Mr. Chairman and Members of the Subcommittee:

My name is Dan Mote, and I am president of the University of Maryland, College Park, the flagship institution of the State of Maryland. I appreciate very much this opportunity to testify before the Subcommittee. I am speaking to you today as the president of a preeminent institution that has built its reputation of distinguished achievement on the impact of its research. I am also speaking as a member of the Association of American Universities (AAU) and National Association of State Universities and Land Grant Colleges (NASUGLC), which together include universities in each of the 50 states that receive significant support from the National Science Foundation.

Speaking on behalf of the higher education and scientific communities, Chairman Smith, I want to report that we are delighted that you and Chairman Boehlert of the full Science Committee are calling for such significant increases in the NSF budget. I am here to offer you my full support for your proposed legislation and to take special note of the urgency of this action. You are major forces for science.

In the letter of invitation to testify today, I was asked to respond to three questions.

The first among these was: Please comment on the potential of this legislation to further NSF’s mission of promoting and advancing progress in science and engineering across all disciplines. How would this legislation, should it be enacted, affect the nation’s overall research and development portfolio?

NSF is the key government agency that funds basic research in many disciplines, and the importance of basic scientific research for the future of the country cannot be overstated. Basic research and the people who engage in basic research give the country its edge in scientific discovery; they underpin the technologies that will be essential to building our defense from terrorism at home and abroad; and they lay the foundation for the technological advances through knowledge and innovation that are primary to
quality of life and economic prosperity.

The United States has clearly led the world in science and technology since World War II, but that leadership is threatened today by the looming shortage of scientists and engineers. If we don't move quickly to attract a much greater number of our young people into science and engineering, and prepare many of them for careers in research, our country will descend a slippery slope toward insufficient workforce to maintain a viable scientific and technological enterprise. Our NSF-funded research has been the proven base for building powerful research and training operations that have provided thousands of skilled people to work in federal agencies (ARL, NRL, NSA, DOE, DARPA, NASA, NIST, NIH) and in the private sector.

The events of 9/11 and the subsequent very real concerns with homeland security add even more urgency to the need to fund basic research. Maintaining a high level of expertise in basic science and technology allows the nation to move relatively quickly as technological need changes abruptly. At the University of Maryland researchers in the Computer Sciences department, for example, are working on high speed human recognition systems and wireless communication systems, important technologies for security.

Issues of security may lead to reductions in the number of international students and ultimately scientists and technologists we employ in the national research enterprise. For the past few decades, the United States research agenda has thrived in large part because of the numbers of international students studying in our graduate schools at universities across the country and remaining here to enrich our scientific and technological workforce. In our colleges of Engineering and Computer, Mathematical, and Physical Sciences, international students compose half of the graduate student body. If we reduce their numbers significantly and, as is conceivable, restrict them substantially, we need to give immediate thought either to increasing the number of American citizens prepared for careers to replace them or to prepare for a society in which science and technology will no longer be preeminent. In fact, without top people in sufficient supply, our science and technology would not be first rate.

Funding for NSF can make the difference. Supporting the highest ranked research proposals by top quality people at our research universities is the only formula we know for supporting the scientific discoveries and producing the workforce we must have. It worked in the past. It will work now. We need to view this as a crisis whose magnitude has elevated substantially since 9/11.

As recommended by AAU, here are some of the goals that can be achieved with the funding levels called for in your legislation:
Advance core programs for research and education. One important indicator of the problem we face is the number of top-rated proposals not funded by NSF because of insufficient resources. Presently, that number is 13 percent. Top quality people whose proposals are not funded will seek other projects or leave the research enterprise. If we concentrate our top people in high-paying jobs in the commercial world, the research enterprise in federal research labs and research universities will be the loser. We need to keep the best in research by allowing them to work. The immediate appeal of AAU and the research community is for additional funding for these highest quality proposals. The proposed increase in your bill would enable more of the top-rated proposals and top-rated people to be funded and would also strengthen NSF's important education programs.

