Testimony for Senate Committee on Energy and Natural Resources

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Senator Alexander and members of the Senate Committee on Energy and Natural Resources, Secretary Abraham, Director Orbach…. It is an honor to be here today and have an opportunity to discuss the importance of basic research in the physical sciences and the role of the Office of Science in the Department of Energy in supporting it. I have been asked to speak more specifically to the importance of basic research and a balanced research portfolio from the perspective of the President's Council of Advisors on Science and Technology (PCAST), of which I am a member, and to the importance of the relationship between research universities and the Office of Science from the perspective of a research university president.

Over the past century, research and innovation in science and technology have become the source and driving force of the leading-edge products and services that have given the United States is economic and military leadership. Our continued economic prosperity, national security, and energy sufficiency are based on our ability to discover new knowledge and develop new technology, and increasing competition from around the world means we cannot afford a leisurely approach to that task. I serve on the executive committee of the U.S. Council of Competitiveness, whose research indicates that the United States needs to be among the leaders if not the leader in every major field of research if we are to sustain the innovation that drives our prosperity and world leadership.

As a member of PCAST, I have a unique opportunity to look broadly at the federal government's research and development portfolio as a whole. When you do that at the 30,000-foot level, three important, overarching characteristics emerge:

First, the portfolio must have length. The time span from the basic research to the working implementation of a technological application is often decades. It will be too little too late if you wait until the need is pressing to ramp up the research. For example, it took Raymond Davis, Jr. thirty years of research at DOE's Brookhaven National Lab to capture solar neutrinos, proving that fusion provides the Sun's energy – an achievement that won him the 2002 Nobel Prize for Physics – and his research was based on other work conducted 70 years ago. Similarly, today's semiconductors emerged from basic research in quantum mechanics in the 1940s. The Internet that is so essential to so many commercial applications today is based on research from the 1960s and 70s. Basic research in fields related to energy has become especially important. According to the advisory committee for Basic Energy Sciences, which is the largest program in the Office of Science, world energy needs are expected to more than double over the next 50 years and the technology does not yet exist to meet them. Creating that technology depends on significant scientific breakthroughs generated by fundamental research, primarily in the Office of Science.

The largest provider of the fundamental research on which industry bases its innovations is research universities and national laboratories, and it is funded largely by the federal government. Industries are reluctant to do basic research, because it is seldom clear exactly who will profit or when, and industry labs to conduct long-term research have all but disappeared. According to the National Council on Research, for example, the computing and semiconductor industries devote less than five percent of their research budget to basic research. Yet Council on Competitiveness studies indicate that almost three-quarters of industrial patents cite publicly funded research as the basis for their invention. Much of this research is conducted or sponsored by the Office of Science. It is the "seed-corn" on which the next generation of industry products and services will be based and which will provide the solutions to problems like national security and an ample supply of clean energy.

The second characteristic of our national research portfolio must be breadth. Many of the problems and opportunities facing us today require the collaboration of multiple disciplines, and the detrimental impact of an unbalanced R&D portfolio will be much broader than the individual disciplines that are short-changed. Last fall, PCAST cautioned that the federal R&D portfolio was becoming unbalanced as a result of the doubling of the budget for the National Institutes of Health. Advances in biomedical research are grounded in fundamental research not just in biology, but also in chemistry and physics, and in electrical and mechanical engineering, which provide insight into the operation of living systems. These disciplines have seen a declining level of federal support over the past decade, and their continued neglect will have a negative impact on the life sciences as well as the physical sciences and engineering.

However, correcting that imbalance will not be a neat and tidy exercise, because research in the physical sciences is spread across a number of agencies and funding for it passes through a number of different Congressional committees. Congress is presently focused on increasing the budget for the National Science Foundation, which is laudable but by itself will not do the job. The single largest supporter of basic research for the physical sciences for the past decade is not the NSF, but the Office of Science in DOE, which provides more than 40 percent of the funding. For example, although the NSF sponsors some research in physics, 70 percent of the federal physics portfolio is in the Office of Science, including 90 percent of the research in high-energy physics and 85 percent of the research in nuclear physics.

Third, any research program is only as good as the researchers who do the work. Over the past several decades, the United States has grown increasingly reliant on foreign talent in its science and engineering research. By the late 1990s, almost half of the Ph.D.s awarded by U.S. universities in computer science, engineering, and mathematics went to international students. Now, however, R&D operations are beginning to move abroad and international universities are improving the quality of their educational programs. As a result, fewer international students are coming to the United States for graduate study and an increasing number of them return home upon graduation. The number of Ph.D.s award in the United States in the sciences peaked in 1998. Engineering Ph.D.s peaked in 1996 and had declined by more than 15 percent by 1999. White males have traditionally comprised the science and engineering workforce, and these sectors are falling behind as women and minorities increase in the overall workforce.

