commencement address there recently. That is a very interesting institution because it has 10,000 students and 80 percent of those students are attending college for the very first time in their lives. The average age is 29. Forty percent are Hispanic, 40 percent are African–American and 20 percent are Asian and Caucasian. These students, the valedictorian was a refugee from, I believe, Afghanistan who arrived at Mercy College speaking no English at all and graduated as the valedictorian and gave the speech in English and has performed extremely well.

I think the talent in the community colleges is sort of like Willy Sutton. Why did you rob banks? Because that is where the money is. Well, we are finding that that is where students are that we really need to bring into the workforce. So that is an area where we are making greater investment.

Senator CLINTON. I look forward to hearing about that because I agree with that completely.

I have some additional questions that I will submit for the record.

[The prepared statement of Senator Clinton follows:]

PREPARED STATEMENT OF SENATOR CLINTON

I would like to thank Chairman Kennedy and Ranking Member Gregg for holding this important hearing today on the reauthorization of the National Science Foundation.

The National Science Foundation has a long-standing reputation as one of the federal government's most efficient and smoothly-operating independent agencies. In honor of those qualities, our Chair has decided to hold just one single hearing on the entire authorization. That is because while NSF faces crucial questions of the day related to our nation's progress—which we could discuss for days—we believe the agency does an excellent job and that this authorization will move swiftly. I do a have a few questions that I will raise later in the hearing.

I am delighted that our committee could hear from such an esteemed panel of witnesses. It is a pleasure to see my friend, Senator John Glenn back in the Senate, where he left an outstanding legacy of promoting the education of the sciences from

kindergarten to the postdoctoral years. And he continues to be such a strong voice through the John Glenn Institute for Public Service and Policy.

The National Science Foundation is a national treasure. Since its establishment more than 50 years ago, it has fueled scientific discovery and spurred technological progress that has transformed our world into a place that is so vastly different from the nation we were at the close of World War II.

Whether its life-saving technology such as magentic resonance imaging, or the dawning of the Information Age, with the creation of the internet, the National Science Foundation is the engine of progress.

I am proud that New York has been on the forefront of that innovation. My state brims over with an extraordinary level of intellectual capital and promise. We have been blessed with hundreds upon hundreds of opportunities, thanks to the NSF. In fact, New York holds the distinct honor of having the second highest number of NSF-funded projects, second to California.

From Ithaca to Buffalo, and from New York City and Long Island, the NSF enables cutting edge research and state-of-the-art experimentation to take place in every corner of my state. Whether it's the Science and Technology Center for High Pressure Research at Stony Brook University exploring the properties of earth materials or the Sciencenter at Cornell where local elementary school children learn about things like nanotechnology and experience the excitement of science, the NSF delivers a bounty of gifts to all New Yorkers.

New York holds a unique and enviable position in the emerging field of nanotechnology. Again, with the help of NSF, New York has become what I like to call "the Nanotech State of the 21st Century."

New York is home to three of the nation's six nanocenters—located Columbia, Cornell, and Rensselaer Polytechnic Institute. These were created as a result of the National Nanotechnology Initiative (NNI) which was established during my husband's administration.

Just this week, New York celebrated another exciting milestone in its emergence as the "capital of Nanotechnology," when the Department of Energy announced its plans to create a seventh center at Brookhaven National Laboratory on Long Island. We are proud that the Center for Functional Nanomaterials at Brookhaven will be added to our amazing arsenal of scientific innovation.

For all these reasons, New Yorkers have a lot at stake in the reauthorization of NSF. We believe, as the House Science Committee supports, that it is high time for us to double NSF budget over five years. The President has proposed a 5 percent increase or $240 million above the fiscal year 2002 level. But factor in inflation, and that increase amounts to a mere 1.4 percent.

Second, while funding for NSF overall has increased from fiscal year 2001 to the fiscal year 2003 budget request, the physical sciences on the whole have not had their fair share of resources, particularly for individual investigator research grants, which have traditionally been at the core of the NSF mission. For example, support for physics research grants has declined by 1.5 percent from FYO1 to the fiscal year 2003 request; Chemistry research research grants support has grown by only 4.2 percent. However, the biological sciences have recently enjoyed a much more privileged provision with substantially higher increases. What's important to remember is that advances in the physical sciences are often the building blocks for advances in the biological and medical sciences.

Finally, I would like to applaud the NSF for it's commitment to funding math and science education in the K-12 level in addition to the post-graduate and doctoral levels.

As President Eisenhower used to say during the Sputnik days, an educated citizenry in the sciences is absolutely vital to our nation's security. Now as our nation tackles the formidable challenge of how to protect our Homeland Security, our investment in progress matters more than ever before and our desire to support the sciences and technology has become an imperative.

Thank you.

Senator JEFFORDS. I want to end with going to another area of great concern for me and that is early education—that is the preschool, especially the zero to five—as to where this Nation is in that regard. Again we are lacking miserably compared to the rest of the world.

Just to give you some information, I know in our own office, for instance, one of my staff members has two children under 5 years, and so he stayed out all night, sleeping overnight, in order to get

a slot to pay $1,000 per child to get an education in the early years. To me, every other nation, industrialized nation, anyway, except ours, provides that under the normal school system and I would hope maybe I can get some sort of study as to where we compare and what we are doing in this country because that is just terrible. As I remember, the studies in the late 1980s and early 1990s showed that if you do not get the education in the 3- to 4-year-old area, that you are bad off the rest of your life. I mean you are not going to maximize the rest of your life. Yet we provide very, very little for that.

I would appreciate it if you have any information on that.

Ms. VERNER. I think you are absolutely right. As a matter of fact, there are a number of studies out now that show that there is a tremendously positive correlation between preschool programs and outcomes later in that child's life.

Also, I think you could turn to neuroscience and cognitive studies now that clearly show that there is a massive and important amount of brain development that is occurring in children of exactly that age and probably in the 3- or 4-year-old group there may be some real potential for developing sort of a continuum with the K–12 system, rather than individual activities in different types of preschools, but actually integrated into a system that the teachers can refer back to some of that early education.

One of the things that comes out of cognitive science is that there is nothing more effective in education, in being able to get new information into the child's mind than referring to previous information and we should use those years of 3- and 4-years old to start putting information into their minds as a part of early education.

Where we are right now, we have submitted a very small local grant with the Harrisburg school district for this LabLion program I talked about earlier, but part of that grant would actually be to try to develop a preschool extension of the elementary school science program and what does that look like? We are not necessarily talking about 3-year-olds with test tubes and graduated cylinders, but they can actually play games where something like density and direction is important for winning the game and maybe even use some of the tools that they will later use in their elementary science education and beyond.

I just think that from my discussion with educators and from neuroscientists that we are certainly wasting a tremendous educational opportunity by not addressing the preschool years in a very serious way.

Senator JEFFORDS. Thank you. That is what I wanted to hear. Now I feel a little more secure about calling an end to the hearing. I would like to stay the rest of the day, but I know you all have places to go and I feel like I am kind of monopolizing here.

I tell you, we have a long way to go and I appreciate your information, which will help us get on the way. Thank you very much.

[Whereupon, at 3:28 p.m., the hearing was adjourned.]

[Additional material follows.]

ADDITIONAL MATERIAL

PREPARED STATEMENT OF SENATOR LIEBERMAN

I am grateful for this opportunity to speak on behalf of the Tech Talent program and the bipartisan legislation that I have introduced to permanently authorize this innovative initiative and to urge the Committee to include this provision in the upcoming reauthorization of the National Science Foundation.

As the Committee well knows, America's technological prowess is unequaled in the world today—which is why, despite our economic slowdown and the financial burdens of prosecuting the war against terror and ensuring our collective defense, we still have the strongest, most vibrant economy on the planet.

However, our long-term competitive standing and economic security could well be at risk if we do not address a troubling trendline in our workforce—the mismatch between the demand and supply of workers with science and engineering training.

Studies show that the number of jobs requiring significant technical skills is projected to grow by more than 50 percent in the United States over the next 10 years. But outside of the life sciences, the number of degrees awarded in science and engineering has been flat or declining. This has helped fuel a well-chronicled shortage of qualified New Economy workers.

We have tried to temporarily plug this human capital hole with a stopgap of foreign workers. Unfortunately, there is a broad consensus among high-tech leaders and policymakers that it could be a serious mistake to prolong this dependence and essentially render our GDP contingent on the supply of H-IB visa holders.

That may sound like a bit of an overstatement to some. But the reality is that technological innovation is now widely understood to be the major driver of economic growth, not to mention a critical factor in our military superiority. It is widely understood, moreover, that we cannot expand our economy in the future if we don't take steps now to expand our domestic pool of human intellectual capital, the next generation of people who will incubate and implement the next generation of ideas.

Now, most answers to serious economic challenges flow from the private sector, which is where growth ultimately occurs. But there are things that the Federal Government can do to help, particularly when it comes to educating and training our workforce. We can provide leadership focus, and not least of all, resources—and that is the purpose of the Tech Talent program.

Specifically, the Tech Talent program aims to fix a critical link in this "tech talent" gap—undergraduate education in science, math, engineering, and technology. As established in our bill, it would provide competitive grants to institutions of higher learning—from universities to community colleges—to encourage them to find creative methods for increasing the number of graduates in these disciplines.

This is not another scholarship program, but a targeted, results-driven initiative that goes straight to the gatekeepers. We're not asking them to change their admissions policies, but, in effect, to design new "e-missions" policies. Come up with effective ideas, and we will provide the dollars to make them work.

For example, institutions could propose to add or strengthen the interdisciplinary components of undergraduate science education. Or they could establish targeted support programs for women and minorities—who are 54 percent of our total workforce, but only 22 percent of scientists and engineers—to increase enrollment in these fields. Or they could partner with local technology companies to provide summer industry internships for ongoing research experience.

This initiative was conceived with strong bipartisan, bicameral support. Last year, Senators Mikulski, Bond, Frist, Domenici, and I introduced S. 1549, the "Technology Talent Act of 2001"; a House companion bill, H.R. 3130, was introduced by House Science Committee Chairman Boehlert and Representative Larson. By the end of the year, Congress had agreed to appropriate $5 million for this fiscal year to jumpstart the program, even though our authorizing legislation had not yet been passed.

Today, the number of co-sponsors of our authorizing bill has risen to 14 on the Senate side. The House bill, which now has 43 co-sponsors, received unanimous support during the House Science Committee markup, and is anticipated to reach the floor soon as the core of a larger undergraduate education bill.

The program also has extremely broad support outside the Congress. The Administration has embraced Tech Talent as a priority, including funding for it in its budget request for FY 2003. And the response from leaders in industry, academia, and educational communities has been tremendous—we have received letters of support from TechNet, Semiconductor Industry Association, National Alliance of Business, K-12 Science, Mathematics, Engineering & Technology Coalition, American

Association of State Colleges and Universities, Texas Instruments, and the American Society for Engineering Education, to name but a few.

Even more encouraging are the preliminary data obtained from NSF's Science, Technology, Engineering, and Mathematics Talent Expansion Program (STEP), which is the formal name of the Tech Talent program that NSF established with its FY02 appropriated funds. With enough money for between 10 to 15 grants, the NSF received 177 applications requesting a total of $59.7 million in aid—clear evidence of the vast interest in, and need for, the Tech Talent program among undergraduate institutions seeking to implement reforms in science and math education.

We all realize that solving the undergraduate problem is not going to single-handedly close our talent gap. At the same time, we should also realize that the talent gap cannot be closed without first solving the problem at the undergraduate level. Therefore, I urge you to consider incorporating the Tech Talent program into this year's NSF reauthorization bill. In doing so, we will be helping to ensure that the young minds of today will be capable of mastering and fueling the high-tech economies of tomorrow.