Let me give you an example from my university. One of our star junior faculty members, an assistant professor in the Department of Geology, has developed a technique called biological forces microscopy to directly measure at the nanoscale the forces between a living cell (biomolecule) and a material surface. This basic research on the interface between biological and mineral surfaces is visionary work that fits NSF, though possibly not other agencies. This research has enormous implications to the environmental and medical sciences, with asbestos poisoning being just one example. His recent proposal to NSF in nanotechnology has been rated as top quality and recommended for funding. If resources at NSF cannot be found to fund his proposal, his ability to pursue this vitally important line of investigation will be in jeopardy.

Continue supporting key initiatives. Nanotechnology; biocomplexity; information technology research; workforce development (including math and science partnerships); mathematics research; and social and behavioral sciences have all been identified as fields ripe for advances and keys to the nation's future. Your legislation would drive progress in these critical areas.

Increase grant size and duration. The average NSF grant awarded in FY2001 was $93,000 and lasted for just under three years. By comparison, the average NIH grant in FY2000 was $338,000 and lasted for just over four years. Increasing the size and length of time of grants will enable highly rated researchers to concentrate on discovery rather than paperwork. My own experience, as a researcher supported by NSF funding continuously from 1962 to 2000, is that small, sub three-year grants do not allow time or funding for a top researcher to achieve a level of productivity we should expect of their efforts. Small grants force top people to serve as office and lab staff since they can't hire support personnel; the short time period requires excessive time commitment, every other year, in preparation of proposals. All this can be done and is done. However, from a public policy perspective, is this really the best way to use the time of the nation's most distinguished scientists and engineers? Your legislation will provide the welcome opportunity for NSF to increase grant size and duration and keep the best people working on the right things.
**Add funding for Major Research Equipment and Facilities Construction and Major Research Instrumentation.** Several proposals are pending for large-scale research resources that would provide benefits not only to the institution or region where the research project is located, but also to researchers throughout the United States and the world. Your legislation would hasten progress on these important capital projects, and provide criteria by which they can be judged on their merit. In FY 2001, the NSF Major Research Instrumentation program awarded $75 million, but many top-rated applications could not be funded. Your legislation would make possible additional needed research instrumentation - and these purchases will benefit the domestic economy, because almost all specialized research instrumentation is procured from American vendors.

**Assist with homeland security and anti-terrorism efforts.** The terrorist acts of September 11 have greatly increased recognition of the role of science and engineering in homeland security. Working closely with other federal agencies, NSF can enhance support for groundbreaking research into information security, detection of airborne hazards, structural studies to improve building safety, psychological effects of living with terrorism, wireless communications, and a broad range of other scientific areas. Your legislation would support grants in critical areas related to the War on Terrorism.

**Increase graduate student stipends.** Providing competitive compensation to graduate students will attract more qualified Americans to science and engineering careers and help address long-term workforce needs. First we need to attract them; then we need to keep them. With an additional $23 million above the FY 2002 appropriation, NSF can increase these stipends from $21,500 per year in FY 2002 to $25,000 in FY 2003. Your legislation would make this possible as well.

The second question I was asked to address today was: *How does basic research, including research done at the University of Maryland, benefit the nation? What is the impact of NSF-sponsored research programs at the University of Maryland on the local and state economy?*

The University of Maryland's total externally-sponsored research and outreach activities topped $300 million in FY2001, and the University's growth of federal research expenditures over the last five years (1995-2000) is 45%, one of the highest rates of growth for an AAU university. The latest NSF summary of R&D expenditures at all universities and colleges by science and engineering fields, for FY 2000 shows that in amount of R&D expenditures, the University of Maryland is among the top recipients. Maryland ranked #13 in total R&D expenditures in engineering; and #10 in federally financed R&D expenditures in the physical sciences.
How has that funding been used? Let me give examples of two research units at the University of Maryland and their work. The Institute for Systems Research is a permanent unit of the University of Maryland created in 1985 by NSF as one of the first Engineering Research Centers. The Institute is a cross-disciplinary organization that addresses problems of national importance in control and communication for complex systems. Its innovations have impacted technology and society in diverse areas such as robotics, wireless communications, aerospace systems, manufacturing, artificial intelligence and transportation. Examples of significant research conducted by the ISR faculty and researchers follow.

