ENERGY AND WATER DEVELOPMENT APPROPRIATIONS FOR FISCAL YEAR 2008

WEDNESDAY, MARCH 21, 2007

U.S. SENATE,
SUBCOMMITTEE OF THE COMMITTEE ON APPROPRIATIONS,
Washington, DC.

The subcommittee met at 2:03 p.m., in room SD–138, Dirksen Senate Office Building, Hon. Byron L. Dorgan (chairman) presiding.

Present: Senators Dorgan, Murray, Domenici, Craig, and Allard.

DEPARTMENT OF ENERGY

OFFICE OF SCIENCE

STATEMENT OF HON. RAYMOND L. ORBACH, DIRECTOR

OPENING STATEMENT OF SENATOR BYRON L. DORGAN

Senator DORGAN. The hearing will come to order. This is the Senate Appropriations Committee, the Subcommittee on Energy and Water Development. We are reviewing today the fiscal year 2008 budget request for the Department of Energy's Office of Science. Mr. Orbach, we welcome you. Thank you for being here.

The proposed budget for the Office of Science is $4.397 billion. That represents 18 percent of the Department of Energy's total budget and an increase of $600 million above the Office of Science's budget in the year 2007.

Mr. Orbach, perhaps sometime you can whisper to us the secret of your relationship with OMB, that you come here with a proposed $600 million budget increase. You, indeed, are a rare species in this coming fiscal year. However it happened, though, we think this is a good outcome. We're committed to improving our Nation's ability to compete in the ever-changing global market place and we recognize that we have to improve our Nation's capabilities in mathematics and the sciences if we're going to continue to lead the way in innovation.

This is particularly true in the physical science fields, where the Department of Energy is the leader among Federal agencies. In the future our country will have to maintain leadership in innovation and development and the Office of Science will be one of the keys in our success in doing that.

A substantial increase in funding raises some different questions than when programs face significant decreases. But underlying both circumstances is the basic question of whether there is a plan to accommodate the change in funding and, if so, what is that plan? A doubling of funding over 9 years, for example, is an admirable goal, but we have to make sure there exists a plan that meets a defined goal.

Further, we have to have a plan to maintain our base infrastructure in order to take advantage of investments in new instruments and new facilities. It's not enough to make investments in new instruments and facilities here at home, or in partnerships abroad, if we don't maintain our base programs and facilities.

So the Office of Science is exploring the development of a number of new projects that also could have significant future costs, significant costs if taken to construction. And we need to know that out year budgeting will assume, or is assuming the construction, operation, and the research cost associated with each of those projects.

So, Dr. Orbach, thank you for your work. I look forward to hearing your testimony. But, first, I will turn to my colleagues for any opening statements they have.

Senator Domenici.

OPENING STATEMENT OF SENATOR PETE V. DOMENICI

Senator DOMENICI. Thank you very much.

We're moving in a direction—this small office becoming a very large and powerful one. Maybe it can stay small and be powerful and you've alluded to how that might be done in early parts of your comments. But, in any event it's going to have a much bigger impact, somewhere, somehow, that seems quite obvious to me.

I think you would be interested to know that Chairman Bingaman and I introduced an amendment to the budget resolution to increase funding for science research by $1 billion. In addition to fully funding the President's budget request, it also adds funding to funds like the America Competes Act. Mr. Chairman, I hope that you will look at this amendment.

Dr. Orbach, you have had a very important job. It is your responsibility to challenge our labs with new and exciting scientific goals, as well as making investment in facilities and infrastructure to ensure U.S. leadership. The Energy Policy Act included a provision elevating your position from Director to Under Secretary to give you responsibility to set the science policies for the labs, including all of the NNSA facilities. And you will note that, the labs continue to support the best science in the world. Unfortunately, the funding provided by the Office of Science to these labs remains disproportionately low. The NNSA labs have great facilities that have been exclusively tools of the weapons program that should be incorporated into the Office of Science programs. Facilities, such as the Z machine and the MESA at Sandia will be open to tremendous new research opportunities to scientists and must be thought of as national user facilities.

I understand that you are making some progress to develop a multi-agency board that will develop a high energy density plasma program consistent with the direction that I included in the 2006–2007 Energy and Water bills.

I want you to know that I appreciate this bill. I still expect to see a viable research program that supports non-weapons research on facilities like NIF and Z. I would also like to remind you of the tremendous computational capability and experience at the NNSA labs. As you know, it was the NNSA stockpile stewardship mission that fostered the undeveloped, high performance computing architecture that enabled this country to be the world leader in computing. Unfortunately, I don't believe the Department has dedicated sufficient resource, nor demonstrated its commitment to developing the next generation of architecture that will enable our country to sustain its world leadership in this field.

Finally, let me say that I believe we need to work hard to address our climate challenges, and science will play a critical role in this, I believe. And, I believe we have two paths to reduce the manmade greenhouse gas emissions. And unless we pursue both, we won't be effective at all.

First, of course, is to reduce our dependence on foreign oil with biomass and alternative energy as well as developing low emission energy sources such as nuclear power. Implementation of EPACT and the American Competitiveness Initiative will ensure we are on the right path.

The second is to ensure that large, fast growing economies like China and India adopt these same technologies. We need to join with these countries as full partners to ensure that technology development and adoption occurs. Without it, we won't be successful. I'm committed to developing a full partnership with China and India, but they need to recognize that this isn't a free ride. It is a partnership. They need to dedicate the resources to solving this problem.

Thank you, Mr. Chairman.

[The statement follows:]

PREPARED STATEMENT OF SENATOR PETE V. DOMENICI

Dr. Orbach, it is a pleasure to welcome you back to the subcommittee. I am pleased with the fiscal year 2008 budget request for the Office of Science because it continues to support objectives provided for in EPACT and sustains the President's commitment to double funding for basic science research over the next decade.

This research is vital to our economic competitiveness and our ability to reduce our dependence on foreign energy, including solving some of the long term R&D challenges associated with solar, biomass, hydrogen and nuclear power.

Dr. Orbach, you have another important responsibility and that is to challenge our labs with new and exciting scientific goals as well as making investments in facilities and infrastructure to ensure U.S. leadership.

The Energy Policy Act included a provision elevating your position from Director to Under Secretary to give you the responsibility to set the science policy for all the labs, including NNSA facilities.

As you well know, NNSA labs continue to support some of the best science in the world and have been recognized with Nobel prizes, E.O. Lawrence Awards and dozens of R&D 100 Awards. Unfortunately, the funding provided by the Office of Science remains disproportionately low.

The NNSA labs have great facilities that have been the exclusive tools of the weapons program that should be incorporated into the Office of Science research programs. Facilities such as the Z machine and MESA at Sandia will open up tremendous new research opportunities to scientists and must be thought of as national user facilities.

I understand that you are making some progress to develop a multi-agency advisory board that will develop the high energy density plasma program consistent with the direction that I included in the fiscal year 2006 and fiscal year 2007 Energy and Water bills.

I want you to know that I appreciate this effort, but I still expect to see a viable research program that supports non weapons research on facilities like NIF and Z.

I would also like to remind you of the tremendous computational capability and experience at NNSA labs. As you know, it was NNSA's Stockpile Stewardship mission that necessitated the development of the current high performance computing architecture that has enabled this country to be the world leader in computing.

As a result, this has also enabled the Office of Science to deploy some of the fastest computers in the world at Oak Ridge, Berkeley and Argonne National labs.

Unfortunately, I don't believe the Department has dedicated sufficient resources, nor demonstrated its commitment to developing the next generation architecture that will enable our country to sustain its leadership in this field.

We continue to have two separate computing programs and this budget diverts resources to DARPA to support a separate R&D program. That must change.

These problems can be solved, but it will force the Office of Science and NNSA to work together on improving scientific research at all of our labs.

Dr. Orbach, I hope I can count on your support to breakdown the walls of bureaucracy to solve this problem.

Thank you, Mr. Chairman.

Senator DORGAN. Senator Craig.

STATEMENT OF SENATOR LARRY CRAIG

Senator CRAIG. Mr. Chairman, I'll be brief. Mr. Secretary, thank you, for being here and thank you for coming to the Idaho lab, the INL, last August. We appreciated your presence there, and I am told you left impressed with the resource and the talent that is available. We have some phenomenal assets and when I'm sitting here listening to Senator Domenici, I'm thinking about the old admonishment in front of the United Nations, "swords into plow shares." And, the ability for us to use these phenomenal laboratories that were once, in part, related to the cold war, some of them more so than others.

Now with assets that they have, that were once for war, can not only be made for peace, but we've already begun to use the tremendous capabilities and talents that are there for those purposes. We have, at our laboratory, some of those unique resources, as you know, the advanced test reactor, the ability to relate it, not just to a Federal mission, but to private and quasi-public relationships, I think is extremely valuable. It is a national asset, unique in many ways, that—something I'll discuss with you later on in questioning, but making it a user facility, I think, becomes increasingly important as we work with and—I was just visiting with Clay Sell today and Dennis Spurgeon. New partnerships between the Federal Government and the private sector. The Federal Government used to be this great black box and DOE especially, into which all things went, especially money.