PREPARED STATEMENT OF SENATOR ROCKEFELLER

Chairman Kennedy and Members of the HELP Committee, I am proud to submit testimony today on behalf of a special, bipartisan initiative within the National Science Foundation (NSF) reauthorization bill that would promote math and science education, known as the National Mathematics and Science Partnership Act. I was proud to sponsor separate legislation last year with Senators Roberts and Kennedy. Chairman Kennedy, your longstanding commitment to quality education is well known, so it is always an honor to work so closely with you and others on education investments.

This legislation, which is incorporated into the National Science Foundation authorization bill, is an important investment in elementary and secondary education, as well as our economy. This legislation would create the Mathematics and Science Partnerships at the NSF, it would invest in the Noyce Scholarships to attract top college math and science students to teach at disadvantaged schools, and it would provide a range of incentives to bolster math and science education, key subjects for our future. In addition to bipartisan support in the Senate, President Bush has included $200 million in his pending budget for the math and science partnerships.

Placing a keen focus on developing quality partnerships with specific funding is targeted at improving teaching of technical subjects to students in elementary and secondary schools. We know that teaching of math and science in the early grades is pivotal to continuing science education in high school and college. Such partnerships will involve the broader community, including local business and industry, in the educational process. They increase the number of qualified teachers while providing for improved access to support in the form of materials, research opportunities, and Centers of Research on Learning.

Too many studies have indicated that as a country, we are seriously failing to effectively convey to K-12 students scientific knowledge that is needed for them to excel in major technical fields. Our elementary and secondary students currently lack mastery of technical subjects. While our 4th graders are on par with the rest of the world, by the time they reach the 12th grade, they rank in the bottom half of countries in these areas.

Students in this country arrive at college ill-equipped to study mathematics, science, and engineering. Part of the problem can be attributed to a serious shortage of qualified math and science teachers to guide our children. As a consequence, we are losing our competitive edge in the modern world. This is an intolerable situation for which there is no excuse. This initiative provides concrete action to solve the problem with a major long-term commitment to invest in our future by increasing funds to improve math and science education.

Such partnerships can help prevent America from losing its competitive edge in the modern technological world. These partnerships will focus on a wide range of efforts, from professional development to curriculum reform for grades K-12. The partnerships may include the State educational agency and half must include businesses. The partnerships are intended to develop and evaluate innovative approaches to education in mathematics, science, engineering, and other technical subjects.

In addition to the partnerships, I am particularly committed to encouraging qualified people to enter the teaching profession. This bill establishes a scholarship program for college students who commit to becoming K-12 math or science teachers after graduation. To keep educators at the top of their field, $15 million in grant

money will be awarded for math and science teachers to do research and improve their own classroom performance. Twenty million dollars are set aside each year to expand the National Science, Mathematics, Engineering, and Technology Education Library, a digital library that disseminates scientific resources through the Internet. Strengthening math and science education within the National Science Foundation for elementary and secondary education is a high priority for me.

The National Science Foundation has been a leader on quality education. My State of West Virginia has been enormously helped by several National Science Foundation education programs. The implementation of the Coordinated and Thematic Science (CATS) grant provided training to nearly 1,000 West Virginia teachers over a 5-year period. I met with the science teachers involved in this project and their enthusiasm and commitment was extraordinary. This statewide award has developed teams of mentor teachers of grades 7-10 who have provided outreach, support, and training to their colleagues. My State is also undertaking a similar initiative in math, known as Project MERIT.

Another example of a successful education investment is the National Science Foundation's Teacher Enhancement Grant, which enabled my State to provide students with a solid foundation in science and technology. This grant has made it possible for students in West Virginia to become better equipped and more competitive in the workplace and in post-secondary classrooms. These efforts made a major difference in the quality of educational offerings available to students, as these programs have provided a tremendous opportunity for West Virginia to invest in our teachers and improve education in our schools. Given the strong record of success for National Science Foundation education initiatives, I believe that this new program is a worthwhile project for my State and our country.

Strengthening the sciences is important not just for the sake of knowledge, but also to ensure that America remains at the forefront of major technological advances. Incorporating the National Mathematics and Partnership Act into the National Science Reauthorization bill should be a priority. These partnerships and investments in scholarships and professional development are key steps to reclaiming the lead in science and mathematics education. Throughout the process, I look forward to working with Chairman Kennedy and others to achieve our goals for math and science education.

PREPARED STATEMENT OF JEROME I. FRIEDMAN

Chairman Kennedy, Senator Gregg and Members of the Committee, I would like to thank you for the opportunity to submit testimony for this hearing to present my views about the National Science Foundation. At the outset, let me express my appreciation for the sustained support that you have provided for the NSF and for your commitment to improving NSF's ability to serve our national interests. I believe that the House of Representatives has shown great wisdom by supporting H.R. 4664, which includes authorization for a 15 percent increase for the NSF budget in each of the next 3 years. In preparing your own NSF reauthorization bill, Mr. Chairman, I urge you to support such an increase, and I hope that you will highlight the importance of the core research programs, since they provide the basis for all of NSF's high-priority areas.

My testimony today concerns two closely related issues: NSF's role in the development and operation of scientific facilities and the NSF's Major Research Equipment and Facilities Construction (MREFC) program, which was established to support the construction of such facilities. To provide a context for my observations and recommendations, let me begin by underscoring the extent to which science has changed since NSF's founding a little more than 50 years ago.

During the first half of the 20th Century, industrial laboratories accounted for most of the research in the United States, both applied and basic. World War II changed the picture dramatically, and by the early 1960s, the Federal Government was sponsoring two-thirds of all American research activity. Excluding work performed under contract by the defense industry, most of those Federal funds supported research carried out by relatively small academic groups. Almost all the researchers were American citizens, and for the most part they worked in on-site university laboratories in self-contained scientific disciplines.

The world of science in the 21st Century is remarkably different. Industry now accounts for more than two-thirds of R&D spending. But unlike the early post war period, when Bell Labs and other private-sector facilities played starring roles in the basic research endeavor, industry now focuses almost strictly on short-term applied research. Today, corporations rely heavily on basic research carried out by university scientists, who are funded almost exclusively by the Federal Government. For

that reason, agencies, such as the NSF, currently play an even more critical role in the science and technology enterprise than they did 50 years ago.

It is important to recognize that the way in which university science is conducted has also changed significantly. Research groups are larger. Equipment is far more complex, and many scientists carry out their research at national facilities. The scientific disciplines are also far less disjointed: they have become intertwined and highly interdependent.

Federal funding of basic research has tried to keep pace with the changing scientific landscape. Programs that cut across disciplines, such as the Nano-Science/Nano-Technology Intiative, have become integral to the Federal research portfolio. And large facilities, such as X-ray light sources and high-resolution telescopes, have become essential to the federally-supported research enterprise.

Although its focus remains the university individual investigator, NSF today supports major facilities where many of these scientists carry out their research. The Cornell Electron Storage Ring (CESR), with its associated X-ray light source (CHESS), is one of the early examples. It has been an extremely productive facility and currently serves particle and condensed matter physicists, as well as structural biologists.

But constructing and operating major facilities can have a substantial impact on NSF's overall programming. To prevent such projects from overwhelming the NSF budget and causing irreparable damage to the individual investigator core programs, NSF established the MREFC account a few years ago. It is a very worthwhile concept, but I believe that it is still suffering from growing pains. While MREFC projects undergo close scrutiny in a competitive peer-review process, NSF currently does not provide the science community or Congress with a prioritized list of approved projects. The lack of transparency has prevented orderly planning by the research community. As a result, science has suffered and international research partners have been left dangling.

The Rare Symmetry Violating Processes (RSVP) project is a good example. Conceived almost 5 years ago, it passed the rigor of peer review and was placed on a "to-do list" by the National Science Board (NSB). The scientists involved were assured that if their project didn't make it into the FY 2002 budget, it would almost certainly be in the FY 2003 presidential request. Neither happened, and $15-million in foreign contributions is about to vaporize, since the collaboration's international partners are understandably losing faith in the selection process.

To remedy the MREFC difficulties, I suggest that the NSF be required annually to submit to Congress the full list of approved projects in a prioritized order that has been established with the concurrence of the NSB. The NSF should provide an explanation of the criteria used for setting these priorities and a statement of its reasons for any deviations from the priorities it set the previous year.

The NSF should also be requested to present a long-range strategic budget that takes into account the operation of the facilities it plans to construct. Otherwise core program budgets could be jeopardized when operating funds are needed to bring a new facility on line. I would also like to emphasize that core program and MREFC funds should not be commingled, either in planning or in practice. Finally, for management and oversight purposes, NSF's annual budget should have a separate line for facilities operation; and all projected facilities operation costs and MREFC construction costs should be presented each year as part of a rolling 5-year plan.

In concluding my remarks, I would like to emphasize how important the National Science Foundation has been in advancing both science and education in our Nation. In addressing some of issues that I have mentioned, legislation should also contain features to increase the effectiveness with which the NSF can carry out its mission.

The NSF is a national treasure. It stands as a model of peer-reviewed science and individual investigator research. Its financial and programmatic health is essential to our Nation's future.

PREPARED STATEMENT OF IOANNIS MIAOULIS

The National Science Foundation—(NSF)—through its numerous investments in research and education, has made this Nation stronger, and better educated. At Tufts University, we are particularly proud of NSF's contributions since the founder of NSF, Dr. Vannevar Bush, was one of our own engineering students and graduates. His assistant in starting the National Science Foundation, Prof. Lloyd Trefethen, was actually my undergraduate advisor and mentor while I was an undergraduate at Tufts.

The following constitutes my perspective concerning the reauthorization of NSF and its mission to advance science and engineering education. My comments center on three issues:

The impact of NSF on the Nation's overall research and development portfolio and the benefits of NSF-funded basic research, including research done at Tufts University.

The impact of NSF on science and engineering education and training programs in universities such as Tufts.

The impact of NSF on improving K-12 science and engineering education programs and encouraging partnerships between K-12 schools and universities

The impact of NSF on the Nation's overall research and development portfolio and the benefits of NSF-funded basic research, including research done at Tufts University

During the past few years, there has been a significant shift of the sources of basic research from industry research facilities to university and national laboratories. Industries are focusing more and more on applied research and development with near-term high return on investment. A major contributor of the growth of the U.S. economy during the second part of the last century was Federal investment in basic scientific research. Investments in the areas of physical science and engineering have resulted in the best science and technology program in the world. Investments in these areas have also advanced other areas of science and even human health. A significant component of the research, which culminated with the development of the CAT scan, was conducted in our Physics department at Tufts under the late Prof. Cormack who won the Nobel Prize in Medicine in 1980. Clearly, computer science, mathematics, physics, and engineering are essential to the advancement of human health and provide the foundation for new discoveries in biomedical science. However, funding for the physical sciences and engineering has remained level, while the increase being proposed for the NIH for FY2003 alone is more than two-thirds of the current total FY2002 NSF budget. Our Nation has an unbalanced R&D portfolio, favoring the life sciences. Under-funding the physical and engineering sciences will in the long run have a detrimental effect on the life sciences.

Inventions and discoveries that help humanity, such as X-ray machines and Penicillin, often occur serendipitously. From my personal experience, the NSF has been critical in supporting basic and applied research activities in my laboratory that has continued to lead from one exciting discovery to another. Moreover, the winding sequence of findings has been supported by a variety of NSF programs that defy logic. I began my research in studying thermal processing to recrystallize silicon films used for the microelectronics industry. This research was supported by the Engineering Directorate at NSF and has helped to improve the way we make computer chips. The research also led to an interesting discovery whereby minute changes in film thickness resulted in large changes in heat absorption and quality of the crystal.