- Research at the University of Maryland produced an engine controller to eliminate stall in gas turbine jet engines. The ultimate goal of implementing stall-resistant jet engines will be achieved once actuator components are developed that can withstand the harsh operating environment of a jet engine.

- A technique for data compression developed at the University of Maryland has been implemented for data transmission over bandlimited communication links such as telephone lines. This technique led to the development of a new Standard for telephone line modems known as V.34 which doubled data transmission speeds to 28.8 k bits per second with profound global impact.

- The NSF-sponsored work at the Human Computer Interaction Laboratory has developed new technologies for visualization of complex data sets. Implementations were built to display directory structures on computer hard drives, basketball player statistics, stock portfolios, business decision making, etc. One well-known product resulting from this work is the "Map of the Market" licensed by Wall Street firms.

The Materials Research Science and Engineering Center (MRSEC), supported by major grants from NSF and by other agencies, focuses on the fundamental aspects of small structures and the reliability and utility of nanostructures. Nanotechnology, the building of machines at an atomic level, holds enormous potential for revolutionizing the fields of materials, electronics, medicine and health care, the environment and energy, biotechnology and agriculture, and national security. A result of our investment in basic sciences over the past 50 years, nanotechnology builds on technology and scientific advances in physics, chemistry, electrical engineering, materials science and biology.

- The Materials Research Science and Engineering Center at Maryland has been a national leader in improving the scan-probe microscopy necessary for work at the atomic level and developing innovative applications of its use in nanotechnology. For example, MRSEC scientists worked with scientists from the National Institute of Standards and Technology to develop the standard for
Testimony of C.D. Mote

measurements in nanotechnology.

- MRSEC scientists have used scanning-probe microscopy in conjunction with a focused ion beam to create and measure tiny capacitors by a process similar to sand blasting, except the "sand" particles are individual atomic ions so that material can be removed atomic layer by atomic layer. This technique is now being used in collaborations with industrial scientists to improve ferro-electric memories for applications in portable storage devices, such as smart cards.

- MRSEC researchers using scan-probe microscopy have shown that "traffic jams" of electrical current can be directly observed around defects in wires in circuit boards. The new ability to observe these jams directly provides a tool for detecting a failure site before the failure occurs.

One more example shows the immediate value and long-term potential of many NSF funded projects. The College of Information Studies, in concert with University of Maryland Institute for Applied Computer Studies (UMIACS), the Department of Computer Science, the Department of Linguistics, Johns Hopkins, and IBM secured a National Science Foundation grant to work on access to the oral and video histories of Holocaust survivors created by the Shoah Foundation, which collected testimonies in 57 countries and 32 languages. It will use its material to promote understanding and help eliminate prejudice. The Maryland team and their colleagues will develop multi-lingual speech processing technology to provide easy access to this material. Because the collection is so large and complex, the project has the added value of accessing oral records and cross-language retrieval in general. This will have applicability in several strategic areas, including retrieving information from foreign languages in the Mid East and elsewhere as a way of contributing to national security and combating terrorism.

I cannot overstate the importance to our nation's future prosperity of investment in basic scientific research and in the people who conduct this research. A study released last year by the prestigious Council On Competitiveness, which includes some of our nation's leading chief executives in industry and academia, called for an increasing commitment to innovation, particularly to federal investments in research and development funding as necessary "just to maintain the position of the United States, much less improve [it] in relative terms."

Innovation comes from basic research findings of the highest caliber in every field, creates all new opportunities, and is vital to them all. We applaud the funding Congress has approved for research in the biological and life sciences and celebrate the many advances that have resulted from this support. Research in the physical sciences, biological sciences, mathematics, and engineering is increasingly interdependent, and interdependence extends between them and the medical sciences. Medical technologies
such as magnetic resonance imagery, ultrasound, and genomic mapping could not have occurred without underlying knowledge in biology, physics, mathematics, computer sciences, chemistry and engineering. Continuing significant medical advances, which are often, and increasingly, advances in technology, not in medicine per se, will require concomitant advances in the sciences and engineering.

Basic research is driving improvements in economic development too. Industries and private companies, state governments, and federal laboratories are entering into partnerships with universities at a rapid and increasing rate. Such partnerships expand the workforce and bring ideas to early application; they lead to new spin-off companies and make new jobs possible. In this knowledge economy our economic leadership depends on ideas and innovations. Universities and university research are a primary source for these ideas. They must be supported.