Today we have phenomenal demand for what can be produced. We don't have the resources, unless we partner and we leverage with the private sector. Not just our private sector, but the world's private sector. Because most of what we want to do needs to be very transparent and available to the rest of the world, whether it's clean energy sources, whether it's human health, and all of those types of things. I'm pleased to see that we're focusing. We've spent a lot of money, appropriately so directed at, by the biological sciences over the last decade. Now I think it's time we pony up on the physical sciences because they're merging out there in a way that probably we could never predicted a decade ago. And, in that is great opportunity.

Thank you.

Senator DORGAN. Senator Allard.

STATEMENT OF SENATOR WAYNE ALLARD

Senator ALLARD. Mr. Chairman, thank you for holding this hearing. And, welcome, Mr. Secretary. As you know, Mr. Chairman, you and I are co-chairmen of the Senate Renewable Energy and Energy Efficiency Caucus. And, I represent a State, which, we have the National Renewable Energy Laboratory. They're doing a lot of good work. They're working on basic technologies, moving those into the marketplace. I think that's a proper focus. And as a scientist, myself, I consider myself an applied scientist. Being a veterinarian, I understand how good basic research has to be done in order for me as a veterinarian, to be able to take care of the livestock industry, or pet animals, whether it's working for the CDC Lab, or FDA, or whatever. And, it all comes down to a lot of good basic research that has to be done.

I note that the Office of Science is the primary agency in the Federal Government in energy-related basic research. I think this a very important distinction that should be pointed out. While basic scientific research is the basis for applied sciences and leads to scientific advancement, it is often not profitable, so industry struggles to invest in basic research. This is where the government comes in, by funding basic research. It is picked up by industry and the advanced science communities.

I've had time to go and visit many of our laboratories, been out to Lawrence Livermore, been to Sandia Laboratory that Senator Domenici mentioned, Los Alamos Lab, and have been following much of the research in MOx Plus, for example. And, I feel that this is where it all starts.

We heard a presentation this morning from Ron Sega who was talking about our satellite program. He talked about his cycle of development. It all starts with good scientific basic research. And then you develop it to applied, then you get your prototype level, and then you get into the production stage. And, so I really can't stress how important I think your job is and responsibilities are.

More attention today is being focused on clean energy and energy efficiency technologies due to ever-increasing supply constraints and demand increases, diversification of our energy portfolios becoming more important than ever. This means the development of alternative energy sources is also more important than ever. Renewable energy is a very important way that we can begin to reduce the demand for oil, and thereby help to make our country more secure. Research and the input of both government and industries are very important allowing these opportunities to live up to their potential.

We must continue to provide incentives for the implementation of renewable technologies and for the infrastructure necessary to support these renewable sources. These technologies are a necessary step in balancing our domestic energy portfolio, increasing our Nation's energy security, and advancing our country's technological excellence.

So, I look forward to working with the committee to ensure research and development, in all fields of energy technology, are funded in a manner that is responsible, but sufficient to ensure that the development and implementation of new technologies continues.

Thank you, Mr. Chairman.

Senator DORGAN. Senator Murray.

STATEMENT OF SENATOR PATTY MURRAY

Senator MURRAY. Mr. Chairman, thank you to you and Senator Domenici for having this important hearing. I think the Office of Science is very important and investment in research and development is obviously critical. Dr. Orbach, I'm glad to see you again. This hearing gives us another opportunity to talk about the Capability Replacement Laboratory for PNNL. This project is a top priority for the lab and I have a couple of questions regarding the funding for that project. As you know there were no funds in the fiscal year 2007 budget request but Congress added $10 million to the Office of Science for the effort. I was pleased to hear from you recently that the additional $10 million would be included in the fiscal year 2007 work plan. However, I understand that funding is being held in reserve and can't be utilized until OMB approves the third party financing package. I also understand the fund requested in the fiscal year 2008 budget will also be held in reserve pending OMB approval.

Would you share with the committee what you intend to do to prevent delay of this critical project?

Senator DORGAN. Senator, actually, Mr. Orbach has not yet given his opening statement.

Senator MURRAY. Oh, I apologize. I came in late and didn't realize we had not heard Dr. Orbach's opening statement.

Senator DORGAN. I would like to give him the opportunity to give his opening statement.

All right. Thank you very much.

Senator Cochran has submitted a statement that he would like placed in the record.

[The statement follows:]

PREPARED STATEMENT OF SENATOR THAD COCHRAN

Mr. Chairman, I am pleased to join you in welcoming the Under Secretary for Science, Dr. Raymond Orbach. I am pleased that we were able to increase the budget for the Office of Science under the Continuing Resolution for fiscal year 2007.

As Under Secretary for Science and Director of the Office of Science, Dr. Orbach has had the responsibility of overseeing research and development at 17 national laboratories across the country, including both the National Nuclear Security Laboratories and the Office of Science Laboratories. I am pleased that the fiscal year 2008 budget includes funding to continue the American Competitiveness Initiative, a program that has become increasingly important to our scientific community in America.

Of particular interest to me is the Basic Energy Sciences program which supports the Advanced Energy Initiative and biomass production research. Mississippi has much to contribute in the emerging biomass arena, and it is my hope that the universities and scientists in Mississippi might work with your researchers in the Office of Science to further develop this field.

It is a pleasure to welcome you to the committee. I look forward to hearing your testimony.

Senator DORGAN. Secretary Orbach, thank you very much. Please proceed. Your entire statement will be a part of the permanent record, and you may summarize.

STATEMENT OF HON. RAYMOND L. ORBACH

Dr. ORBACH. Thank you, Chairman Dorgan, Senator Domenici, members of the committee. And, indeed, I will answer those questions.

I'm very grateful. Thank you for this opportunity for me to present the President's fiscal year 2008 budget request for the Department of Energy's Office of Science.

As some of you noted, we are the primary agency in the Federal Government for energy-related basic research. Our office interfaces with the Department's applied research and defense programs upon which our Nation relies for both energy security and national defense. Our goal is to underpin the applied research programs with the finest basic science and, at the same time, to energize our basic research with the insights and opportunities that come from advanced applied research.

Transformational basic science discoveries are essential for the success of the Department's efforts in such renewable energy sources as hydrogen, solar power, and bio-fuels. And in electrical energy storage, which is critical for many renewable energy sources because they are intermittent. We are one department and we have been working very hard to strengthen the relationship between the Department's basic and applied research programs.

Let me say a few words this afternoon about the critical role that basic science plays in addressing our Nation's energy challenge and the role of the Office of Science. First, cellulosic ethanol. To make this bio-fuel truly cost effective, we must produce ethanol from cellulose efficiently. The problem is that the lignins surrounding the cellulose in plants inhibit currently available enzymes from breaking down the cellulose to sugars that then are fermented into ethanol.

The Office of Science will be deploying three new innovative bioenergy research centers, studying both microbes and plants, developing new methods, based on processes actually found in nature, to create the breakthroughs we need.

I can give you an example. Our Department of Energy Joint Genome Institute recently announced in conjunction with the U.S. Forest Service, the identification of the metabolic pathway in a fungus found in the bowels of insects that holds the secret to effective fermentation of the sugar xylose, a key to making cellulosic ethanol cost-effective.

Second, intermittent sources of electricity, such as solar and wind. The key to base-load electrical generation from these intermittent renewable sources is electrical energy storage. In April of this year, we'll be bringing together leading scientists, technologists, and industry at a major workshop to chart a transformational path forward for electrical energy storage. We shall be considering super-capacitors and other innovative approaches based on the latest advances in material science and nanotechnology to change the way we approach electrical energy storage. Solving this problem is a key to enabling renewable energy to make major contributions to electric base-load generation.

These are examples of our mission in the Office of Science. To invest in basic research designed to create transformational breakthroughs for our Nation. Supporting transformational research also means providing cutting-edge scientific facilities through our national laboratories that will allow scientists from universities and the private sector to do the analysis that will give them an advantage over their colleagues in other countries, thereby contributing to American competitiveness. It means educating, training, and sustaining a world-class scientific workforce, thousands strong, 25,500 in our fiscal year 2008 budget in universities and laboratories across our Nation for the sake of our country's future.

PREPARED STATEMENT

We are not doing this in a vacuum. Other nations are increasing their investment in basic research because they know those who dominate science will dominate the 21st century global economy. The President's fiscal year 2008 budget request for the Office of Science totals $4.4 billion, an increase of 15.8 percent or $600 million over the fiscal year 2007 appropriation. It is an important milestone on the path towards doubling Federal support for basic research and the physical sciences over the next 10 years.

And, in my view, an indispensable investment in our Nation's energy security and America's continued competitiveness in the global economy.

Thank you.

[The statement follows:]

PREPARED STATEMENT OF HON. RAYMOND L. ORBACH

Mr. Chairman and members of the committee, thank you for the opportunity to testify today on the Office of Science's fiscal year 2008 budget request. I appreciate your support for the Office of Science and basic research in the physical sciences, Mr. Chairman, and your understanding of the importance of this research to our Nation's energy security and economic competitiveness. I also want to thank the members of the committee for their support. I believe this budget will enable the Office of Science to deliver on its mission and enhance U.S. competitiveness through our support of transformational science, national scientific facilities, and the scientific workforce for the Nation's future.