This fascinating phenomenon appeared to be a powerful means of controlling the thermal process. As an aside, I wondered whether nature had taken advantage of this phenomenon. Asking a graduate student to take a leap of faith, we delved into an exploration to find examples of biological thin films that utilize the phenomenon. We found that butterflies do, in fact, have thin films optimized to serve multi-functions as signaling as well as collecting solar energy. The NSF Biology Division funded a project to develop an innovative tool to examine these structures. Our results found an amazing array of complex thin film structures, some that looked like spherical mirrors and others like pine trees in a forest. Why and how these structures are created is a subject of interest and debate among academic communities.

These complex structures inspired my research team to look into emerging research areas in microelectromechanical systems and nanotechnologies. How can we create these microscale structures in innovative ways to serve interesting engineering functions? NSF's Engineering Directorate again is supporting my team's research into rapid manufacturing of microscale and mesoscale structures. This research may lead to new means of developing sensors and actuators to be used in Homeland Security as pathogen detectors or to create high throughput scanners to discover life-saving drugs. Through NSF's support of basic and applied research, we have been able to make a number of key findings that have linked together progressively.

Other Tufts engineering faculty have obtained NSF support for fundamental studies into fibrous protein structure assembly for the past 6 years. These studies are supported through the Divisions of Materials Research, Bioengineering and Biology. The scientific insights gained from these studies have provided an improved understanding of this important family of structural proteins (e.g., collagens, silks). This information has led to the direct use of these proteins in new biomaterials applica-

tions and in new tissue engineering studies. The result of these efforts have included a variety of clinically relevant studies supported through the NIH, new interdisciplinary studies and opportunities for undergraduate, graduate and post-graduate students, and new spin-off companies based on the findings. Other engineering faculty at Tufts is working on NSF-funded projects that will revolutionize mammography techniques by using optical spectroscopy for imaging of human tissues.

Although we have had our successes in attracting NSF funds for conducting basic research, we have had numerous disappointing moments. Many good ideas that are submitted and are rated excellent by the majority of the reviewers do not get funded. And the funding for the fortunate ones is limited in duration and annual amount. In his March 12, 2002 testimony before your committee, Dr. Stephen Director from the University of Michigan, presented detailed statistics of this problem. Additional funds are needed to enable NSF to fund more great ideas at a higher funding level and duration. The Nation's creative minds should spend more time focusing on their research and less time trying to get funding.

THE IMPACT OF NSF ON SCIENCE AND ENGINEERING EDUCATION AND TRAINING PROGRAMS IN UNIVERSITIES SUCH AS TUFTS

Two of the greatest challenges that our Nation's engineering schools face today are attracting and retaining students in general, and more specifically, women and students of color. Although the demand for engineering graduates has increased dramatically, engineering enrollments have decreased by approximately 15 percent during the last 8 years. In addition, the percentages of students of color and women are quite small. Approximately 18 percent of the undergraduate engineering population nationally is female. It is difficult to attract engineering students, yet it is more challenging to retain them. It is customary for an engineering school to lose 30-50 percent of its undergraduate population during the undergraduate years. At Tufts, we have reversed both of these trends, and I strongly believe that without the support we received from NSF we would not have been able to succeed.

Most students do not drop out of Engineering because they cannot handle the work. In fact, the national average grade point average of female students transferring out of Engineering is a B+. They transfer out because they simply do not find the field interesting. Unfortunately, most of them transfer out during their first year, before they have taken any engineering courses. Through a grant we received in the early 1990s from the Division of Undergraduate Education of NSF we were able to change the engineering curriculum so that in their first year, students take courses designed to introduce engineering in an interesting and playful way. We now have a pool of over 60 engineering courses that stem from personal research interests and hobbies of our faculty. We have courses focusing on acoustics (Design and Performance of Musical Instruments), Fluid Mechanics (Life in Moving Fluids), Heat Transfer (Gourmet Engineering), Biotechnology, and Digital Image Processing. They are taught by our best teachers with passion, since they created them and focus on their personal interest. We use to have a net loss of 15 percent of our undergraduates. With this NSF-funded curriculum we managed to become the only engineering school in the country where more students transfer into engineering from liberal arts than from engineering to liberal arts. We actually see an increase in our class size most years.

Funding from NSF has enabled us to reshape our curriculum and make it attractive to both men and women. We were able to adjust our pedagogies in laboratory activities to better deliver the content to our students, and provide them with numerous opportunities to engage in research through NSF's Research Experiences for Undergraduate program. As a result, our program grew to be very desirable. During the last 8 years, our application pool doubled, the average SAT scores of our incoming students increased by 70 points exceeding 1400, and the high school graduation ranking of our students decreased from top 13 percent of their class to top 5 percent of their class. Also the number of women students increased by 26 percent. About a third of our undergraduate students are women. The 4-year graduation rate of our women students is over 95 percent.

Although we received a number of grants from NSF to be able to accomplish this, we had many, many excellent proposals rejected simply because of lack of funds. Just imagine the impact that NSF grants could have nationally in attracting and retaining engineering students if the Undergraduate Division had more funds to award. Many other engineering schools can design and implement programs such as the one that transformed our school.

THE IMPACT OF NSF ON IMPROVING K-12 SCIENCE AND ENGINEERING EDUCATION PROGRAMS AND ENCOURAGING PARTNERSHIPS BETWEEN K-12 SCHOOLS AND UNIVERSITIES

NSF is the most significant supporter of technological and scientific literacy in our Nation. For the last 15 years, the Tufts School of Engineering has been a national leader in engineering and science outreach in preK-12 schools. We have re-architected the entire K-8 science curricula for the public school districts, written textbooks that are currently used by millions of middle-school children, created Robolab, a Lego-based educational product that is used by more in more than 15,000 classrooms in twenty different countries and won numerous international awards. Our goal is to introduce engineering as a new discipline in all preK-12 public and private schools in the U.S. and make engineering an equally appealing and exciting discipline to both girls and boys. The National Science Foundation has been the biggest supporter of these efforts. Massachusetts is now the first State in the Nation to require, through standards-based programs and testing, engineering as a discipline, starting at the kindergarten level. Many other States have expressed interest in following Massachusetts' innovative step.

Of course, not all children want to become, or should become engineers and scientists. While our Nation desperately needs more engineers and scientists who would clearly benefit from engineering education beginning in grade school, why introduce engineering to all young children?

Technological literacy has become basic literacy. Most of the tangible products such as cars, telephones, and airplanes, and processes, with which we spend most of our lives, are technologies that resulted from engineering efforts. A literate citizen is one that understands the world around her. Children need to understand the engineering process and the results of these processes: the technologies, in order to become fully literate in our complex, human-made world.

Engineering offers an excellent platform for project/problem-based learning. Children have opportunities to move from observing and formulating ideas to constructing projects and communicating about their work. This problem/project-based learning helps children integrate knowledge from all disciplines, including math, science, social studies, English, and art.

Engineering motivates students to pursue math and science studies. Partnerships among math, science and technology/engineering educators make for powerful teaching teams. Engineering brings math and science alive and creates links to everyday life. This important relevance factor encourages girls in particular, who typically chose profession that "make a difference," to pursue careers in these male-dominated professions.

Engineering sharpens young people's ability to visualize and think in three dimensions. Rather than exploring three-dimensional objects by building with models or taking apart radios, most children watch television, play computer games, and surf the Internet, building skills that sharpen eye-hand coordination in two dimensions. We are raising generations of people that cannot visualize things in three dimensions. By nurturing both spatial visualization and communication skills, engineering enhances children's ability to design and present ideas in graphical form. These skills improve students' understanding of the technological world, and enable them to become the problem-solvers and designers of tomorrow.

NSF has been very supportive of our effort to introduce engineering into the lives of younger people. We currently are working at the State level with the Massachusetts Department of Education, with teachers through the professional associations, with targeted school districts, and with children. Our initial prototype program was a partnership between our School of Engineering and the Stow Schools of the Nashoba Regional School District in Massachusetts. This effort was funded by two different grants, from the Engineering Division, and the Human Resources division of NSF. Our success in changing the science performance of the children within two years is evident through the results of the statewide Science and Technology/Engineering tests at the fourth grade level. In 1998, 6 percent of the 4th grade students scored "Advanced", 66 percent "Proficient", 27 percent "Needs Improvement, and 1 percent "Failed". In 2000, 31 percent scored "Advanced", 62 percent "Proficient, 7 percent "Needs Improvement", and 0 percent failed. The State averages in these categories stayed quite flat. The State averages for 2000 are 5 percent "Advanced", 37 percent "Proficient", 32 percent "Needs Improvement", and 26 percent Failed. Our partnership worked well. Enhanced NSF funding in these areas, can help other university-school partnership achieve similar results.

We need enhanced funding for the University-School Partnerships program. We also need to include Engineering in the National Mathematics and Science Education Partnerships. Engineering schools can energize teachers at all levels and significantly enhance math, science, and technology/engineering preK-12 literacy. As a

member of the American Society of Mechanical Engineers (ASME), I understand they have endorsed partnerships as a method to improve K-12 Science, Technology, Engineering, and Mathematics education. I encourage the committee to propose a change to the name and charge of the Partnerships to "National Science, Mathematics, and Engineering Partnerships" and to propose a significant increase of the funding of this NSF program. In addition, I encourage the committee to also support full funding for Science, Math, and Engineering education at the Department of Education as well. We have a unique opportunity to significantly enhance this important area of national interest. In closing, I feel that NSF budget increases will move us in the right direction in enhancing basic research, promoting diverse representation in the field, and promoting technological literacy of the citizens of tomorrow.

PREPARED STATEMENT OF WARREN WASHINGTON

Chairman Kennedy, Ranking Member Gregg, and Members of the Committee, I appreciate having the opportunity to testify before you as Chair of the National Science Board. I am Warren Washington, Senior Scientist and Section Head of the Climate Change Research Section at the National Center for Atmospheric Research.

On behalf of the National Science Board, I thank the Committee for its sustained commitment to a broad portfolio of investments in science, mathematics, engineering, and technology research and education. These investments contribute to our Nation's long-term security and economic vitality and to the well being of all Americans.

THE NATIONAL SCIENCE FOUNDATION'S BUDGET REQUEST

The National Science Board has approved and supports the National Science Foundation's budget request for fiscal year 2003. The 5 percent increase in funding will allow NSF to continue to nurture the people, ideas, and tools needed to generate new knowledge and new technologies. Among the important initiatives that this budget includes are priorities for the science and engineering workforce; mathematical and statistical science research that will advance interdisciplinary science and engineering; and research in the social, behavioral, and economic sciences to explore the complex interactions between technology and society. The budget continues support for the Math and Science Partnership program; increases funding for the Foundation's six priority areas, which have the potential of enormous payoff for the Nation; and provides a much-needed increase in annual stipends for graduate fellows—a critical investment the future U.S. science and engineering workforce. The NSF Director, Dr. Rita Colwell, will discuss these and other specifics of the budget request in her testimony.

As this Committee recognizes, NSF is a major contributor both to scientific research and science education. Federal investments in the basic sciences through NSF have produced new discoveries and new technologies essential to our national security and economic prosperity. In addition, NSF supports innovative education programs from pre-kindergarten through graduate school, preparing the next generation of scientists and engineers and contributing to a more scientifically literate workforce and society.

Each year NSF evaluates, primarily through external peer review, 32,000 proposais from 2,000 colleges, universities, and institutions. The value of the proposals is approximately $16 billion. NSF annually makes 10,000 awards, totaling nearly $3 billion, in a highly competitive merit review process. It is estimated that NSF proposals representing an additional $5 billion are worthy of investment if the funds were available.

