Testimony of

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before the

Subcommittee on Energy
Committee on Energy and Natural Resources
United States Senate

July 29, 2003

Chairman Alexander and other members of this Subcommittee, thank you for inviting me to testify about the unique role that the DOE's Office of Science plays in supporting basic research in the physical sciences. I have prepared this written statement, and with your permission, I would like to enter it into the record. I will briefly summarize my statement this morning.

DOE's Office of Science has invested in basic scientific knowledge for more than half a century. Given the Department's dominant missions in national security and energy supply, DOE's Office of Science has become over this period the Federal government's primary sponsor of research in the physical sciences. Although DOE is a mission agency, its leaders have always recognized that it is impossible to know in advance exactly what discovery will prove crucial to its mission success. Therefore, DOE's investments through its Office of Science in research projects, facilities, and people have tended to broadly cover the physical, chemical, materials, and computational sciences and engineering, along with studies aimed at understanding and mitigating biological and environmental effects of its energy and national security work.

Studies by the National Academy of Sciences have shown that more than half of our nation's economic growth stems from research and development. The nation's R&D enterprise lays the foundation for the future products and technologies that will keep Americans safe, secure, healthy, prosperous, and intellectually alive. History has proven that the basis for all fruitful R&D is a fundamental understanding of the laws of nature — a field of inquiry where DOE's Office of Science is a recognized leader.

New fundamental facts are continually being discovered. They are continually leading to new technologies that benefit society—often in surprising and unexpected ways. A telling example is Lord Rutherford's retrospectively naive comment, after discovering that there is a compact, massive nucleus deep inside every atom, that he was especially delighted to know that his discovery would have no practical application whatsoever. Of course, Lord Rutherford was wrong. What he considered knowledge for the sake of knowledge set the stage for nuclear medicine, nuclear energy, and many other modern advances.

The R&D enterprise has three main components:

1. Private-sector institutions and their research laboratories;
2. Universities and their research laboratories; and
3. Federally funded R&D centers, including the national laboratories.

According to the National Science Foundation, industry plays the major role in the U.S. R&D enterprise. In 2002, industry accounted for two-thirds of the nation's overall $292 billion R&D expenditure. But with a few notable exceptions, financial pressures force industry to focus on applied projects with relatively short-term payoffs. This means that industry is hard-pressed to pursue the longer-term, fundamental science that is so important to our nation's future.

Universities play a central role in the discovery of fundamental laws of nature. In a real sense, all R&D originates in universities, since they educate our scientists and engineers. It is the graduate students who carry the future of our R&D enterprise. To be at the frontier, they need research opportunities second to none. This is the reason why universities – and top universities in particular – need to be involved in the national laboratory system.

National laboratories were created during the mid-20th century to provide centers of research excellence that could focus on problems of national concern and to create closely cooperating, multidisciplinary teams to address long-term scientific problems.

National laboratories also turned out to be ideal places to design, build and operate large national R&D facilities – we call them "user facilities" – which have become essential for forefront research in all the sciences. These are large, one-of-a-kind facilities that attract and serve industrial, academic and government scientists from all over the nation – indeed, from all over the world – to carry out cutting-edge research. These user facilities provide resources, such as intense beams of subatomic particles or electromagnetic radiation, that speed up experiments by orders of magnitude and open up otherwise inaccessible facets of nature to scientific inquiry. Many of the important discoveries made in the physical sciences in the second half of the 20th century were made at – or were made possible by – user facilities. Moreover, most of these user facilities, which were justified and built to serve one scientific field in the physical sciences, have made significant contributions to knowledge and technology in many other fields, including biology and medicine. Examples of great value to society and human health include medical diagnostics and treatment using physics accelerators, and protein crystallography at synchrotron radiation sources.

The design, construction, and operation of these multimillion-dollar facilities requires sophisticated, multidisciplinary science and engineering approaches and complex management structures that are well beyond the means of most academic institutions. Moreover, these facilities are too large and have too long-term an investment horizon to motivate industry to build and operate them.
Imagine that an advisory committee to the government recommended a national initiative in structural biology to lead to better diagnosis and treatment of diseases. This would be an initiative in both the physical and biological sciences to understand the structure and behavior of proteins found in the human body.

This initiative would be a billion dollar project with a 5- to 10-year construction horizon and a 20- to 30-year research lifetime. Because of the size of this initiative, funding would likely come from DOE's Office of Science, which, in fact, funds many user facilities. As you recognize, this example describes exactly what happens with major user facilities in our national laboratory system. And that's why DOE's Office of Science, under the leadership of Ray Orbach, is preparing a multi-year plan for the facilities of the future.