The Office of Science requests $4,397,876,000 for the fiscal year 2008 Science appropriation, an increase of $600,582,000 over the fiscal year 2007 appropriated level. The fiscal year 2008 budget request for the Office of Science represents the second year of the President's commitment to double the Federal investment in basic research in the physical sciences by the year 2016 as part of the American Competitiveness Initiative. It also represents a continued commitment to maintain U.S. leadership in science and recognition of the valuable role research in the physical sciences plays in technology innovation and global competitiveness.

With the fiscal year 2008 budget request the Office of Science will continue to support transformational science—basic research for advanced scientific breakthroughs that will revolutionize our approach to the Nation's energy, environment, and national security challenges. The Office of Science is the Nation's steward for fields such as high energy physics, nuclear physics, heavy element chemistry, plasma physics, magnetic fusion, and catalysis. It also supports unique components of U.S. research in climate change and geophysics.

Researchers funded through the Office of Science are working on some of the most pressing scientific challenges of our age including: (1) Harnessing the power of microbial communities and plants for energy production from renewable sources, carbon sequestration, and environmental remediation; (2) Expanding the frontiers of nanotechnology to develop materials with unprecedented properties for widespread potential scientific, energy, and industrial applications; (3) Pursuing the breakthroughs in materials science, nanotechnology, biotechnology, and other fields needed to make solar energy more cost-effective; (4) Demonstrating the scientific and technological feasibility of creating and controlling a sustained burning plasma to generate energy, as the next step toward making fusion power a commercial reality; (5) Using advanced computation, simulation, and modeling to understand and predict the behavior of complex systems beyond the reach of some of our most powerful experimental probes, with potentially transformational impacts on a broad range of scientific and technological undertakings; (6) Understanding the origin of the universe and nature of dark matter and dark energy; and (7) Resolving key uncertainties and expanding the scientific foundation needed to understand, predict, and assess the potential effects of atmospheric carbon dioxide on climate and the environment.

U.S. leadership in many areas of science and technology depends in part on the continued availability of the most advanced scientific facilities for our researchers. The Office of Science builds and operates national scientific facilities and instruments that make up the world's most sophisticated suite of research capabilities. The resources available for scientific research include advanced synchrotron light sources, the new Spallation Neutron Source, state-of-the-art Nanoscale Science Research Centers, supercomputers and high-speed networks, climate and environmental monitoring capabilities, particle accelerators and detectors for high energy and nuclear physics, and genome sequencing facilities We are in the process of developing new tools such as an X-ray free electron laser light source that can image single large macromolecules and measure in real-time changes in the chemical bond as chemical and biological reactions take place, a next generation synchrotron light source for X-ray imaging and capable of nanometer resolution, and detectors and instruments for world-leading neutrino physics research. SC will also select and begin funding in fiscal year 2007 for three Bioenergy Research Centers to conduct fundamental research on microbes and plants needed to produce biologically-based fuel.

Office of Science leadership in support of the physical sciences and stewardship of large national research facilities is directly linked to our historic role in training America's scientists and engineers. In addition to funding a diverse portfolio of research at more than 300 colleges and universities nationwide, we provide direct support and access to research facilities for thousands of university students and researchers. Facilities at the national laboratories provide unique opportunities for researchers and their students from across the country to pursue questions at the intersection of physics, chemistry, biology, computing, and materials science. About half of the annual 21,000 users of the Office of Science's scientific facilities come from universities. The fiscal year 2008 budget will support the research of approximately 25,500 faculty, postdoctoral researchers, and graduate students throughout the Nation, an increase of 3,600 from fiscal year 2006, in addition to supporting undergraduate research internships and fellowships and research and training opportunities for K–14 science educators at the national laboratories.

The approximate $600 million increase in fiscal year 2008 from the fiscal year 2007 appropriated level will bring manageable increases to the Office of Science programs for long planned for activities. The fiscal year 2008 request will allow the Office of Science to increase support for high-priority DOE mission-driven scientific research and new initiatives; maintain optimum operations at our scientific user facilities; continuing major facility construction projects; and enhance educational, research, and training opportunities for the Nation's future scientific workforce. The budget request will also support basic research that contributes to Presidential initiatives such as the Hydrogen Fuel Initiative and the Advanced Energy Initiative, the Climate Change Science and Technology Programs, and the National Nanotechnology Initiative.

The following programs are supported in the fiscal year 2008 budget request: Basic Energy Sciences, Advanced Scientific Computing Research, Biological and Environmental Research, Fusion Energy Sciences, High Energy Physics, Nuclear Physics, Workforce Development for Teachers and Scientists, Science Laboratories Infrastructure, Science Program Direction, and Safeguards and Security.

OFFICE OF SCIENCE FISCAL YEAR 2008 PRESIDENT'S REQUEST SUMMARY BY PROGRAM

[In thousands of dollars]

	Fiscal Year 2006 Approp.	Fiscal Year 2007 Request	Fiscal Year 2007 Approp.[1]	Fiscal Year 2008 Request	Fiscal Year 2008 Request vs.	
					Request	Approp.
Basic Energy Sciences	1,110,148	1,420,980	....	1,498,497	+77,517	....
Advanced Scientific Computing Research	228,382	318,654	....	340,198	+21,544	....
Biological and Environmental Research	564,077	510,263	....	531,897	+21,634	....
High Energy Physics	698,238	775,099	....	782,238	+7,139	....
Nuclear Physics	357,756	454,060	....	471,319	+17,259	....
Fusion Energy Sciences	280,683	318,950	....	427,850	+108,900	....
Science Laboratories Infrastructure	41,684	50,888	....	78,956	+28,068	....
Science Program Direction	159,118	170,877	....	184,934	+14,057	....
Workforce Development for Teachers and Scientists	7,120	10,952	....	11,000	+48	....
Safeguards and Security	68,025	70,987	....	70,987	....	....
SBIR/STTR	116,813	....	....	....	....	....
Total, Office of Science	3,632,044	4,101,710	3,797,294	4,397,876	+296,166	+600,582

[1] Fiscal year 2007 program allocation plan not yet finalized.

FISCAL YEAR 2008 SCIENCE PRIORITIES

The challenges we face today in energy and the environment are some of the most vexing and complex in our history. Our success in meeting these challenges will depend in large part on how well we maintain this country's leadership in science and technology because it is through scientific and technological innovation and a skilled workforce that these challenges will be solved.

President George W. Bush made this point in his State of the Union Message on January 23, 2007, when he stated,

"It's in our vital interest to diversify America's energy supply—the way forward is through technology . . . We must continue changing the way America generates electric power, by even greater use of clean coal technology, solar and wind energy, and clean, safe nuclear power. We need to press on with battery research for plug-in and hybrid vehicles, and expand the use of clean diesel vehicles and biodiesel fuel. We must continue investing in new methods of producing ethanol—using everything from wood chips to grasses, to agricultural wastes . . .

"America is on the verge of technological breakthroughs that will enable us to live our lives less dependent on oil. And these technologies will help us to be better stewards of the environment, and they will help us confront the serious challenge of global climate change."

In 2006, the President announced a commitment to double the budget for basic research in the physical sciences at key agencies over 10 years to maintain U.S. leadership in science and ensure continued global competitiveness. This commitment received bipartisan support in both the House of Representatives and the Senate and the fiscal year 2008 budget request for the Office of Science represents the second year of this effort. Through the fiscal year 2008 budget, the Office of Science will build on its record of results with sound investments to keep U.S. research and development at the forefront of global science and prepare the scientific workforce we will need in the 21st century to address our Nation's challenges.

Determining and balancing science and technology priorities across the Office of Science programs is an ongoing process. Several factors are considered in our prioritization, including scientific opportunities identified by the broader scientific community through Office of Science sponsored workshops; external review and recommendations by scientific advisory committees; DOE mission needs; and national and departmental priorities. In fiscal year 2008, we will support the priorities in scientific research, facility operations, and construction and laboratory infrastructure established in the past few years and outlined in the Office of Science Strategic Plan and Twenty-year Facilities Outlook, in addition to national and departmental priorities and new research opportunities identified in recent workshops.

National initiatives in hydrogen fuel cell and advanced energy technologies will be supported through our contributions to basic research in hydrogen, fusion, solar energy-to-fuels, and production of ethanol and other biofuels from cellulose. We will also continue strong support for other administration priorities such as nanotechnology, advanced scientific computation, and climate change science and technology.

The Office of Science will support three Bioenergy Research Centers in fiscal year 2008 as part of the broader Genomics: GTL program. These centers, to be selected in fiscal year 2007 and fully operational by the end of 2008, will conduct comprehensive, multidisciplinary research programs focused on microbes and plants to drive scientific breakthroughs necessary for the development of cost-effective biofuels and bioenergy production. The broader GTL program will also continue to support fundamental research and technology development needed to understand the complex behavior of biological systems for the development of innovative biotechnology solutions to energy production, environmental mitigation, and carbon management.

The Office of Science designs, constructs, and operates facilities and instruments that provide world-leading research tools and capabilities for U.S. researchers and will continue to support next generation tools for enabling transformational science. For example, the Spallation Neutron Source (SNS), the world's forefront neutron scattering facility, increases the number of neutrons available for cutting-edge research by a factor of 10 over any existing spallation neutron source in the world. SNS was completed and began operations in 2006 and in fiscal year 2008 full operations are supported and additional experimental capabilities continue to be added.