THE HEALTH OF THE SCIENCE AND ENGINEERING ENTERPRISE

The new knowledge and technologies emerging today are a tribute to Federal research investments made years ago in a spirit of bipartisanship. When those investments began, no one could foresee their future impact. Revolutionary advances such as those in information technology, nanotechnology, materials, and biotechnology remind us that such breakthroughs with promising benefits to the economy, the workforce, our educational systems, and national security require long-term, high-risk investments.

Among Federal agencies, NSF has the unique mission of advancing the Nation's health, prosperity, and welfare by supporting research and education in all fields of science and engineering. NSF plays a critical role in supporting new discoveries and knowledge as well as innovative educational programs at all levels. NSF-funded

research and education are critical to sustaining U.S. strength in science and technology, a key element of national security.

Despite widespread recognition of the benefits that result from federally-supported scientific research, as a Nation, we are seriously under-investing in basic research. In our $10 trillion Gross Domestic Product, the Federal Government budgets $24 billion to basic research, which represents one-fourth of 1 percent of the Nation's Gross Domestic Product. Of the $24 billion, NSF receives $3 billion to support cutting-edge science and the search for new knowledge.

Achieving a balanced portfolio in the basic sciences is as important as the quality and quantity of research funded. For example, as Congressional leaders and others have pointed out, the success of the National Institutes of Health's efforts to find cures for deadly diseases depends heavily on the underpinning of basic research supported by the National Science Foundation.

NATIONAL SCIENCE BOARD POLICY STUDIES

In addition to providing oversight to NSF, the Board provides advice to the President and the Congress on matters of science and engineering policy. I would like to mention some of our current activities related to major issues affecting the health of the science and engineering enterprise.

FEDERAL INVESTMENT IN SCIENCE AND ENGINEERING

The level of Federal investment is crucial to the health of the science and engineering enterprise. Equally crucial is how effectively that investment is made. The growing opportunities for discovery and the inevitable limits on Federal spending mean that hard choices must be made and priorities set.

In its recent report, *Federal Research Resources: A Process for Setting Priorities*, the Board offers its recommendations for a more effective budget process, including an improved information base and a decision-making process for allocating Federal funding to research. The Board's conclusions are based on reviews of the literature on budget coordination and priority setting for public research and invited presentations from and discussions with representatives of the Office of Management and Budget, the Office of Science and Technology Policy, the Federal research and development agencies, congressional staff, high-level science officials from foreign governments, experts on data and methodologies, and spokespersons from industry, the National Academies, research communities, science policy community, and academe.

U.S. GOVERNMENT ROLE IN INTERNATIONAL SCIENCE AND ENGINEERING

In the 21St Century, advances in science and engineering will to a large measure determine economic growth, quality of life, and the health and security of our planet. The conduct, communication, and use of science are intrinsically global. New ideas and discoveries are emerging all over the world and the balance of expertise is shifting among countries. Collaborations and international partnerships contribute to addressing a broad range of international problems. They also contribute to building more stable relations among nations by creating a universal language and culture based on commonly accepted values of objectivity, sharing, integrity, and free inquiry. The Federal Government plays a significant role in promoting international science and engineering activities and supporting research with international dimensions.

In its recent report entitled *Toward a More Effective Role for the U.S. Government in Intemational Science and Engineering*, the Board concludes that new approaches to the management and coordination of U.S. international science and engineering activities are needed if the United States is to maintain the long-term vitality of its science and engineering enterprise and the vitality of its economy. The Board recommends that the Federal Government: (1) increase the effectiveness of its coordination of international science and engineering activities; (2) increase international cooperation in fundamental research and education, particularly with developing countries and by younger scientists and engineers; and (3) improve the use of science and engineering information in foreign policy deliberations and in dealing with global issues and problems.

U.S. SCIENCE AND ENGINEERING INFRASTRUCTURE

An area of constant concern for NSF and the Board is the quality and adequacy of infrastructure to enable scientific discoveries in the future. The rapidly changing environment of new knowledge, new tools, and new information capabilities has created a demand for more complex and more costly facilities for scientific research.

A Board task force is assessing the current status, changing needs, and strategies needed to ensure that the Nation will have the infrastructure to sustain cutting-edge science and engineering research. We expect to receive the task force's preliminary findings this summer.

NATIONAL WORKFORCE POLICIES FOR SCIENCE AND ENGINEERING

For U.S. leadership in science and engineering, there is no more important issue than the development of a skilled technical workforce. As a Nation, we are not attracting the numbers of science and engineering students our Nation needs to sustain its leadership. Nor are we successfully tapping all our domestic resources, especially under-represented minorities and women. The pool of potential science and engineering students will increasingly reflect the growing diversity in the American workforce and society.

A Board task force on workforce policies for science and engineering is reviewing U.S. workforce needs, the role of foreign students and workers, and policy options for ensuring an adequate science and engineering workforce for the future. We anticipate receiving the task force's report by the end of this year.

Mr. Chairman, at this point I would like to close my formal remarks. I thank the Committee for its long-time support of the science community, especially the National Science Foundation, and for allowing me to comment on significant national policy concerns, as well as on the Foundation's budget request.

PREPARED STATEMENT OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

INTRODUCTION

ASME International is a 125,000-member organization focused on technical, educational and research issues. ASME conducts one of the world's largest technical publishing operations, holds numerous technical conferences worldwide, and offers hundreds of professional development courses each year. ASME sets internationally recognized industrial and manufacturing codes and standards that enhance public welfare and safety.

In a survey this year, ASME members ranked pre-college science, technology, engineering, and mathematics (STEM) education as our number one public policy priority. Another issue of importance to our members is the desire to increase the Federal investment in research and development, particularly in the physical sciences. The National Science Foundation (NSF) plays a critical role in both of those priorities.

PRE-COLLEGE EDUCATION

The engineering community has long been concerned with the state of pre-college science, technology, engineering, and mathematics (STEM) education. To increase student learning in these areas, and enable the United States to compete globally with a strong, technologically literate workforce, we need to commit a significant amount of resources for STEM education now.

The U.S. Commission on National Security for the 21st Century warns, "The harsh fact is that the U.S. need for the highest quality human capital in science, mathematics, and engineering is not being met. We not only lack the homegrown science, technology, and engineering professionals necessary to ensure national prosperity and security, but also the next generation of teachers of science and math at the K-12 level. The Nation is on the verge of a downward spiral in which current shortages will beget even more acute future shortages of high-quality professionals and competent teachers."

According to the 2000 National Assessment of Educational Progress (NAEP), student science scores for grades 4 and 8 are flat and there has been a slight decline in scores for grade 12 since the assessment was last administered in 1996. Furthermore, 84 percent of science teachers and 86 percent of mathematics teachers in grades 5-8 did not major in science or mathematics. This report further underscores the need for reform and investment in math and science education, particularly at a time when our economy, national security and technological advances are heavily dependent on the quality of our future workforce.

The National Science Foundation has funded a number of programs, which are consistent with ASME's pre-college science, technology, engineering, and mathematics (STEM) education policy. Specifically, we support programs that: increase federally-funded research focused on STEM teaching and learning to cultivate the most effective teaching methods; recruit, train, and retain qualified STEM teachers to meet demand; foster partnerships among educational institutions, industry, and

non-profit organizations; encourage the adoption of curriculum standards that cultivate high student performance; the development of curricula that foster creativity, experiential problem-solving and critical thinking, and, the development of assessments aligned with these standards and curricula; and, encourage women and minorities to pursue STEM coursework and careers.

The ASME Council on Education supports S.1262, by Senator Rockefeller, et al. In particular, we support: (1) the inclusion of engineering departments as eligible partners and technology teachers within the definition of math and science teachers; (2) the Robert Noyce Scholarship Program to attract science, math and engineering majors and professionals to teaching; (3) the Teacher Research Scholarship Program to provide STEM related research experiences for teachers; and (4) efforts to attract greater participation of women and minorities in STEM pre-college, undergraduate and graduate coursework and eventually STEM careers.

UNDERGRADUATE AND GRADUATE EDUCATION

During the next decade, the U.S. demand for scientists and engineers is expected to increase at more than double the rate for all other occupations, according to the National Science Board. The need for a scientifically literate population is essential for our economy and our national security. Moreover, technology and the innovations it has spawned drive productivity gains and economic growth.

But today's high school students are not performing well in math and science overall, and a decreasing number of American students are pursuing degrees in technical fields. America's K-12 students score far below the best in the world on domestic and international tests.

Senators Lieberman, Bond, Frist, Mikulski and Domenici introduced S.1549, "The Technology Talent Act," designed to increase the United States' technically trained workforce. It is imperative to develop a highly skilled workforce to maintain our national security and foster future economic growth.

This legislation encourages universities to partner with community colleges, industry organizations, professional societies and local schools to pave the way for students of all ages and backgrounds to further their interests in science, technology, engineering, and mathematics (STEM) coursework and career paths.

In October 2001, the deans of engineering and the deans of education from 50 universities met in concert to develop strategic collaborations to enhance K-12 teacher preparation in STEM and to invigorate engineering education. Collaborations of this type can and should be replicated by more universities and across all science, mathematics, engineering, and technological disciplines.

This bill will assist in the development and implementation of innovative approaches to increasing enrollments and graduates in key STEM degrees. Providing incentives and rewards to educational institutions for increasing STEM enrollments and graduates is an excellent approach to jumpstart that process, therefore the Council supports enactment of S.1549.

RESEARCH & DEVELOPMENT FUNDING

The Council acknowledges the visionary leadership role that NSF has played in guiding the Nation's basic research and development activities. NSF has greatly contributed to the technological superiority that the United States enjoys today. As such, the Council strongly endorses the Foundation and its efforts to improve and expand the innovative ideas, outstanding people, and cutting-edge tools that comprise the Nation's technological and scientific infrastructure.

However, the decline in Federal R&D funding remains a major concern. ASME members are particularly concerned over the widening gap between Federal funding of life sciences and the physical sciences and engineering, and therefore support efforts to dramatically increase NSF funding. The Council strongly encourages members of the Committee to consider the following points during its deliberations: the critical need for the Nation to increase its support for the R&D portfolio including a viable component of pure science and engineering research; enhancing the integrity of the core research mission of the NSF in light of its new responsibilities; the need for balance within NSF between its initiative-driven research and developing and maintaining a healthy core effort; and, that the integrity and strength of NSF must remain rooted in strict adherence to a rigorous peer-review process free from earmarking.

The Council supports: (1) increasing the size and duration of NSF grants, which will allow scientists and researchers to produce more results and spend less time writing grants; (2) increasing graduate stipends, which will attract more undergraduates to pursue graduate degrees in science and engineering; and (3) increasing

funding for the NSF by 15 percent for fiscal years 2003-2005, (like H.R. 4664) thereby placing the NSF budget on a doubling track.

STATEMENT OF

ASTRA,
The Alliance for Science & Technology
Research in America

TO THE

SENATE HEALTH, EDUCATION, LABOR AND PENSIONS COMMITTEE

on

Proposed Legislation Authorizing Funds for the National Science Foundation

and

Focusing on Math and Science Research & Development and Education in the 21st Century

JUNE 19, 2002

I. INTRODUCTION

ASTRA, The Alliance for Science & Technology Research in America, is pleased to submit comments to the Senate Health, Education, Labor and Pensions Committee on National Science Foundation (NSF) reauthorization.

ASTRA is a newly established policy research collaboration comprised of 47 of America's leading science and technology companies, associations, professional societies, universities, and research institutions. ASTRA's underlying companies and institutions in turn represent hundreds of thousands of science and technology professionals across dozens of scientific disciplines through their workplaces, professional organizations and academic institutions.