Federal funding of university research is seen by graduate students as a bell-weather for career opportunities in research. They flock to fields in which federal R&D funding is strong and shun those for which it is stagnant or declining. This trend is not merely a reflection of the increase or decrease in graduate fellowships that accompany federal R&D funding. It holds for the broader graduate student body and is, in fact, strongest among students who are not receiving any federal assistance at all. As research emphasis shifted to the life sciences, the number of full-time graduate students in the physical sciences declined. From 1993 to 2000, the number of full-time graduate students in physics declined by more than 20 percent and the number in chemistry declined by almost 10 percent. Federal support for basic research in the physical sciences is very important to producing the talent the nation needs in these fields.

While federal funding for research conducted at universities invariably involves graduate students, we have been witnessing the erosion in recent years of federal support specifically for fellowships and dissertation awards. The funds appropriated to support DOE fellowships and dissertation awards saw an especially dramatic decline during recent years when the focus has been on the life sciences. DOE fellowship and dissertation award recipients decreased from more than 1,000 students in 1995 to less than 170 in 2000, and that number is even smaller today. This decline in federally funded fellowships is of particular concern to PCAST.

If we want to maintain our standard of living and our position of world leadership, it is crucial that we invest in long-term, fundamental research, which is conducted largely at universities and national labs; that we maintain a balance across the disciplines so that they move forward together; and that we pay attention to the education of the next generation of scientists and engineers. All of these things on which the well-being of future generations depends are essentially in the hands of Congress.

All three of these essential characteristics of a vibrant federal R&D program also come together in the DOE Office of Science. The Office funds basic research that will both provide the necessary balance in our national portfolio and lay the groundwork for the innovations on which our national security, energy efficiency, and economic prosperity rest. The Office also promotes the education of the next generation of research scholars in the physical sciences by providing opportunities for them to engage in research, counteracting to some extent the declining number of DOE fellowships. One-third of the $3 billion budget of the Office of Science supports university research involving approximately 250 universities in 49 of the 50 states and engaging tens of thousands of graduate and post-graduate students. The Office also offers students opportunities for engagement at its national labs.

The Office of Science has multi-faceted relationships with the nation's research universities that are unique among federal agencies. Beyond the usual avenue of providing grants and contracts for research conducted at universities, the Office offers university researchers access to the extraordinary facilities of its system of ten national laboratories and fourteen technology centers. This unique arrangement allows for maximum utilization of expensive research tools like the Spallation Neutron Source at Oak Ridge National Lab, the National Synchrotron Light Source at the Brookhaven National Lab, and the Nuclear Magnetic Resonance Spectrometer at the Pacific Northwest National Lab. Some of these facilities are one-of-a-kind in the world, and no other entity in the world controls the range of them that the Office of Science does. Access to unique research resources like these provides incredible opportunities for university research scholars to move their work forward – opportunities that are not available through any other means.

But the relationship between the national labs and research universities extends beyond allowing access to unique facilities. Five of DOE's national labs and technology centers are located at research universities, and others have close working relationships with research universities. Georgia Tech, for example, has a close working relationship with Oak Ridge National Laboratory in Tennessee. We are one of six universities that as a consortium have a formal partnership with Battelle to participate in the operation of the Oak Ridge National Laboratory and to help promote and manage collaborate partnerships among 87 members of the Oak Ridge Associated Universities and the national lab. Last year we connected Georgia Tech and Oak Ridge National Lab with a high-speed computer link that is 200,000 times faster than the fastest dial-up connections typical of home computers. In addition to promoting collaboration and data sharing between researchers at Georgia Tech and Oak Ridge, this powerful computer link also forms the connecting point between the Department of Energy's ESnet and Internet2, which is a high-speed network that connects the nation's top-tier research universities. Establishing this broader link through Georgia Tech and Oak Ridge National Lab was a logical step because Georgia Tech is the hub through which research universities throughout the Southeast are connected to Internet2, and Oak Ridge's Center for Computational Sciences is the primary site for DOE's Scientific Discovery Through Advanced Computing, an initiative that involves extensive partnerships between 13 DOE labs and technology centers and about 50 universities to address computing problems of national importance. The new high-speed connecting linking two powerful computer networks will allow the partnership between the Office of

Science and the nation's leading research universities to evolve to a new level of collaboration in research and education.

This multi-faceted working partnership between Georgia Tech and Oak Ridge National Laboratory is just one example of many similar relationships between universities and the national labs of the Office of Science. These close relationships are essential to the important task aligning the research work of the national labs and the work of the nation's research universities, so that our efforts are correlative and collaborative, and we realize the maximum progress and potential from our work.

Senator Alexander and members of the committee, this concludes my prepared statement. I will be glad to answer any questions you might have.