When it comes on line, the Linac Coherent Light Source (LCLS) at the Stanford Linear Accelerator Center (SLAC) will produce X-rays 10 billion times more intense than any existing X-ray source in the world, and will allow structural studies on individual nanoscale particles and single biomolecules. Construction of LCLS continues in fiscal year 2008.

A next generation synchrotron light source, the National Synchrotron Light Source-II (NSLS–II), would deliver orders of magnitude improvement in spatial resolution, providing the world's finest capabilities for X-ray imaging and enabling the study of material properties and functions, particularly at the nanoscale, at a level of detail and precision never before possible. Its energy resolution would explore dynamic properties of matter as no other light source has ever accomplished. Support for continued R&D and project engineering and design (PED) are provided in fiscal year 2008.

All five of DOE's Nanoscale Science Research Centers (NSRCs) will be operating in fiscal year 2008. These facilities are the Nation's premier nanoscience user centers, providing resources unmatched to the scientific community for the synthesis, fabrication, and analysis of nanoparticles and nanomaterials.

We will fully fund the programs for advanced scientific computing, including: continued support for high-performance production computing at the National Energy Research Scientific Computing Center (NERSC), which will increase capacity to 100–150 teraflops in fiscal year 2007; support for advanced capabilities for modeling and simulation of scientific problems in combustion, fusion, and complex chemical reactions at Oak Ridge National Laboratory's Leadership Computing Facility, which should deliver 250 teraflops computing capability by the end of fiscal year 2008; and support for the upgrade to 250–500 teraflop peak capacity of the IBM Blue Gene P system at Argonne National Laboratory's Leadership Computing Facility to extend architectural diversity in leadership computing.

The Office of Science continues to be a partner in the interagency Climate Change Science Program focusing on understanding the principal uncertainties of the causes and effects of climate change, including abrupt climate change, understanding the global carbon cycle, developing predictive models for climate change over decades to centuries, and supporting basic research for biological sequestration of carbon. We also continue to support research in geosciences and environmental remediation towards the development of scientific and technological solutions to long-term environmental challenges.

The Office of Science will continue to actively lead and support the U.S. contributions to ITER, the international project to build and operate the first fusion science facility capable of producing a sustained burning plasma to generate energy on a massive scale without environmental insult. The historic international fusion energy agreement to build ITER with six other international partners was signed in November 2006.

We continue strong support for experimental and theoretical high energy physics and the study of the elementary constituents of matter and energy and interactions at the heart of physics. Full operations at the Tevatron Collider at Fermilab and the B-factory at SLAC are supported to maximize the scientific research and data derived from these facilities. Full operation of the neutrino oscillation experiment at Fermilab and start of fabrication of a next generation detector are supported to provide a platform for a world-leading neutrino program in the U.S. International Linear Collider (ILC) R&D and superconducting radio frequency technology R&D are supported to enable the most compelling scientific opportunities in high energy physics in the coming decades.

Our research programs in nuclear physics continue to receive strong support. Operations at the Relativistic Heavy Ion Collider (RHIC) and additional instrumentation projects for RHIC are supported for studies of the properties of hot, dense nuclear matter, providing insight into the early universe. We will also support operations at the Continuous Electron Beam Accelerator Facility (CEBAF), the world's most powerful "microscope" for studying the quark structure of matter, and project engineering and design and R&D for doubling the energy of the existing beam at CEBAF to 12 gigaelectron volts (GeV). Support for R&D to develop advanced rare isotope beam capabilities for the next generation U.S. facility for nuclear structure and astrophysics is also provided.

The standard of living we enjoy and the security of our Nation now and in the future rests on the quality of science and technology education we provide America's students from elementary through graduate school and beyond. The fiscal year 2008 budget will provide support for over 25,500 Ph.D.s, graduate students, engineers, and technical professionals, an increase of 3,600 over the number supported in fiscal year 2006. The Office of Science will also support the development of leaders in the science and mathematics education community through participation of K–14 teachers in the DOE Academies Creating Teacher Scientists program, formerly the Laboratory Science Teacher Professional Development program. This immersion program at the national laboratories is an opportunity for teachers to work with laboratory scientists as mentors and to build content knowledge, research skills, and lasting connections to the scientific community, ultimately leading to more effective teaching that inspires students in science and math. The year 2008 will also mark the 18th year of DOE's National Science Bowl® for high school students. National Science Bowl® events for high school and middle school students, which will involve 17,000 students across the Nation this year, provide prestigious academic competitions that challenge and inspire the Nation's youth to excel in math and science.

SCIENCE ACCOMPLISHMENTS

For more than 50 years, the Office of Science (SC) has balanced basic research, innovative problem solving, and support for world-leading scientific capabilities, enabling historic contributions to U.S. economic and scientific preeminence. American taxpayers have received good value for their investment in basic research sponsored by the Office of Science; this work has led to significant technological innovations, new intellectual capital, improved quality of life, and enhanced economic competitiveness. The following are some of the past year's highlights:

Nobel Prize in Physics.—The 2006 Nobel Prize in physics was awarded to Dr. George Smoot (DOE Lawrence Berkeley National Laboratory and University of California, Berkeley) and Dr. John Mather (NASA Goddard Space Flight Center) for their discovery of "the blackbody form and anisotropy of the cosmic microwave background radiation," the pattern of minuscule temperature variations in radiation which allowed scientists to gain better understanding of the origins of galaxies and stars. These two American scientists led the teams of researchers who worked on the historic 1989 NASA COBE satellite. The results of their work provided increased support for the "Big Bang" theory of the universe and marked the inception of cosmology as a precise science. SC supported Dr. Smoot's research during the period in which he worked on the COBE experiment, and continues to support his research today. One of the principal instruments used to make the discoveries was built at SC-supported facilities at Lawrence Berkeley National Laboratory and DOE's National Energy Research Scientific Computing Center supercomputers were used to analyze the massive amounts of data and produce detailed visual maps.

Advancing Science and Technology for Bioenergy Solutions.—Harnessing the capabilities of microbes and plants holds great potential for the development of innovative, cost-effective methods for the production of biofuels and bioenergy. Sequencing of the poplar tree genome was completed as part of a DOE national laboratory-led international collaboration; the information encoded in the poplar genome will provide researchers with an important resource for developing trees that produce more biomass for conversion to biofuels and trees that can sequester more carbon from the atmosphere. The DOE Joint Genome Institute (JGI) marked a technical milestone this year with the 100th microbe genome sequenced; Methanosarcina barkeri fusaro is capable of living in diverse and extreme environments, produces methane from digesting cellulose and other complex sugars, and provides greater understanding of potential new methods for producing renewable sources of energy. A chemical imaging method developed using a light-producing cellulose synthesizing enzyme allowed researchers to observe the enzyme as it deposited cellulose fibers in a cell, providing greater understanding of the mechanism for cellulose formation.

Delivering Forefront Computational and Networking Capabilities for Science.—Several 2006 advances in computing, computational sciences, and networking enabled greater opportunities for computational research and effective management of data collected at DOE scientific user facilities. NERSC began to increase its peak capacity by a factor of 100 and the Oak Ridge National Laboratory (ORNL) Leadership Computing Facility doubled its capability to 54 teraflops to provide additional resources for computationally intensive, large-scale projects. The Energy Sciences Network expanded in 2006 to include the Chicago and New York-Long Island metropolitan area networks (MANs), bringing dual connectivity at 20 gigabits per second and highly reliable, advanced network services to accommodate next-generation scientific instruments and supercomputers. Chemistry software using parallel-vector algorithms developed by researchers at ORNL has enabled computations 40 times more complex and 100 times faster than previous state-of-the-art codes. The development of a multiscale mathematical framework for simulating the process of self-organization in biological systems has led to the discovery of a previously unidentified cluster state, providing possible applications to modeling microbial populations.

Advances in Basic Science for Energy Technologies.—Current and future national energy challenges may be partially addressed through scientific and technological innovation. Some recent accomplishments in basic science that may contribute to future energy solutions include the following. Basic research on the molecular design and synthesis of new polymer membranes has lead to the discovery of a new fuel cell membrane that is longer lasting and three times more proton conductive than the current gold standard for proton exchange membrane fuel cells. Computational studies showing that in titanium-coated carbon nanotubes a single titanium atom can adsorb four hydrogen molecules opens new ways that the control of matter on the nanoscale can lead to the creation of novel materials for hydrogen storage. Recent work demonstrating that visible light can split carbon dioxide into carbon monoxide and a free oxygen atom, the critical first reaction in sunlight-driven transformation of carbon dioxide into methanol, makes it feasible to consider harnessing sunlight to drive the photocatalytic production of methanol from carbon dioxide. Demonstration of the effect known as carrier multiplication in which a single photon creates multiple charge carriers during the interaction of photons with a nanocrystalline sample could lead to substantial increases in solar cell conversion efficiency.