ASTRA's mission is quite simple: we strive to increase public funding for basic research in the physical, mathematical and engineering sciences based upon overwhelming evidence that under-funding and imbalance in the current federal research portfolio has reached crisis proportions.

ASTRA believes funding for the National Science Foundation needs to be very substantially increased not just for FY 2003, but in a sustained and meaningful fashion for many years to come. Years of neglect of funding for the physical sciences, mathematics and engineering are now exacting a toll in the form of 1) loss of U.S. competitiveness and migration of U.S.-based R&D offshore; 2) lack of an adequately trained and sufficiently large science and technology (S&T) workforce; and 3) increasing imbalance between the scientific disciplines being funded by the federal government.

II. THE PROBLEM DEFINED IN TERMS OF THE NATIONAL SCIENCE FOUNDATION

A. Federal funding of basic research in the physical, mathematical and engineering sciences is in long-term decline, and NSF is a key part of turning this decline around because of its pivotal role in funding the sciences through the academic research structure.

B. Under-funding creates imbalance in the scientific research portfolio, disrupts academic recruiting and grant making, stymies faculty development, and thwarts infrastructure investment. This in turn hampers the traditional educational "pipeline" which is tasked with creating new S&T workers for industry, academe, and other research institutions.

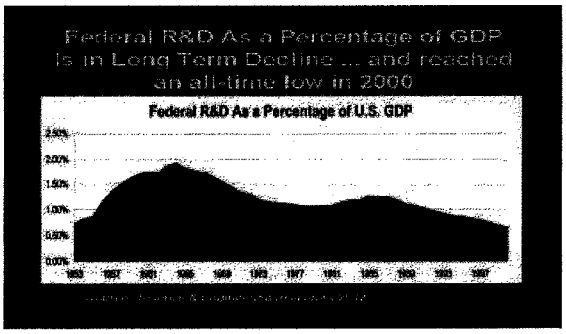
C. The consequences of such under-funding have been the subject of many public and private studies, perhaps the most compelling of which was the prescient February, 2001 *Report* of the U.S. Commission on National Security **(Hart-Rudman),** whose assessment has been borne out by painful loss. The Commission called for a doubling of federal S&T funding across the board over the next decade.

D. The *Hart-Rudman Report* details the need for "recapitalizing" America's science and technology educational structure, and it suggests many excellent steps for averting future crises in the areas of U.S. industrial competitiveness, national security, and technological leadership. NSF funding plays a critical role in any potential turnaround.

E. Similarly, the July 2001 *Report of the Committee on Trends in Federal Spending on Scientific and Engineering Research of the Board on Science, Technology, and Economic Policy (STEP)* of the **National Research Council** detailed alarming erosion of federal funding in specific disciplines and made very worthwhile recommendations on improvements.

III. MAKING THE CASE FOR INCREASING NSF FUNDING

A. Federal R&D as a percentage of GDP reached an all time low in the year 2000, the latest year for which we have measurement. Since 1953, when such measurement began, this figure had never fallen below 0 .75 % until the year 2000.

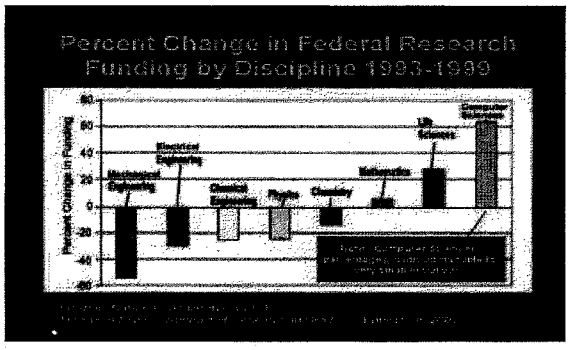


B. The federal government must increase its overall spending in the physical sciences, engineering and mathematics and arrest the long-term decline in such funding. The NSF is a key agency for accomplishing this purpose immediately, although more attention needs to be paid as well to such entities as the **Office of Science** at the **U.S. Department of Energy** and **U.S. Department of Defense** expenditures because of their profound impact on the physical sciences, mathematics and engineering disciplines as well.

C. Since the late 1980's, failure to adequately fund most of the physical, mathematical and engineering sciences has led to serious disruption in the academic training pipeline, which is heavily dependent upon such funding. This is especially problematic with the operations of NSF because it provides so many investments in the form of grants. NSF is the key generator of the

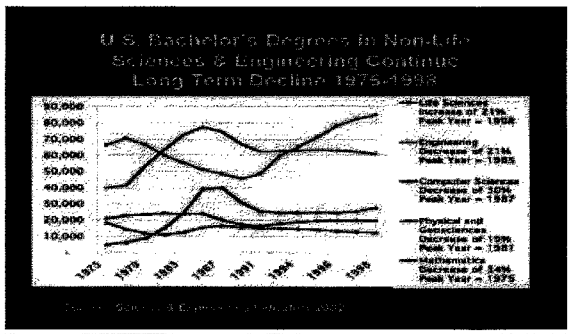
"fuel" which powers the academic research pipeline. Its assessments of how and where to invest public funds affects all aspects of science R&D.

D. The overall percentage change in federal research funding by discipline between 1993 - 1999 portrays a situation potentially disastrous for the future of U.S. economic, scientific and military leadership:

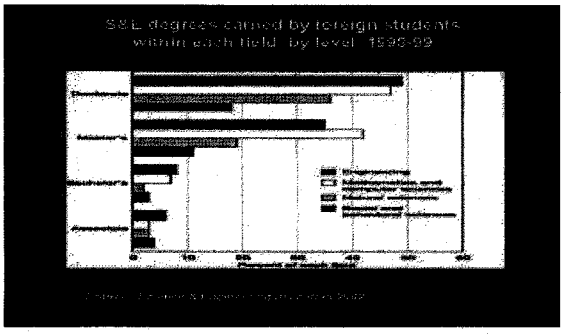


IV. DYSFUNCTION IN THE S&T EDUCATIONAL SYSTEM IS CLOSELY RELATED TO LACK OF FEDERAL SUPPORT BEGINNING IN THE LATE 1980'S

A. U.S. Bachelor Degree Production in non-life Sciences and Engineering continues its long-term decline. Between 1975 and 1998, the following patterns occurred (see chart below). ASTRA has calculated the peak year of undergraduate enrollment and the increase or decrease since that time. Only the "life sciences" category has increased during the period 1975-1998. This comes at a time when Asia and Europe are increasing their number of overall science degrees significantly.

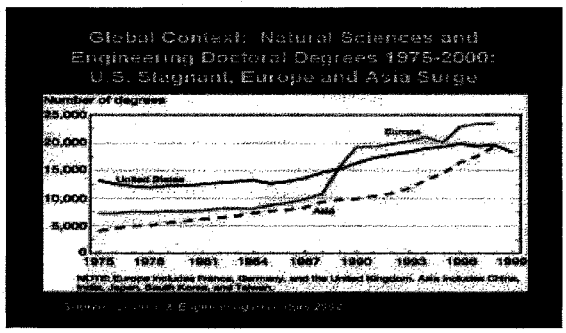


B. Even more disconcerting is that participation by foreign students in U.S. S&T doctoral degree production is now essential. Depending upon the scientific discipline being measured, anywhere from about 18 percent of doctoral degrees in the Behavioral Sciences to about 58 percent of doctorates awarded in Engineering are being awarded to non-U.S. citizens:



C. Reliance on foreign student matriculation has profound implications for the federal S&T workforce in particular. More than 50 percent of federal S&T workers will elect to retire from the workforce over the next ten years, and restrictions on non-U.S. citizen employment within the federal S&T workforce apply to many areas of federal research.

D. While U.S. universities retain their edge as world-class institutions of scientific learning, the rapid growth of prestigious scientific teaching faculties elsewhere, especially in Asia, suggests that in the near future, many outstanding science students in other countries will see no need to matriculate to U.S. institutions.

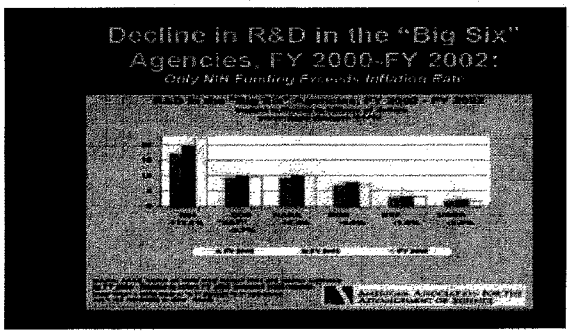


E. While the U.S. is not as challenged by a generation-long decline in birth rates affecting most European countries and Japan, it is clear that the overall demographic dynamics of the U.S. population are working against increasing science degrees among native-born Americans. Without the significant immigration of foreign-born S&T workers over the past two generations, the U.S. could never have sustained its long dominance of most scientific and technological fields.

F. Failure of U.S.-born students to undertake science training and possible reasons for this state of affairs have been analyzed by others. Many factors are at play, and they may include cultural, gender-based, economic and educational disincentives for science education and the relative attractiveness (money, prestige, ease of learning) of other professions to our brightest students. Current research suggests that science is hard to understand for most people, and it is difficult to teach as well. The language of science — mathematics — presents special problems throughout the teaching continuum.

V. NSF'S BUDGET IN CONTEXT

A. If we take the six largest federal R&D Agencies, only one, the National Institutes of Health (NIH), has received funding in excess of the inflationary rate over the past three fiscal years:



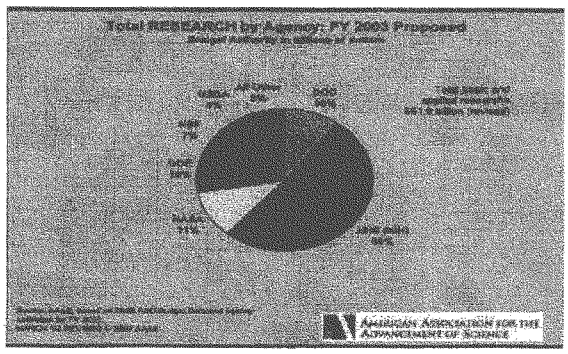
B. ASTRA is deeply concerned about the very sustainability of NSF programs without significant increases in its budget. ASTRA supports efforts to double the NSF budget over the next several fiscal years as one means of catching up with the disastrous 1990's and has confidence that NSF's peer review processes will ensure that increased research funding is well spent. We also think a pent-up demand for research funding exists throughout the S&T community, and many unfulfilled projects may yet see the light of day. Simply put, today professors are spending too much time chasing money and too little time chasing knowledge. NSF turns down a significant number of proposals deemed meritorious by reviewers.

VI. IMBALANCE IN THE RESEARCH PORTFOLIO MUST BE RECTIFIED

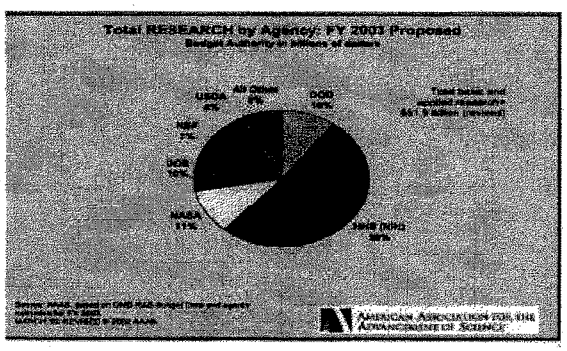
A. A serious imbalance exists in the current federal research portfolio in several key ways:

1) the types of scientific discipline being funded; and
2) the types of research being performed (i.e., "basic," "applied," "developmental").