Scientists from academia and national laboratories use these facilities for the new research opportunities. Industry uses them for their importance in developing new products and technologies. More importantly, national laboratories build and operate such facilities, because they have the necessary management and technical resources and because they have the scientific and technical staff to support and partner with users.

The most effective way to pursue fundamental understanding and knowledge is through an open exchange of ideas that involves participation from all three components of the R&D enterprise: industry, academia and government. Scientists regularly collaborate with each other across these institutional boundaries.

This type of cooperation also extends across national borders. While the U.S. has been and continues to be the overall leader of the R&D community, we have a long-standing tradition of mutually beneficial international partnerships, especially in the physical sciences. Even during the darkest days of the Cold War, the U.S. and U.S.S.R. maintained a highly productive "Joint Program on the Fundamental Properties of Matter." This and other projects helped keep our important channels of communication open with our Soviet colleagues.

Of course, national laboratories, like all other institutions, must be held accountable for performing high-quality work on schedule and within budget. The contractors who operate them must be committed to being "best in class" in all aspects. Because science works at the frontiers of knowledge, it is not an easy task to develop metrics for measuring excellence, but a number of such metrics exist. Most important among these metrics are peer review, awards and prizes – such as the

R&D 100 Awards, and the Fermi and Lawrence Awards from DOE's Office of Science – membership in prestigious professional bodies, such as the National Academies of Science, and citations in the professional research papers of colleagues.

Allow me to address the funding needs of the U.S. R&D enterprise. It is appropriate for industry to fund projects expected to have near-term, profitable outcomes, and thankfully, the Federal government accepts the responsibility for supporting and encouraging longer-term R&D for which the benefits are more likely to accrue to society as a whole than to any specific company or industry. Much of the strength of the U.S. R&D enterprise comes from its diversity. This diversity is reflected in the variety of fields, research-performing institutions, and R&D-sponsoring Federal agencies that make up our nation's R&D enterprise.

Over the last century, the physical sciences have provided the underpinning of our growing prosperity and security. Because of these impressive accomplishments, the "holy grail" of simulating a living cell in all its complexity is now a realistic goal. This leap in biological science would have been impossible without previous work in understanding the underlying physical laws, developing new instrumentation, and making huge advances in the computer sciences.

We can expect the physical sciences to continue to provide for advances in other sciences and medicine, as well as for the creation of new technologies and economic growth. But over the last decade, Federal funding for the physical sciences has been neglected. Unless this trend is reversed, the research engine will slow seriously that has driven more than half our economic growth for the last 60 years.

To maintain America's economic health, R&D requires a high priority. But how high? How do we know when the sciences are receiving adequate funding?

The total scientific enterprise needs enough support to attract and retain the "best and brightest" on a continuing basis. The way to do this is to offer them the resources they need to pursue exciting research opportunities. Bright young people are still challenged by careers in science and engineering, provided they have stable support and the opportunity to participate in world-leading research.

The DOE's Office of Science continues to be the largest source of Federal support for fundamental research in the physical sciences. As Chairman Alexander correctly stated in his letter to me, "The research of the Office of Science lays the foundation for many of the current and future developments in the applied missions of the DOE in energy, defense, and environmental issues." The Office of Science has built many of the big R&D facilities needed to advance the frontiers of knowledge in many fields. These facilities are used each year by more than 16,000 scientists and students from every state. In addition, the Office of Science supports a dynamic and diverse portfolio of forefront research done in universities and at national laboratories throughout the nation.

Compared to other Federal funding agencies, the significant role played by the Office of Science in America's R&D enterprise is not adequately appreciated. Although the Senate has passed an FY04 budget of $3.36 billion for the Office of Science, that office remains significantly underfunded. It's up to the Administration and Congress to ensure that the foundation for our future is strong; to neglect physical science is to jeopardize the entire enterprise.

My testimony has discussed the "why" and "how" of a well-functioning research establishment. In terms of dollars expended, the bulk of R&D in the U.S. continues to be performed by industry. The science, math, and engineering departments of our nation's top universities train the pre-eminent scientists, engineers and research managers in the government and other sectors. The role of the national laboratories is to expand the reach of universities and together to provide the foundations for future industrial enterprises. For our system to work, these entities, and the Federal government, must understand their respective roles, have the highest regard for each other, and deliver research results that will drive our future security and prosperity.