Maintaining World-leading Research Tools for U.S. Science.—The Office of Science continues to construct and maintain powerful tools and research capabilities that will accelerate U.S. scientific discovery and innovation. The following highlight a few recent accomplishments. Construction and commissioning of the Spallation Neutron Source (SNS), an accelerator-based neutron source that will provide the most intense pulsed neutron beams in the world for scientific research and industrial development, was completed and began operations. Full operation of four of the five DOE Nanoscale Science Research Centers began in 2006, providing resources unmatched anywhere in the world for the synthesis, fabrication, and analysis of nanoparticles and nanomaterials. A nanofocusing lens device at the Advanced Photon Source at Argonne National Laboratory has set a world's record for line size resolution produced with a hard X-ray beam and enables such capabilities as three-dimensional visualization of electronic circuit boards, mapping impurities in biological and environmental samples, and analyzing samples inside high-pressure or high-temperature cells. A new record for performance, a 77 percent increase in peak luminosity in 2006 from the previous year, was achieved at the Tevatron, the world's most powerful particle collider for high energy physics research at Fermilab. Evidence of the rare single top quark was observed at Fermilab in 2006, bringing researchers a step closer to finding the Higgs boson. The Large Area Telescope (LAT), a DOE and NASA partnership and the primary instrument on NASA's GLAST mission, was completed in 2006 and will be placed in orbit in the fall of 2007 to study the high energy gamma rays and other astrophysical phenomena using particle physics detection techniques. During the 2006 operation of the Relativistic Heavy Ion Collider (RHIC), polarized protons were accelerated to the highest energies ever recorded—250 billion electron volts—for world-leading studies of the internal quark-gluon structure of nucleons.

PROGRAM OBJECTIVES AND PERFORMANCE

The path from basic research to technology development and industrial competitiveness is not always obvious. History has taught us that seeking answers to fundamental questions can ultimately result in a diverse array of practical applications as well as some remarkable revolutionary advances. Working with the scientific community, the Office of Science invests in the promising research and sets long-term scientific goals with ambitious annual targets. The intent and impact of our performance goals may not always be clear to those outside the research community. Therefore the Office of Science has created a website (www.sc.doe.gov/measures) to better communicate to the public what we are measuring and why it is important.

Further, the Office of Science has revised the appraisal process it uses each year to evaluate the scientific, management, and operational performance of the contractors who manage and operate each of its 10 national laboratories. This new appraisal process went into effect for the fiscal year 2006 performance evaluation period and provides a common structure and scoring system across all 10 Office of Science laboratories. The performance-based approach focuses the evaluation of the contractor's performance against eight Performance Goals (three Science and Technology Goals and five Management and Operation Goals). Each goal is composed of two or more weighted objectives. The new process has also incorporated a standardized five-point (0–4.3) scoring system, with corresponding grades for each Performance Goal, creating a "Report Card" for each laboratory.

The fiscal year 2006 Office of Science laboratory report cards have been posted on the SC website (http://www.science.doe.gov/News__Information/News__Room/2007/Appraisa__%20Process/index.htm).

SCIENCE PROGRAMS

Basic Energy Sciences

Fiscal Year 2007 Request—$1,421.0 Million; Fiscal Year 2008 Request—$1,498.5 Million

Basic research supported by the Basic Energy Sciences (BES) program touches virtually every aspect of energy resources, production, conversion, efficiency, and waste mitigation. Research in materials sciences and engineering leads to the development of materials that may improve the efficiency, economy, environmental acceptability, and safety of energy generation, conversion, transmission, and use. Research in chemistry leads to the development of advances such as efficient combustion systems with reduced emission of pollutants; new solar photo-conversion processes; improved catalysts for the production of fuels and chemicals; and better separations and analytical methods for applications in energy processes, environmental remediation, and waste management. Research in geosciences contributes to the solution of problems in multiple DOE mission areas, including reactive fluid flow studies to understand contaminant remediation and seismic imaging for reservoir definition. Research in the molecular and biochemical nature of photosynthesis aids the development of solar photo-energy conversion and biomass conversion methods. BES asks researchers to reach far beyond today's problems in order to provide the basis for long-term solutions to what is one of society's greatest challenges—a secure, abundant, and clean energy supply. In fiscal year 2008, the Office of Science will support expanded efforts in basic research related to transformational energy technologies. Within BES, there are increases to ongoing basic research for the hydrogen economy and effective solar energy utilization. The fiscal year 2008 budget request also supports increased research in electric-energy storage, accelerator physics, and X-ray and neutron detector research.

BES also provides the Nation's researchers with world-class research facilities, including reactor- and accelerator-based neutron sources, light sources (soon to include an X-ray free electron laser), nanoscale science research centers, and electron beam micro-characterization centers. These facilities provide outstanding capabilities for imaging and characterizing materials of all kinds from metals, alloys, and ceramics to fragile biological samples. The next steps in the characterization and the ultimate control of materials properties and chemical reactivity are to improve spatial resolution of imaging techniques; to enable a wide variety of samples, sample sizes, and sample environments to be used in imaging experiments; and to make measurements on very short time scales, comparable to the time of a chemical reaction or the formation of a chemical bond. With these tools, we will be able to understand how the composition of materials affects their properties, to watch proteins fold, to see chemical reactions, and to understand and observe the nature of the chemical bond. For fiscal year 2008, BES scientific user facilities will be scheduled to operate at an optimal number of hours.

Construction of the Spallation Neutron Source (SNS) was completed in fiscal year 2006 ahead of schedule, under budget, and meeting all technical milestones. In fiscal year 2008 fabrication and commissioning of SNS instruments will continue, funded by BES and other sources including non-DOE sources, and will continue to increase power towards full levels. Two Major Items of Equipment are funded in fiscal year 2008 that will allow the fabrication of approximately nine to ten additional instruments for the SNS, thus nearly completing the initial suite of 24 instruments that can be accommodated in the high-power target station.

All five Nanoscale Science Research Centers will be fully operational in fiscal year 2008: the Center for Nanophase Materials Sciences at Oak Ridge National Laboratory, the Molecular Foundry at Lawrence Berkeley National Laboratory, the Center for Nanoscale Materials at Argonne National Laboratory, the Center for Integrated Nanotechnologies at Sandia National Laboratories and Los Alamos National Laboratory, and the Center for Functional Nanomaterials at Brookhaven National Laboratory. In fiscal year 2008, funding for research at the nanoscale increases for activities related to the hydrogen economy and solar energy utilization.

The Linac Coherent Light Source (LCLS) at the Stanford Linear Accelerator Center (SLAC) will continue construction at the planned levels in fiscal year 2008. Funding is also provided for primary support of the operation of the SLAC linac. This marks the third year of the transition of linac funding from the High Energy Physics program to the Basic Energy Sciences program. The purpose of the LCLS Project is to provide laser-like radiation in the X-ray region of the spectrum that is 10 billion times greater in peak power and peak brightness than any existing coherent X-ray light source and that has pulse lengths measured in femtoseconds—the timescale of electronic and atomic motions. The LCLS will be the first such facility in the world for groundbreaking research in the physical and life sciences. Funding is provided separately for design and fabrication of instruments for the facility. Project Engineering and Design (PED) and construction for the Photon Ultrafast Laser Science and Engineering (PULSE) building renovation begins in fiscal year 2008. PULSE is a new center for ultrafast science at SLAC focusing on ultrafast structural and electronic dynamics in materials sciences, the generation of attosecond laser pulses, single-molecule imaging, and understanding solar energy conversion in molecular systems. Support continues for PED and R&D for the National Synchrotron Light Source-II (NSLS–II), which would be a new synchrotron light source, highly optimized to deliver ultra-high brightness and flux and exceptional beam stability. This would enable the study of material properties and functions with a spatial resolution of one nanometer (nm), an energy resolution of 0.1 millielectron volt (meV), and the ultra-high sensitivity required to perform spectroscopy on a single atom, achieving a level of detail and precision never possible before. NSLS–II would open new regimes of scientific discovery and investigation.

The Scientific Discovery through Advanced Computing (SciDAC) program is a set of coordinated investments across all Office of Science mission areas with the goal of using computer simulation to achieve breakthrough scientific advances that are impossible using theoretical or laboratory studies alone. The SciDAC program in BES consists of two activities: (1) characterizing chemically reacting flows as exemplified by combustion and (2) achieving scalability in the first-principles calculation of molecular properties, including chemical reaction rates.

Advanced Scientific Computing Research

Fiscal Year 2007 Request—$318.7 Million; Fiscal Year 2008 Request—$340.2 Million

The Advanced Scientific Computing Research (ASCR) program is expanding the capability of world-class scientific research through advances in mathematics, high performance computing and advanced networks, and through the application of computers capable of many trillions of operations per second (terascale to petascale computers). Computer-based simulation can enable us to understand and predict the behavior of complex systems that are beyond the reach of our most powerful experimental probes or our most sophisticated theories. Computational modeling has greatly advanced our understanding of fundamental processes of nature, such as fluid flow and turbulence or molecular structure and reactivity. Soon, through modeling and simulation, we will be able to explore the interior of stars to understand how the chemical elements were created and learn how protein machines work inside living cells to enable the design of microbes that address critical energy or waste cleanup needs. We could also design novel catalysts and high-efficiency engines that expand our economy, lower pollution, and reduce our dependence on foreign oil. Computational science is increasingly important to making progress at the frontiers of almost every scientific discipline and to our most challenging feats of engineering. Leadership in scientific computing has become a cornerstone of the Department's strategy to ensure the security of the Nation and success in its science, energy, environmental quality, and national security missions.