Under current FY 2003 Budget proposals, NSF would continue to languish, as would other agencies like DOE and DOD which play an essential role in scientific discovery:



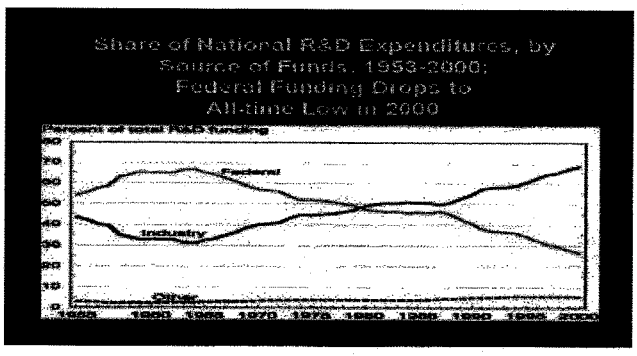
B. Going beyond the overall R&D budgets by agency, it is all the more telling that in terms of **basic research**, the physical sciences, mathematics and engineering continue their decline because of specific under-funding for all of the major agencies other than NIH:

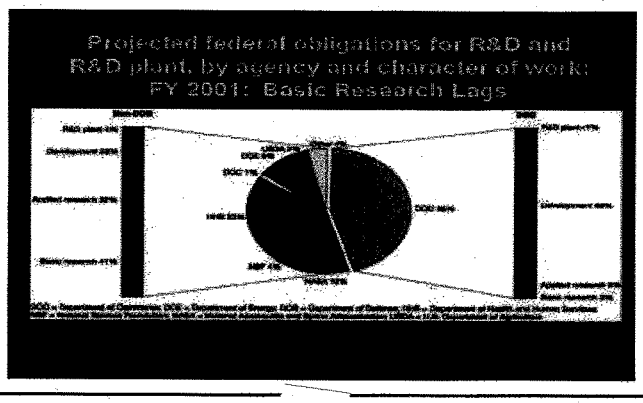


VII. "BASIC" RESEARCH FUNDING IS A GOVERNMENT RESPONSIBILITY, AND NSF NEEDS MORE FOCUS ON BASIC RESEARCH

A. One unfortunate consequence of mergers, consolidations and the slow recovery in the high technology sector is that Wall Street and the investment community generally disfavor companies that cannot show near-term and consistent profitability. Our own ASTRA members tell us that the days of the great industrial laboratories performing research for research's sake are long gone. And this makes NSF's role in basic scientific research all the more important for our university and basic research community structure.

B. Unfortunately, government's role is shrinking in terms of overall R&D investment as a percentage of GDP, and basic research activity lags by all measurements of such activity:



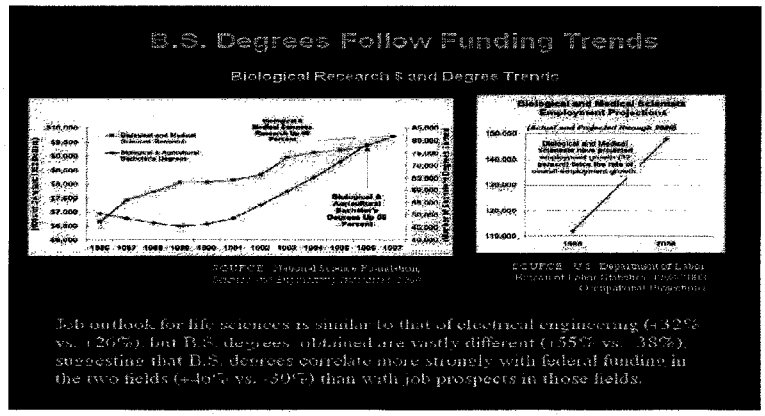


VIII. IMPACT ON SOCIETY

A. The impact of such under-funding of agencies like NSF is potentially devastating to our economy and military security. Of all citations in U.S. industry patents, 73% originate from research conducted through publicly-supported institutions (universities, colleges, certain nonprofit research institutions) — about five citations per patent.

B. Approximately one dozen economic studies, including those of **Nobel Laureate Robert Solow** of the **Massachusetts Institute of Technology**, show that technological progress as defined by various scientists and economists has accounted for about 50% of economic growth, for all time periods studied, between the years 1869 – 1979. Federal Reserve Board Chairman Alan Greenspan and noted economists have also cited the contribution of technology applications to non-inflationary growth.

C. It is also proven that there is a strong correlation between federal R&D Funding and the creation of technically trained workers. Students follow the money and the incentives provided through NSF funding. They clearly discern "winning" and "losing" disciplines based upon funding received by their schools, as seen in the following example:



IX. CONCLUSIONS:

ASTRA appreciates the opportunity to review NSF funding in light of the prolonged decline in federal investment in the physical sciences, mathematics and engineering. We firmly believe that the most critical step at this point in time is to change the trend, fund NSF adequately, and develop a long-range vision of what outcomes we as a nation need from our strong commitment to public science. The imperative to renew this commitment is urgent.

Something to Ponder ...

"If there are not enough trained people in the U.S., corporations will have to move R&D operations to where the trained people are. The pilot plant follows, because you need the R&D people nearby to help make it work. The manufacturing plant follows the pilot plant. Distribution, sales, and management follow the manufacturing. Once this process is started, it is not reversible.

Corporations may not like it but they will survive if there is no R&D in the U.S. They will just go overseas. The U.S. economy, however, will not recover from the loss of this business."

-- Quoted with permission from Bill Joyce, CEO of Hercules and previously CEO of Union Carbide

APPENDIX A

THE ALLIANCE FOR SCIENCE & TECHNOLOGY RESEARCH IN AMERICA

Sponsoring Organizations as of 6/13/02

Agilent Technologies
Alfred P. Sloan Foundation
American Association for the Advancement of Science
American Association of Engineering Societies
American Chemical Society
American Institute of Chemical Engineers
America Institute of Physics
American Physical Society
American Mathematical Society
Association of American Universities
AVS — The Science & Technology Society
Battelle
California State University System
David & Lucille Packard Foundation
DuPont
Dow Chemical
Federation of Materials Societies
Florida State University
General Electric
Golden Family Foundation
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IBM Corporation
Institute of Electrical and Electronics Engineers, Inc. — USA
Kent State University
Lucent Technologies
Materials Research Society
The Minerals, Metals and Materials Society (TMS)
National Association of Manufacturers
New Jersey State Institute of Technology
Northern Illinois University
Optical Society of America
Rensselaer Polytechnic Institute

Semiconductor Equipment Manufacturers International (SEMI)
Semiconductor Industry Association
SPIE – The International Society for Optical Engineering
University Corporation for Atmospheric Research (UCAR)
University of Arkansas, Fayetteville
University of Arkansas, Little Rock
University of Central Florida
University of Kansas
University of New Orleans
University of North Texas
University of South Carolina
Worcester Polytechnic Institute

Friends of ASTRA

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For more information about ASTRA,
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Testimony of the
NATIONAL COUNCIL FOR SCIENCE AND THE ENVIRONMENT
Craig M. Schiffries, Ph.D., Director of Science Policy
Peter D. Saundry, Ph.D., Executive Director

To the
UNITED STATES SENATE
Committee on Health, Education, Labor, and Pensions

Hearing on
NATIONAL SCIENCE FOUNDATION AUTHORIZATION

June 19, 2002

Summary

The National Council for Science and the Environment (NCSE) strongly supports bipartisan efforts to double the budget of the National Science Foundation (NSF) in five years. To that end, we encourage the Senate to authorize at least $5.5 billion for NSF in FY 2003, an increase of $719 million or 15 percent relative to the FY 2002 level.

Federal investments in R&D and science education are essential to the future well-being and prosperity of the nation and deserve the highest priority of Congress. The long-term prosperity of the nation and the maintenance of our quality of life depend on a steady and growing commitment of federal resources to science and technology. Environmental R&D is a critical component of the nation's R&D portfolio and an essential element of homeland security. We encourage Congress to explore the role of environmental R&D in homeland security and counterterrorism and to recommend actions that would improve the nation's capacity in this area.

We encourage Congress to strongly support full and effective implementation of the National Science Board (NSB) report, *Environmental Science and Engineering for the 21st Century: The Role of the National Science Foundation*, within the context of efforts to double the budget of the NSF. The NSB report calls for significant improvements in the way that NSF supports environmental research, assessment and education, and proposes that the Foundation invest an additional $1 billion per year in these areas, to be phased in over five years. NSF has begun to implement the NSB report and deserves full support from Congress. We also emphasize the need for increased funding for NSF's priority area on Biocomplexity and the Environment. In addition, we recommend full funding for two large projects—the National Ecological Observatory Network (NEON) and EarthScope—which are included in NSF's budget request for Major Research Equipment and Facilities Construction. These projects would create unprecedented opportunities for environmental research.

Introduction

The National Council for Science and the Environment appreciates the opportunity to provide testimony on authorization of the National Science Foundation.

NCSE is a nonprofit, nonpartisan organization that has been working since 1990 to improve the scientific basis for environmental decisionmaking. Our work is endorsed by nearly 500 organizations, ranging from the U.S. Chamber of Commerce to the Sierra Club, including the National Association of Attorneys General, National Association of Counties, some 300 colleges and universities, and more than 80 scientific and professional societies. As a neutral science-based organization, NCSE promotes science and its relationship with decisionmaking but does not take positions on environmental issues themselves.

We greatly appreciate the Committee's sustained support for the National Science Foundation. Investments in the National Science Foundation continue to pay enormous dividends to the nation.

Federal Investments in Environmental R&D

Federal investments in R&D and science education are essential to the future well-being and prosperity of the nation and deserve the highest priority of the Congress. The long-term prosperity of the nation and the maintenance of our quality of life depend on a steady and growing commitment of federal resources to science and technology.

Environmental R&D is a critical component of the nation's R&D portfolio. Based on NCSE's *Handbook of Federal Funding for Environmental R&D,* we estimate that federal funding for environmental R&D in FY 2002 is approximately $7.5 billion, an increase of $315 million or 4.4 percent relative to FY 2001 (Table 1). In FY 2002, federal funding for environmental R&D grew at less than one-third the rate of total R&D, which increased by 13.5 percent to $103.7 billion. Federal investments in environmental R&D need to keep pace with the growing need to improve the scientific basis for environmental decisionmaking.

Appended to our testimony is a letter signed by more than 120 university and college presidents, as well as business, scientific and environmental leaders calling for significantly increased funding for scientific programs about the environment at the National Science Foundation, EPA, NASA, and other federal agencies. We encourage Congress to support this initiative.

Table 1. Environmental R&D by Federal Agency
(budget authority in millions of dollars)

Agency	Environmental R&D ($ Millions)				Change from FY2001 (Percent)	
	FY 2000 Actual	FY 2001 Estimate	FY 2002 Request	**FY 2002 Enacted**	FY 2002 Request	**FY 2002 Enacted**
National Aeronautics and Space Admin.	1,690	1,716	1,515	**1,573**	-11.7%	**-8.3%**
Department of Energy	1,502	1,774	1,398	**1,862**	-21.2%	**5.0%**
National Science Foundation*	671	752	829	**829**	10.2%	**10.2%**
Environmental Protection Agency	558	609	569	**702**	-6.5%	**15.4%**
Department of Defense	399	450	382	**410**	-15.1%	**-9.0%**
Department of Commerce - NOAA	643	726	772	**836**	6.4%	**15.3%**
Department of the Interior	618	631	593	**673**	-6.1%	**6.5%**
U.S. Department of Agriculture	370	410	411	**451**	0.2%	**9.9%**
National Institutes of Health	60	63	70	**81**	11.7%	**28.4%**
Department of Transportation	37	41	61	**71**	47.0%	**72.2%**
Smithsonian Institution	14	14	14	**14**	1.4%	**1.4%**
Corps of Engineers	11	10	11	**11**	1.4%	**1.4%**
TOTAL	**6,573**	**7,197**	**6,624**	**7,512**	-8.0%	**4.4%**

Source: AAAS/NCSE estimates of environmental R&D based on enacted appropriations bills, OMB R&D data, *Budget of the United States Government*, agency budget documents, and information from agencies.
*NSF Environmental R&D provided by NSF.