According to an AAU analysis of the economic impact of NSF funding, $1M in research grants generates approximately 36 jobs. We currently have approximately $40M in NSF awards, which would yield about 1400 positions for the State and $80M in economic output impact. Industry-sponsored university research grows from a strong federally funded research base, which is more likely to yield products for commercialization, and the University accounts for the bulk of industry-sponsored public university research in Maryland. The University accounted for 44% of invention disclosures, 68% of patent applications, and 35% of patents issued to Maryland public universities in 1999 and is a major source of new company start-up activity.

Finally, I was asked to answer the following: What is the role of NSF funding in the education and training of scientists, mathematicians, and engineers in the U.S.? How will this legislation affect education and training programs at institutions of higher education, including the University of Maryland, and what are your thoughts on how best these programs can be strengthened?

The National Science Foundation (NSF), the heart of the federal investment in basic scientific research, has had an extraordinary impact on American scientific discovery and technological innovation. It is the only federal agency with responsibility for research and education in all major scientific and engineering fields. Consequently, both directly and through grant-funded graduate research assistants and post-doctoral fellows NSF plays a lead role in the training of future scientists, mathematicians and engineers that provide the base of the federal and private sector creative workforce in high-tech areas. At Maryland the largest support for graduate research assistants from a single federal source (25% of our total funds) comes from NSF funding. The availability directly impacts the numbers of top quality graduate students we can attract.

The School of Engineering has an aggressive focus on undergraduate education, and
NSF support has led to several significant educational programs with a lasting positive impact. An example of an NSF-supported program highly successful in attracting talented undergraduates in Maryland to exciting research programs and research-oriented careers is MERIT (Maryland Engineering Research Internship Teams), an innovative team-based research project for undergraduates in telecommunications, computer systems and power and energy. The School has received an additional grant from NSF's Research Experiences for Undergraduates (REU) Program in Molecular and Cellular Bioengineering, an important emerging field of study. Such programs are vital if we want to increase the number of young people interested in science. Another compelling example is the work of Dr. Patricia Campbell, professor in Mathematics Education, principal investigator for "Mathematics: Application and Reasoning Skills (MARS)," a project funded by NSF, 1996-2001, for $6M. The project's goal was to develop a model for systemic reform in elementary mathematics across the Baltimore City Public School System and increase student achievement through teacher enhancement. The results are remarkable: between 1996 and 2000, the proficiency percentage as measured on state standardized tests increased by 71% in grade 3 and by 60% in grade 5. Performance on the Comprehensive Tests on Basic Skills national standardized tests was also remarkable: between 1998 and 2001 in the 107 schools participating, the average increase for grades 1-5 was over 100%. NSF is widely recognized for excellence in the management of federal funds. Approximately 95 percent of the agency's total budget goes directly to support the actual conduct of research and education, while less than five percent is spent on administration and management. NSF was the only agency in the entire federal government to receive a "green light" for Financial Management in a review by the Treasury Department, General Accounting Office and Office of Management and Budget, published in the Administration's FY 2003 budget request. Consequently, I believe the primary way to help NSF better accomplish its objectives is a significant increase in funding.

Two years ago, congressmen and senators from both parties set an ambitious and appropriate goal: to double the budget of NSF from its funding level in FY 2000 ($3.9 billion) to approximately $8 billion by FY2005. For the past two years, Congress has voted strong support for this goal. AAU and the university community believe it is critical to build on this strong start now and continue to invest in research in which the pay-offs are so high for the citizens of the country. Your authorization bill will send a strong signal to the appropriators, the rest of the Congress, and the Administration that support for NSF is strong, it is bipartisan, and it is grounded in sound arguments.

I want to close by emphasizing the importance of competitive merit review. NSF's numerous scientific achievements are due both to the work of the principal investigators and to the agency's use of merit review for allocating research funding. We believe that merit review must continue to be the method NSF uses to allocate research funds, since this process has helped produce the discoveries and advances from which the nation has benefited. It works.
Thank you for your leadership on these issues, and for the opportunity to provide this testimony.