The demands of today's facilities, which generate millions of gigabytes of data per year, now outstrip the capabilities of the current Internet design and push the state-of-the-art in data storage and utilization. But, the evolution of the telecommunications market, including the availability of direct access to optical fiber at attractive prices and the availability of flexible dense wave division multiplexing (DWDM) products gives SC the possibility of exploiting these technologies to provide scientific data where needed at speeds commensurate with the new data volumes. To take advantage of this opportunity, the Energy Science Network (ESnet) has entered into a long term partnership with Internet 2 to build the next generation optical network infrastructure needed for U.S. science. To fully realize the potential for science, however, significant research is needed to integrate these capabilities, make them available to scientists, and build the infrastructure which can provide cybersecurity. ASCR is leading an interagency effort to develop a Federal Plan for Advanced Networking R&D. This plan will provide a strategy for addressing current and future networking needs of the Federal Government in support of science and national security missions and provide a process for developing a more detailed roadmap to guide future multi-agency investments in advancing networking R&D.

ASCR supports core research in applied mathematics, computer sciences, and distributed network environments. The applied mathematics research activity produces fundamental mathematical methods to model complex physical and biological systems. The computer science research efforts enable scientists to perform scientific computations efficiently on the highest performance computers available and to store, manage, analyze, and visualize the massive amounts of data that result. The networking research activity provides the techniques to link the data producers with scientists who need access to the data. Results from enabling research supported by ASCR are used by scientists supported by other SC programs. This link to other DOE programs provides a tangible assessment of the value of ASCR's core research program for advancing scientific discovery and technology development through simulations. In fiscal year 2008 expanded efforts in applied mathematics will support critical long-term mathematical research issues relevant to petascale science, multiscale mathematics, and optimized control and risk analysis in complex systems. Expanded efforts in computer science will enable scientific applications to take full advantage of petascale computing systems at the Leadership Computing Facilities.

In addition to its research activities, ASCR plans, develops, and operates supercomputer and network facilities that are available 24 hours a day, 365 days a year to researchers working on problems relevant to DOE's scientific missions. Investments in the ESnet will provide the DOE science community with capabilities not available through commercial networks or the commercial internet to manage increased data flows from petascale computers and experimental facilities. In fiscal year 2008 ESnet will deliver a 10 gigabit per second (gbps) core Internet service as well as a Science Data Network with 20 gbps on its northern route and 10 gbps on its southern route. Delivery of the next generation of high performance resources at the National Energy Research Scientific Computing Center (NERSC) is scheduled for fiscal year 2007. This NERSC–5 system is expected to provide 100–150 teraflops of peak computing capacity. The NERSC computational resources are integrated by a common high performance file storage system that enables users to use all machines easily. Therefore the new machine will significantly reduce the current oversubscription at NERSC which serves nearly 2,000 scientists annually.

In fiscal year 2008, the Oak Ridge National Laboratory (ORNL) Leadership Computing Facility (LCF) will continue to provide world leading high performance sustained capability to researchers through the Innovative and Novel Computational Impact on Theory and Experiment (INCITE) program. The acquisition of a 250 teraflop Cray Baker system by the end of fiscal year 2008 will enable further scientific advancements in areas such as combustion simulation for clean coal research, simulation of fusion devices that approach ITER scale, and quantum calculations of complex chemical reactions. In addition, further diversity with the LCF resources will be realized with an acquisition by Argonne National Laboratory (ANL) of a high performance IBM Blue Gene/P with low-electrical power requirements and a peak capability of up to 100 teraflops in 2007, and further expansion to 250–500 teraflops in fiscal year 2008 will bring enhanced capability to accelerate scientific understanding in areas such as molecular dynamics, catalysis, protein/DNA complexes, and aging of material. With the ORNL and ANL LCF facilities SC is developing a multiple set of computer architectures to enable the most efficient solution of critical problems across the spectrum of science, ranging from biology to physics and chemistry.

The Scientific Discovery through Advanced Computing (SciDAC) program is a set of coordinated investments across all SC mission areas with the goal of using computer simulation and advanced networking technologies to achieve breakthrough scientific advances via that are impossible using theoretical or laboratory studies alone. In fiscal year 2006 ASCR recompeted its SciDAC portfolio, with the exception of activities in partnership with the Fusion Energy Sciences program that were initiated in fiscal year 2005. The new portfolio, referred to as SciDAC–2, enables new areas of science through Scientific Application Partnerships; Centers for Enabling Technologies (CET) at universities and national laboratories; and University-led SciDAC Institutes to establish centers of excellence that complement the activities of the CETs and provide training for the next generation of computational scientists.

Advancing high performance computing and computation is a highly coordinated interagency effort. ASCR has extensive partnerships with other Federal agencies and the National Nuclear Security Administration (NNSA). Activities are coordinated with other Federal efforts through the Networking and Information Technology R&D (NITR&D) subcommittee of the National Science and Technology Council Committee on Technology. The subcommittee coordinates planning, budgeting, and assessment activities of the multi-agency NITR&D enterprise. DOE has been an active participant in these coordination groups and committees since their inception. ASCR will continue to coordinate its activities through these mechanisms and will lead the development of new coordinating mechanisms as needs arise such as the ongoing development of a Federal Plan for Advanced Networking R&D.

Biological and Environmental Research

Fiscal Year 2007 Request—$510.3 Million; Fiscal Year 2008 Request—$531.9 Million

Biological and Environmental Research (BER) supports basic research with broad impacts on our energy future, our environment, and our health. By understanding complex biological systems, developing computational tools to model and predict their behavior, and developing methods to harness nature's capabilities, biotechnology solutions are possible for DOE energy, environmental, and national security challenges. An ability to predict long-range and regional climate enables effective planning for future needs in energy, agriculture, and land and water use. Understanding the global carbon cycle and the associated role and capabilities of microbes and plants can lead to solutions for reducing carbon dioxide concentrations in the atmosphere. Understanding the complex role of biology, geochemistry, and hydrology beneath the Earth's surface will lead to improved decision making and solutions for contaminated DOE weapons sites. Understanding the biological effects of low doses of radiation can lead to the development of science-based health risk policy to better protect workers and citizens. Both normal and abnormal physiological processes—from normal human development to cancer to brain function—can be understood and improved using radiotracers, advanced imaging instruments, and novel biomedical devices.

The fiscal year 2008 BER request continues expansion of the Genomics: GTL program. This program employs a systems approach to biology at the interface of the biological, physical, and computational sciences to determine the diverse biochemical capabilities of microbes, microbial communities, and plants, with the goal of tailoring and translating those capabilities into solutions for DOE mission needs. In fiscal year 2005 BER engaged a committee of the National Research Council (NRC) of the National Academies to review the design of the Genomics: GTL program and its infrastructure plan. The NRC committee report, Review of the Department of Energy's Genomics: GTL Program was released in fiscal year 2006 and provided a strong endorsement of the GTL program, recommending that the program's focus on systems biology for bioenergy, carbon sequestration, and bioremediation be given a "high priority" by DOE and the Nation. The report also recommended that the program's plan for new research facilities be reshaped to produce earlier and more cost-effective results by focusing not on particular technologies, but on research underpinning particular applications such as bioenergy, carbon sequestration, or environmental remediation.

In response, SC revised its original single-purpose user facilities plan to instead develop and support vertically-integrated GTL Research Centers to accelerate systems biology research. BER will support the development of three Bioenergy Research Centers to be selected and initiated in fiscal year 2007, and fully operational by the end of 2008. All three centers will conduct comprehensive, multidisciplinary research programs focused on microbes and plants to drive scientific breakthroughs necessary for the development of cost-effective biofuels and bioenergy production. These centers will not only possess the robust scientific capabilities needed to carry out their broad mission mandates, but will also draw upon the broader GTL program for technology development and foundational research. The vertically-integrated GTL Research Centers will not require construction of facilities. Moreover, the competition to establish and operate them is open to universities, non-profit research organizations, the national laboratories, and the private sector—an approach that is new for the Department. The first three research centers will focus on bioenergy research. The Department announced the solicitation for Bioenergy Research Centers in August 2006, and proposals were due on February 1, 2007.

Development of a global biotechnology based energy infrastructure requires a science base that will enable scientists to control or redirect genetic regulation and redesign specific proteins, biochemical pathways, and even entire plants or microbes. Renewable biofuels could be produced using plants, microbes, or isolated enzymes. Understanding the biological mechanisms involved in these energy producing processes will allow scientists and technologists to design novel biofuel production strategies involving both cellular and cell free systems that might include defined mixed microbial communities or consolidated biological processes. Within the Genomics: GTL program, BER supports basic research aimed at developing the understanding needed to advance biotechnology-based strategies for biofuel production, focusing on renewable, carbon-neutral energy compounds like ethanol and hydrogen, as well as understanding how the capabilities of microbes can be applied to environmental remediation and carbon sequestration.