National Science Foundation Budget Request for FY 2003

The National Council for Science and the Environment strongly supports bipartisan efforts to double the budget of the National Science Foundation in five years. We encourage the Senate to authorize at least $5.5 billion for NSF in FY 2003, an increase of $719 million or 15 percent relative to the FY 2002 level. This level of funding is specified in the NSF authorization bill (H.R. 4664) that passed the House of Representatives on June 5, 2002. It is also recommended by the Coalition for National Science Funding, which includes NCSE and 70 other scientific organizations and academic institutions.

Biocomplexity in the Environment Priority Area. NCSE is particularly supportive of NSF's priority area on Biocomplexity in the Environment. This initiative provides a focal point for investigators from different disciplines to work together to understand complex environmental systems, including the roles of humans in shaping these systems. The resolution of many important environmental and societal problems is lagging, in part, because of insufficient scientific understanding of complex issues that span the boundaries of traditional scientific disciplines.

NSF is already a leading federal sponsor of peer-reviewed research regarding the environment, with a portfolio exceeding $700 million. Most of this investment is directed at scientific advances within particular disciplines. An interdisciplinary approach is needed to build on this base to truly understand the environment and the relationships between people and the environment. The Biocomplexity in the Environment priority area is an important step towards a comprehensive understanding.

NSF proposes to increase funding for its priority area on Biocomplexity in the Environment by 36 percent to $79 million. This priority area would be expanded to include research in two new areas this year—microbial genome sequencing and ecology of infectious diseases—to help develop strategies to assess and manage the risks of infectious diseases, invasive species, and biological weapons. We urge Congress to support this critical initiative and to consider funding it at a level of $136 million, as proposed in the FY 2000 budget request for NSF.

Major Research Equipment. The NSF budget request includes initial funding for two large projects, the National Ecological Observatory Network (NEON) and EarthScope, under its account for Major Research Equipment and Facilities Construction (MRE). These projects would provide major new opportunities for environmental research.

- **National Ecological Observatory Network**. NEON would be a continental scale research instrument consisting of 10 geographically distributed observatories, networked via state-of-the-art communications, for integrated studies to obtain a predictive understanding of the nation's environments. In addition, NEON would serve as a "biological early detection system" that is designed to provide an invaluable resource and a front line of homeland defense—both for its scientific potential and for enabling rapid detection of chemical and biological terrorist threats. NSF is requesting $12 million in initial funding for this project for proof of concept prototyping and for construction and networking of two initial sites.

- **EarthScope**. EarthScope would be a distributed, multi-purpose geophysical instrument array that is designed to make major advances in our knowledge and understanding of the structure and dynamics of the North American continent. Three components of the project would be the United States Seismic Array (USArray), the San Andreas Fault Observatory at Depth, and the Plate Boundary Observatory. NSF is requesting $35 million for initial funding of this project.

Both NEON and EarthScope were included in NSF's budget request for FY 2001 but funding for the projects was not included in the enacted appropriations bill. NSF's budget request for FY 2002 did not contain any new starts for the MRE account. We urge Congress to provide full funding for NEON and EarthScope.

National Science Board Report on Environmental Science and Engineering

The National Council for Science and the Environment is the primary proponent of an effort to expand, improve and enhance the relevancy of the scientific efforts of the National Science Foundation regarding the environment. We believe that NSF—as an independent, non-regulatory science-funding agency—is an important source of credible scientific knowledge about the environment.

NCSE's efforts have had considerable support from Congress. The House Appropriations Committee report to accompany the FY 1998 appropriations bill directed NSF to study how it would establish and operate a National Institute for the Environment that, "provides a major role for stakeholders in defining questions needing scientific attention and which funds ongoing knowledge assessments, extramural research, on-line information dissemination, and education and training through a competitive peer reviewed process."

The National Science Board responded to Congress by unanimously approving a report, *Environmental Science and Engineering for the 21st Century: The Role of the National Science Foundation,* on February 2, 2000. The NSB report sets out a bold, ambitious set of recommendations that could dramatically improve the scientific basis for environmental decisionmaking. The first keystone recommendation is as follows:

> "Environmental research, education, and scientific assessment should be one of NSF's highest priorities. The current environmental portfolio represents an expenditure of approximately $600 million per year. In view of the overwhelming importance of, and exciting opportunities for, progress in the environmental arena, and because existing resources are fully and appropriately utilized, new funding will be required. We recommend that support for environmental research, education, and scientific assessment at NSF be increased by an additional $1 billion, phased in over the next 5 years, to reach an annual expenditure of approximately $1.6 billion."

The National Council for Science and the Environment encourages Congress to support full and effective implementation of the National Science Board's report, *Environmental Science and Engineering for the 21st Century: The Role of the National Science Foundation,* within the context of a doubling of the budget for the NSF.

NSF has begun to implement the recommendations of the NSB. It has appointed an environmental coordinator and created a new position in the office of the Director. NSF has formed an Advisory Committee on Environmental Research and Education. It has established a priority area on Biocomplexity and the Environment that provides new opportunities for multidisciplinary research on the interactivity of biota and the environment.

Full implementation of the NSB report will require strong support from Congress and a significant increase in funding for NSF's portfolio of environmental science, engineering and education.

Homeland Security and Environmental R&D

Environmental R&D is a critical component of homeland security. For example, understanding the dispersal of radionuclides and toxic substances in air, water, and land is directly relevant to homeland defense. NSF has supported research in these areas for many years. NSF is requesting funding for new environmental projects that could strengthen homeland security. For example, NSF Director Rita Colwell said that NSF's proposed National Ecological Observatory Network (NEON) could detect abrupt changes or long-term trends in the environment and could also serve as "an early warning and detection system for a wide array of chemical and biological warfare agents." We encourage Congress to explore the role of environmental R&D in homeland security and counterterrorism and to recommend actions that would improve the nation's capacity in this area.

Thank you very much for your interest in improving the scientific basis for environmental decisionmaking.

Attachments

1. Letter calling for significant funding increases for environmental science, engineering, and education programs signed by more than 120 national leaders of academic, scientific, environmental, and business organizations.
2. Biographical sketches of Dr. Craig M. Schiffries and Dr. Peter D. Saundry.

March 8, 2001

President George W. Bush
The White House
1600 Pennsylvania Avenue NW
Washington, DC 20500

Dear President Bush:

During your recent election campaign, you talked about the importance of basing environmental decisions on science. We, as a diverse coalition of academic, business, environmental, governmental and community leaders, working with the National Council for Science and the Environment agree with you in this regard.

We are writing to urge you to implement your campaign commitment by making investment in science for environmental decisionmaking a priority in your administration. In particular, we are asking you to provide significantly increased funding for scientific programs to:

- Assess what is known about the environment
- Better understand the environment
- Provide scientific information about the environment
- Support science-based education about the environment.

These programs include:
- National Science Foundation's biocomplexity in the environment initiative and portfolio of environmental science, engineering and education programs
- U.S. Geological Survey's biological, geological, hydrological, and mapping divisions
- U.S. Environmental Protection Agency's Office of Research and Development, especially the Science To Achieve Results (STAR) research and fellowship programs
- National Oceanographic and Atmospheric Administration
- US Department of Agriculture's environmental research programs through CSREES and the Agricultural Research Service, particularly the Natural Resource Initiative
- US Forest Service forestry research
- Department of Energy's environmental science programs
- National Aeronautics and Space Administration earth exploration programs.
- National Institute of Environmental Health Sciences

We hope that your initial budget will support science as an investment that will lead to a stronger economy, healthy people, and a healthy environment.

Sincerely,

Peter D Saundry, Ph.D.
Executive Director
National Council for Science & the Environment
1725 K St., NW Suite 212
Washington DC 20006
Ph: 202-530-5810

(See attached pages for additional signatures)

Mary Lynne Bird, Executive Director
The American Geographical Society

Mark F. Deering, President- Ohio Section
American Institute of Professional Geologists

Michael S. Giaimo, V.P.
Business and Industry Association of New Hampshire

Roger McManus, President Emeritus
Center for Marine Conservation

William C. Baker, President
Chesapeake Bay Foundation

George Colvin, Craig Cox, and Martin Schmidt
Certified Professional Geologists
Cox-Colvin & Associates

Rita McManamon, Director
Conservation Action Resource Center

James Lazell, President
The Conservancy Agency

Mark Shaffer, Senior Vice President
Defenders of Wildlife

Martin J. Muggleton, President
Greater Corning Area Chamber of Commerce

T. Nejat Veziroglu, President
International Association for Hydrogen Energy

Elliot Norse, President
Marine Conservation Biology Institute

Dick Bartlett, Vice Chairman
Mary Kay Holding Corp.

Daniel A. Lashof, Senior Scientist
Natural Resources Defense Council

Joan Verplanck, President
NJ Chamber of Commerce

Gerlad M. Meral, Executive Director
Planning and Conservation League

Robert Engelman, Vice President for Research
Population Action International

Eugene V. Coan, Sr. Advisor to the Executive Director
The Sierra Club

John G. Robinson, Senior Vice President
Wildlife Conservation Society

Donald Brunning, Chairman and Curator
Wildlife Conservation Society

G. Thomas Bancroft, Vice President
The Wilderness Society

Gregory H Aplet, Forest Ecologist
The Wilderness Society

Richard A. Anthes, President
University Corporation for Atmospheric Research

Universities

John T. Gibson, President
Alabama A&M University

Richard J. Cook, President
Allegheny College

Tom Gerety, President
Amherst College

Lattie Coor , President
Arizona State University

Jeanne O'Laughlin, President
Barry University

David H. Swinton, President
Benedict College

Gloria R. Scott, President
Bennett College

Larry Shinn, President
Berea College

Oswald P. Bronson, President
Bethune-Cookman College

Jon Westling, President
Boston University

Jehuda Reinharz, President
Brandeis University

Gwen Fountain, Interim President
Butler University

James Rosser, President
California State University, L.A.