In 2003, the administration launched the Climate Change Research Initiative (CCRI) to focus research on areas where substantial progress in understanding and predicting climate change, including its potential causes and consequences, is possible over the next 5 years. In fiscal year 2008, BER will contribute to the CCRI by focusing on (1) helping to resolve the North American carbon sink question (i.e., the magnitude and location of the North American carbon sink); (2) deployment and operation of a mobile ARM facility to provide data on the effects of clouds and aerosols on the atmospheric radiation budget in regions and locations of opportunity where data are lacking or sparse; (3) using advanced climate models to simulate potential effects of natural and human-induced climate forcing on global and regional climate and the potential effects on climate of alternative options for mitigating increases in human forcing of climate, including abrupt climate change; and (4) developing and evaluating assessment tools needed to study costs and benefits of potential strategies for reducing net carbon dioxide emissions.

In fiscal year 2008, BER will continue to support research aimed at advancing the science of climate and Earth system modeling by coupling models of different components of the earth system related to climate and by significantly increasing the spatial resolution of such models. SciDAC-enabled activities will allow climate scientists to gain unprecedented insights into interactions and feedbacks between, for example, climate change and global cycling of carbon, the potential effects of carbon dioxide and aerosol emissions from energy production and their impact on the global climate system. BER will also add a SciDAC component to GTL and Environmental Remediation research. GTL SciDAC will initiate new research to develop mathematical and computational tools needed for complex biological system modeling and for analysis of complex data sets, such as mass spectrometry metabolomic or proteomic profiling data. Environmental Remediation SciDAC will provide an opportunity for subsurface and computational scientists to develop and improve methods of simulating subsurface reactive transport processes on "discovery class" computers.

Research emphasis within BER's Environmental Remediation Sciences subprogram will focus on issues of subsurface cleanup such as defining and understanding the processes that control contaminant fate and transport in the environment and providing opportunities for use or manipulation of natural processes to alter contaminant mobility. In fiscal year 2008, BER will support the development of two additional field research sites (for a total of 3), providing opportunities to validate laboratory findings under field conditions. The resulting knowledge and technology will assist DOE's environmental clean-up and stewardship missions. Funding for the William R. Wiley Environmental Molecular Sciences Laboratory (EMSL) at Pacific Northwest National Laboratory (PNNL) will be increased in fiscal year 2008 to maintain operations at full capacity.

Also continuing in fiscal year 2008 is BER support for fundamental research in genomics, medical applications and measurement science, and the health effects of low dose radiation in fiscal year 2008. Resources are developed and made widely available for determining protein structures at DOE synchrotrons, and for DOE-relevant high-throughput genomic DNA sequencing. Building on DOE capabilities in physics, chemistry, engineering, biology and computation, BER supports fundamental imaging research, maintains core infrastructure for imaging research and develops new technologies to improve the diagnosis and treatment of psycho-neurological diseases and cancer and to improve the function of patients with neurological disabilities like blindness. Funding for Ethical, Legal, and Societal Issues (ELSI) associated with activities applicable to SC, increases to support research on the ecological and environmental impacts of nanoparticles resulting from nanotechnology applied to energy technologies.

High Energy Physics

Fiscal Year 2007 Request—$775.1 Million; Fiscal Year 2008 Request—$782.2 Million

The High Energy Physics (HEP) program provides over 90 percent of the Federal support for the Nation's high energy physics research. This research advances our understanding of the basic constituents of matter, deeper symmetries in the laws of nature at high energies, and mysterious phenomena that are commonplace in the universe, such as dark energy and dark matter. Research at these frontiers of science may uncover new particles, forces, or undiscovered dimensions of space and time; explain how matter came to have mass; and reveal the underlying nature of the universe. HEP supports particle accelerators and very sensitive detectors to study fundamental particle interactions at the highest possible energies as well as non-accelerator studies of cosmic particles using experiments conducted deep underground, on mountains, or in space. These research facilities and basic research supported by HEP advance our knowledge not only in high energy physics, but increasingly in other fields was well, including particle astrophysics and cosmology. Research advances in one field often have a strong impact on research directions in another. Technology that was developed in response to the pace-setting demands of high energy physics research has also become indispensable to other fields of science and has found wide applications in industry and medicine, often in ways that could not have been predicted when the technology was first developed.

In fiscal year 2008 HEP supports core experimental and theoretical research to maintain strong participation in the Tevatron, Large Hadron Collider (LHC) at CERN (the European Organization for Nuclear Research), and B-factory physics program, and supports research activities associated with development of potential new initiatives such as International Linear Collider (ILC) R&D, neutrinos, dark energy, and dark matter. HEP places a high priority on maximizing scientific data derived from the three major HEP user facilities: the Tevatron Collider and Neutrinos at the Main Injector (NuMI) beam line at Fermilab, and the B-factory at SLAC. HEP will continue to lead the international scientific community with these world-leading user facilities at Fermilab and SLAC in fiscal year 2008, but these facilities will complete their scientific missions by the end of the decade. Thus, the longer-term HEP program supported in fiscal year 2008 begins to develop new cutting-edge facilities in targeted areas (such as neutrino physics) that will establish U.S. leadership in these areas in the next decade, when the centerpiece of the world HEP program will reside at CERN.

In fiscal year 2008 HEP continues to support software and computing resources for U.S. researchers participating in the LHC program at CERN as well as pre-operations and maintenance of the U.S.-built systems that are scientific components of the LHC detectors. R&D in support of the proposed ILC is maintained in fiscal year 2008 to support U.S. participation in a comprehensive, coordinated international R&D program and to provide a basis for U.S. industry to compete successfully for major subsystem contracts, should the ILC be designed and then built. The long-term goal of this effort is to provide robust cost and schedule baselines to support design and construction decisions for an international electron-positron linear collider. The ILC would provide unprecedented power, clarity, and precision to unravel the mysteries of the next energy frontier, which we will just begin to discover with the LHC. In 2006 the ILC Reference Design Report was completed, and in fiscal year 2007 further work toward the design, including some site-specific studies and detector studies, will be performed. In fiscal year 2008 further work on both accelerator systems and detector studies will be performed.

To provide a nearer-term future HEP program, and to preserve future research options, R&D for accelerator and detector technologies, particularly in the growing area of neutrino physics, will continue in fiscal year 2008. With Tevatron improvements completed, much of the accelerator development effort at Fermilab in fiscal year 2008 will focus on the neutrino program to study the universe's most prolific particle. The Neutrinos at the Main Injector (NuMI) beam allows studies of the fundamental physics of neutrino masses and mixings using the proton source section of the Tevatron complex. The NuMI beam has begun operations and will eventually put much higher demands on that set of accelerators. A program of enhanced maintenance, operational improvements, and equipment upgrades is being developed to meet these higher demands, while continuing to run the Tevatron. Fabrication of the NuMI Off-axis Neutrino Appearance (NOνA) Detector, which was originally proposed as a line item construction project in fiscal year 2007 under the generic name of Electron Neutrino Appearance (EνA) Detector, is funded in fiscal year 2008 and will utilize the NuMI beam. This project includes improvements to the proton source to increase the intensity of the NuMI beam. Meanwhile, fabrication will begin for the Reactor Neutrino Detector and two small neutrino experiments, the Main Injector Experiment ν-A (MINERνA) in the MINOS near detector hall at Fermilab and the Tokai-to-Kamioka (T2K) experiment using the Japanese J–PARC neutrino beam. R&D will continue for a large double beta decay experiment to measure the mass of a neutrino. These efforts are part of a coordinated neutrino program developed from an American Physical Society study and a joint HEPAP/Nuclear Sciences Advisory Committee (NSAC) subpanel review.

To exploit the unique opportunity to expand the boundaries of our understanding of the matter-antimatter asymmetry in the universe, a high priority is given to continued operations and infrastructure support for the B-factory at SLAC. Final upgrades to the accelerator and detector are scheduled for completion in fiscal year 2007, and B-factory operations will conclude in fiscal year 2008. HEP support of SLAC operations decreases in fiscal year 2008 as the contribution from BES increases for SLAC linac operations in preparation for the Linac Coherent Light Source (LCLS).

As the Large Hadron Collider (LHC) accelerator nears its turn-on date in 2007, U.S. activities related to fabrication of detector components will be completed and new activities related to commissioning and pre-operations of these detectors, along with software and computing activities needed to analyze the data, will ramp-up significantly. Support of an effective role for U.S. research groups in LHC discoveries will continue to be a high priority of the HEP program. R&D for possible future upgrades to the LHC accelerator and detectors will also be pursued.

Enhanced support for R&D on ground- and space-based dark energy experimental concepts, begun in fiscal year 2007, will be continued in fiscal year 2008. These experiments should provide important new information about the nature of dark energy, leading to a better understanding of the birth, evolution, and ultimate fate of the universe. For example, the Super Nova/Acceleration Probe (SNAP) will be a mission concept proposed for a potential interagency-sponsored experiment with NASA, and possibly international partners: the Joint Dark Energy Mission (JDEM). DOE and NASA are jointly funding a National Academy of Sciences study to determine which of the proposed NASA "Beyond Einstein" missions should launch first, with technical design of the selected proposal to begin at the end of this decade. JDEM is one of the candidate missions in this study. In fiscal year 2008, fabrication for the Dark Energy Survey Project will begin.

The HEP program re-competed its SciDAC portfolio in fiscal year 2006. Major thrusts in theoretical physics, astrophysics, and particle physics grid technology will be supported through the SciDAC program in fiscal year 2008, as well as proposals in accelerator modeling and design to be selected in fiscal year 2007. These projects will allow HEP to use computational science to obtain significant new insights into challenging problems that have the greatest impact in HEP mission areas.