John D. Welty, President
California State University- Fresno

Mathew Goldstein, Chancellor
City University of New York

Claire A. Van Ummerson, President
Cleveland State University

Henry N. Tisdale, President
Claflin University

Steven K. Katona, President
College of the Atlantic

Albert C. Yates, President
Colorado State University

George Rupp, President
Columbia University

William Cibes, Chancellor
Connecticut State University System

Joseph R. Fink, President
Dominican University of California

Nannerl O. Keohane, President
Duke University

David R. Black, President
Eastern College

William M. Chace, President
Emory University

Anthony J. Catanese, President
Florida Atlantic University

Carl V. Patton, President
Georgia State University

Eugene M. Tobin, President
Hamilton College

Walter M. Bortz III, President
Hampden-Sydney College

Thomas R. Tritton, President
Haverford College

Myles Brand, President
Indiana University

David F. Brakke, Dean College of Science & Mathematics
James Madison University

Laurence I. Peterson, Dean
Kennesaw State University

Wesley C. McClure, President
Lane College

Michael Mooney, President
Lewis and Clark College

David B. Henson, President
Lincoln University

Constance Woo, Dean of Library
Long Island University

Michael S. McPherson, President
Macalester College

Geoffrey Gamble, President
Montana State University

Earl S. Richardson, President
Morgan State University

Joanne V. Creighton, President
Mount Holyoke College

Daniel H. Lopez, President
New Mexico Institute of Mining and Technology

Clara Lovett, President
Northern Arizona University

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Delbert Baker, President
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Ohio University

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Paul Yu, President
State University of New York - Brockport

Roger W. Bowen, President
State University of New York- New Paltz

Horace A Judson, President
State University of New York- Plattsburg

Shirley Kenny, President
State University of New York - Stony Brook

Beheruz N. Sethna, President
State University of West Georgia

Peter Likins, President
University of Arizona

Henry T. Yang, Chancellor
University of California Santa Barbara

M.R.C. Greenwood, Chancellor
University of California- Santa Cruz

Anibal Colon Rosado, President
Universidad Central de Bayamon

Linda Bunnell Shade, Chancellor,
University of Colorado- Colorado Springs

Georgia Lesh-Laurie, Chancellor
University of Colorado- Denver

Kenneth P. Mortimer, President
University of Hawaii

Freeman Hrabowski, President
University of Maryland- Baltimore County

Donald N. Langenberg, Chancellor
University of Maryland System

Blanch Touhill, Chancellor
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William McCoy, Interim Chancellor
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James Woodard, Chancellor
University of North Carolina-Charlotte

Patricia A Sullivan, Chancellor
University of North Carolina-Greensboro

Charles Kupchella, President
University of North Dakota

Jess K. Zimmerman, Director
University of Puerto Rico

Terry A. Cooney, Acting President
University of Puget Sound

Robert L. Carothers, President
University of Rhode Island

William E. Cooper, President
University of Richmond

Steve Privett, President
University of San Francisco

John M. Palms, President
University of South Carolina-Columbia

John T. Casteen III, President
University of Virginia

John D. Wiley, Chancellor
University of Wisconsin - Madison

Thomas F. George, Chancellor
University of Wisconsin- Stevens Point

Julius E. Erlenbach, Chancellor
University of Wisconsin- Superior

Philip L. Dubois, President
University of Wyoming

Frances D. Fergusson, President
Vassar College

Eugene P. Trani, President
Virginia Commonwealth University

Charles W. Steger, President
Virginia Polytechnic Institute and State University

Bernard Franklin, President
Virginia Union University

Brian C. Mitchell, President
Washington & Jefferson College

Karen W. Morse, President
Western Washington University

M. Lee Pelton, President
Willamette University

Perry Moore, Provost
Wright State University

Biographical Sketches of Witnesses

Craig M. Schiffries is Senior Scientist at the National Council for Science and the Environment. He previously served as a Congressional Science Fellow on the staff of the United States Senate Judiciary Committee; Director of Government Affairs for the American Geological Institute; Director of the Board on Earth Sciences and Resources of the National Academy of Sciences / National Research Council; visiting faculty member at Yale University; and consultant with Monitor Company. Dr. Schiffries simultaneously earned his B.S. and M.S. degrees from Yale University, where was he was elected to *Phi Beta Kappa*, graduated *summa cum laude,* and double-majored in Geology and Geophysics and in Economics and Political Science. He was a Marshall Scholar at Oxford University, where he earned an honors B.A. in Philosophy, Politics, and Economics. He received a Ph.D. in Geology from Harvard University, where he held a fellowship from the Hertz Foundation.

Peter D. Saundry is the Executive Director of the National Council for Science and the Environment, a nonpartisan organization of scientists, environmentalists, business people, and policy makers working to improve the scientific basis of environmental decisionmaking. Dr. Saundry specializes in the connection between science and environmental decisionmaking and policy, and programs involving scientists and policy makers and shapers. From 1991 - 92, Dr. Saundry was a Congressional Science Fellow with the U.S. Senate Appropriations Committee, where he was an advisor on science and technology issues related to the National Science Foundation, National Aeronautic and Space Administration, and the Environmental Protection Agency. Dr. Saundry has a Ph.D. in Physics from the University of Southern California.

June 19, 2002

The Honorable Edward M. Kennedy
Chair
Senate Committee on Health, Education, Labor and Pensions

Dear Chairman Kennedy:

We write to you on behalf of science and mathematics educators throughout the nation who congratulate your leadership to improve pre-service and in-service education opportunities for all teachers. The reauthorization of the National Science Foundation (NSF) Act offers an important opportunity to strengthen the federal investment in the preparation of teachers and therefore the academic achievement of students in math, science, and technology. It is a chance to build on the successful reform of the repealed Eisenhower Professional Development Program, now authorized as Title II Part B of the No Child Left Behind Act (Math and Science Partnerships).

NSF funding of systemic reform initiatives in math and science, and many other high-quality initiatives, has helped State and Local Education Agencies develop high-quality programming, curriculum, and teacher training institutes. The high-quality programs that have been born of that investment have been successfully replicated in many communities. It is our hope that as a result of this reauthorization, these programs will be expanded and funding increased so more effective partnerships between K-12 schools and institutions of higher education can be created.

While we were very pleased with the reforms included in Title II of No Child Left Behind, we have been disappointed with the funding provided by the Congress to support this much needed reform. Between FY 2001 and FY 2002, dedicated support for math and science teacher professional development effectively declined by 95 percent (from $250 million to $12.5 million). It was a precipitous drop. The funding increase in Part A of Title II, available to all educators, will surely be spent in part on math and science, but we view the absence of a federal priority as a loss.

It is our hope that in future years, support for the Math and Science Partnership Program at the Department of Education will be restored to previous levels for the Eisenhower State Grant program ($485 million). Once that is achieved, real partnership between NSF and the Department of Education can take place. We believe the appropriate role for NSF is to stimulate the design and redevelopment of the highest quality programs for math and science educators. With Department of Education dollars, these models can be replicated in targeted areas—where the need is greatest—in urban and rural communities around the country.

We believe our sense of urgency regarding teacher preparedness, and, consequently student performance, in math and science, is justified. Over the past two

decades, commission reports, studies, and international comparisons have documented the crisis.

- In 1983, *A Nation at Risk* raised awareness of the state of K-12 education in the United States. The report led to the historic 1989 education summit in Williamsburg, Virginia where the nation's governors mapped out a list of goals our schools would strive to meet by the year 2000. One clear goal stated: "*By the year 2000, United States students will be the first in the world in mathematics and science achievement.*" Clearly this goal has not been met.

- The 1995 Third International Math and Science Study (TIMSS) shows that while U.S. fourth grade students scored above the international average in science and mathematics, eighth grade students scored far below their international counterparts. The TIMSS results from U.S. 12th grade students were especially disappointing. The results of the 1999 TIMMS-Repeat found that U.S. students have shown "no statistically significant changes in their level of achievement from 1995 to 1999." Scores from the National Assessment of Education Progress (NAEP), the "Nation's Report Card," confirm that less than one-third of all students in grades 4, 8, and 12 performed at or above the proficient level in mathematics and science.

- A report issued in February 2001 from the Commission on National Security for the 21st Century calls attention to the serious problems inherent in K-12 mathematics and science education. *Roadmap for National Security: Imperative for Change* states, "Americans are living off the economic and security benefits of the last three generations' investment in science and education, but now we are consuming capital. Our systems of basic scientific research and education are in serious crisis, while other countries are redoubling their efforts. . .The quality of the U.S. education system has fallen behind those of scores of other nations. This has occurred at a time when vastly more Americans will have to understand and work competently with science and math on a daily basis . . . In this commission's view, the inadequacies of our systems of research and education pose a greater threat to U.S. national security over the next quarter century than any potential conventional war that we might imagine. American national leadership must understand these deficiencies as threats to national security. If we do not invest heavily and wisely in rebuilding these two core strengths, America will be incapable of maintaining its global position long into the 21st century."

- Far too many teachers are teaching out of field, or with little training in mathematics or science. Of the 300,000 middle-and high-school science and mathematics teachers in the United States, nearly 30 percent—46,000 mathematics teachers and 40,000 science teachers—neither majored nor minored in the subjects they teach, according to a 1999 study conducted by the Council of Chief State School Officers. High-poverty schools are even worse: Students there have less than a 50 percent chance of having a science or mathematics teacher who holds both a license and a degree in these subjects.

- Last fall, the report *Before It's Too Late: A Report to the Nation from the National Commission on Mathematics and Science Teaching for the 21st Century* was issued. This report culminated a yearlong study by blue-ribbon panel of educators, policymakers and state leaders, led by Senator John Glenn. The Glenn Commission's work was based on three premises: 1. "The Commission is convinced 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." 2. "Our children are falling behind; they are simply not 'world-class learners' when it comes to mathematics and science." 3. "The most powerful instrument for change, and therefore the place to begin, lies at the very core of education—*with teaching itself*."

- Our children are simply not receiving the world-class education in mathematics and the sciences that they deserve. While this fact alone is serious, the long-term implications that our nation's economic growth, national security, workforce development, and science, mathematics, and technology literacy cannot be ignored. It is estimated that nearly **half of all economic growth** in the United States results directly from research and development in science and technology. Our K-12 education is not producing the intellectual capital necessary to ensure that future generations of scientists and engineers can maintain the research and development vital to our continued economic growth. As the economy becomes increasingly more global and technologically complex, it is essential that K-12 education be strengthened to prepare today's students to be tomorrow's productive workers and citizens. The less-than-adequate preparation of potential scientists, mathematicians, and engineers in the formative K-12 years can also pose a **serious threat to national security**. Mathematics, science, and engineering supply the basis for the development of satellite communications technologies, information technologies, and other high-tech methods now employed by our nation's armed forces. Our **changing workforce** means that new workers will need even sharper skills in science, mathematics, engineering and technology. In today's market, businesses are begging for skilled, technical workers to fill open positions. For several years now, Congress has raised the ceiling on the number of H-1B visas allowing more skilled foreign workers into the United States. The Congress recently raised that ceiling to just under 200,000 workers per year until 2003. What's more, U.S. businesses spent $62.5 billion last year to upgrade basic employee skills. There is an urgent need to develop a technologically capable workforce that can compete in the global economy. Employers are increasingly concerned about the lack of technically skilled workers. Much more emphasis must be placed on the education we provide to K-12 students if this skill deficit is to be overcome.

- In U.S. colleges and universities, non-resident aliens earned 34 percent of all bachelors' degrees and 44 percent of all masters degrees awarded in engineering, mathematics, and information science. We are simply not doing enough to

motivate our K-12 students, especially girls and minorities, to seek out higher degrees (and careers) in science, mathematics, engineering, and technology.

- Research has shown that K-12 education is not producing citizens who are able to understand even basic science and technology concepts, let alone the knowledge needed to understand emerging issues such as cloning, DNA and global warming. "In the coming decades, science literacy may well be the defining factor for our success as individuals and as a nation," according to the Bayer Corporation report *What America Thinks About Science Education Reform.* "Indeed, the United States' global competitiveness rests firmly on its ability to educate a workforce capable of generating and coping with rapid technological changes. In order to adapt, each of us will need to be scientifically literate, not to become scientists, but rather to be able to act as responsible citizens and participate fully in a technology-driven age."

We look forward to working with the Committee as you begin the reauthorization of the National Science Foundation legislation. We believe this offers an important opportunity to build on the accomplishments of the No Child Left Behind Act and to strengthen the important ties between the work of NSF and the Department of Education in support of improved student achievement in math and science education. Though we failed as a nation to reach the goal set by former President Bush to be "first in the world in math and science by the year 2000," it remains an important and achievable goal that we should continue to strive toward.

Sincerely,

James Rubillo
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Gerald Wheeler, PhD.
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