Nuclear Physics

Fiscal Year 2007 Request—$454.1 Million; Fiscal Year 2008 Request—$471.3 Million

The Nuclear Physics (NP) program is the major sponsor of fundamental nuclear physics research in the Nation, providing about 90 percent of Federal support. Scientific research supported by NP is aimed at advancing knowledge and providing insights into the nature of energy and matter and, in particular, at investigating the fundamental forces which hold the nucleus together and determining the detailed structure and behavior of the atomic nuclei. NP builds and supports world-leading scientific facilities and state-of-the-art instrumentation to carry out its basic research agenda—the study of the evolution and structure of nuclear matter from the smallest building blocks, quarks and gluons, to the stable elements in the universe created by stars, to unique isotopes created in the laboratory that exist at the limits of stability and possess radically different properties from known matter. NP also trains a workforce needed to underpin the Department's missions for nuclear-related national security, energy, and environmental quality.

Key aspects of NP research agenda include understanding how the quarks and gluons combine to form the nucleons (proton and neutron), what the properties and behavior of nuclear matter are under extreme conditions of temperature and pressure, and what the properties and reaction rates are for atomic nuclei up to their limits of stability. Results and insight from these studies are relevant to understanding how the universe evolved in its earliest moments, how the chemical elements were formed, and how the properties of one of nature's basic constituents, the neutrino, influences astrophysics phenomena such as supernovae. Knowledge and techniques developed in pursuit of fundamental nuclear physics research are also extensively utilized in our society today. The understanding of nuclear spin enabled the development of magnetic resonance imaging for medical use. Radioactive isotopes produced by accelerators and reactors are used for medical imaging, cancer therapy, and biochemical studies. Advances in cutting-edge instrumentation developed for nuclear physics experiments have relevance to technological needs in combating terrorism. The highly trained scientific and technical personnel in fundamental nuclear physics who are a product of the program are a valuable human resource for many applied fields.

The fiscal year 2008 budget request supports operations of the four National User Facilities and research at universities and laboratories, and makes investments in new capabilities to address compelling scientific opportunities and to maintain U.S. competitiveness in global nuclear physics efforts. In fiscal year 2008 support continues for R&D on rare isotope beam development, relevant to the next-generation facilities that will provide capabilities for forefront nuclear structure and astrophysics studies and for understanding the origin of the elements from iron to uranium.

When the universe was a millionth of a second old, nuclear matter is believed to have existed in its most extreme energy density form called the quark-gluon plasma. Experiments at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National

Laboratory (BNL) are searching to find and characterize this new state and others that may have existed during the first moments of the universe. These efforts will continue in fiscal year 2008. The NP program, together with the National Aeronautics and Space Administration (NASA), will continue construction of a new Electron Beam Ion Source (EBIS) to provide RHIC with more cost-effective, reliable, and versatile operations. Research and development activities, including the development of an innovative electron beam cooling system for RHIC, are expected to demonstrate the feasibility of increasing the luminosity (or collision rate) of the circulating beams by a factor of 10, which would increase the long-term scientific productivity and international competitiveness of the facility. Support for participation in the heavy ion program at the Large Hadron Collider (LHC) at CERN allows U.S. researchers the opportunity to search for new states of matter under substantially different initial conditions than those provided at RHIC. The interplay of the different research programs at the LHC and the ongoing RHIC program will allow a detailed tomography of the hot, dense matter as it evolves from the "perfect fluid" (a fluid with zero viscosity) discovered at RHIC.

Operations of the Continuous Electron Beam Accelerator Facility (CEBAF) at Thomas Jefferson National Accelerator Facility (TJNAF) in fiscal year 2008 will continue to advance our knowledge of the internal structure of protons and neutrons. By providing precision experimental information concerning the quarks and gluons that form protons and neutrons, the approximately 1,200 experimental researchers who use CEBAF, together with researchers in nuclear theory, seek to provide a quantitative description of nuclear matter in terms of the fundamental theory of the strong interaction, Quantum Chromodynamics (QCD). In fiscal year 2008, the accelerator will provide beams simultaneously to all three experimental halls and funding is provided for engineering design activities for the 12 GeV CEBAF Upgrade Project. This upgrade is one of the highest priorities for NP and would allow for a test of a proposed mechanism of "quark confinement," one of the compelling, unanswered puzzles of physics.

Efforts at the Argonne Tandem Linear Accelerator System (ATLAS) at ANL and the Holifield Radioactive Ion Beam Facility (HRIBF) at ORNL will be supported in fiscal year 2008 to focus on investigating new regions of nuclear structure, studying interactions in nuclear matter like those occurring in neutron stars, and determining the reactions that created the nuclei of the chemical elements inside stars and supernovae. The GRETINA gamma-ray tracking array, which continues fabrication in fiscal year 2008, will revolutionize gamma ray detection technology and offer dramatically improved capabilities to study the structure of nuclei at ATLAS, HRIBF, and elsewhere. The Fundamental Neutron Physics Beamline (FNPB) under fabrication at the SNS will provide a world-class capability to study the fundamental properties of the neutron, leading to a refined characterization of the weak force. Support continues in fiscal year 2008 for the fabrication of a neutron Electric Dipole Moment experiment, to be sited at the FNPB, in the search for new physics beyond the Standard Model.

Funds are provided in fiscal year 2008 to initiate U.S. participation in the fabrication of an Italian-led neutrino-less double beta decay experiment, the Cryogenic Underground Observatory for Rare Events (CUORE). A successful search for neutrinoless beta decay will determine if the neutrino is its own antiparticle and provide information about the mass of the neutrino. Neutrinos are thought to play a critical role in the explosions of supernovae and the evolution of the cosmos. A successful search for neutrino-less beta decay will determine if the neutrino is its own antiparticle and provide information about the mass of the neutrino.

Following the re-competition of SciDAC projects in fiscal year 2006, NP currently supports efforts in nuclear astrophysics, grid computing, Lattice Gauge (QCD) theory, and low energy nuclear structure and nuclear reaction theory. NP is also supporting R&D in an international effort to develop a larger, more sensitive neutrinoless beta decay experiment.

Fusion Energy Sciences

Fiscal Year 2007 Request—$319.0 Million; Fiscal Year 2008 Request—$427.9 Million

The Fusion Energy Sciences (FES) program advances the theoretical and experimental understanding of plasma and fusion science, including a close collaboration with international partners in identifying and exploring plasma and fusion physics issues through specialized facilities. The FES program supports research in plasma science, magnetically confined plasmas, advances in tokamak design, innovative confinement options, non-neutral plasma physics and high energy density laboratory plasmas (HEDLP), and cutting edge technologies. FES also leads U.S. participation in ITER, an experiment to study and demonstrate the sustained burning of fusion fuel. This international collaboration will provide an unparalleled scientific research opportunity with a goal of demonstrating the scientific and technical feasibility of fusion power. Fusion is the energy source that powers the sun and stars. Fusion power could play a key role in U.S. long-term energy plans and independence because it offers the potential for plentiful, safe, and environmentally benign energy. On November 21, 2006, the DOE signed the ITER agreement with its counterparts in China, the European Union, India, Japan, the Republic of Korea and the Russian Federation, formalizing this historic arrangement for international scientific cooperation.

The U.S. Contributions to ITER project is being managed by the U.S. ITER Project Office (USIPO), established as an Oak Ridge National Laboratory (ORNL)/ Princeton Plasma Physics Laboratory (PPPL) partnership. The fiscal year 2008 request for the U.S. Contributions to ITER project reflects a significant increase in procurement, fabrication activities, and delivery of medium- and high-technology components, assignment of U.S. personnel to the International ITER Organization abroad, and the U.S. share of common costs at the ITER site in Cadarache, France, including installation and testing. These costs are part of the Total Estimated Cost (TEC) for the U.S. Contributions to ITER project. There is a second category of costs, Other Project Costs (OPC), which is for the supporting research and development activity for our U.S. Contributions. Together the TEC and OPC make up the overall Total Project Cost which is $1,122,000,000.

In support of ITER and U.S. Contributions to ITER, FES has placed an increased emphasis on its national burning plasma program—a critical underpinning to the fusion science in ITER. FES has enhanced burning plasma research efforts across the U.S. domestic fusion program, including: carrying out experiments on our national FES facilities that are exploring new modes of improved or extended ITER performance with diagnostics and plasma control that can also be extrapolated to ITER; developing safe and environmentally attractive technologies that could be used in future upgrades of ITER; exploring fusion simulation efforts that examine the complex behavior of burning plasmas in tokamaks; and integrating all that is learned into a forward-looking approach to future fusion applications. The U.S. Burning Plasma Organization has been established to coordinate these efforts.

Section 972(c)(5)(C) of the Energy Policy Act (EPAct) of 2005, required the Secretary of Energy to provide "a report describing how United States participation in the ITER will be funded without reducing funding for other programs in the Office of Science (including other fusion programs) . . .". This report as well as all the other requirements for FES in EPAct have been or are in the process of being completed. The Department's fiscal year 2008 budget provides for modest increases for all programs within the Office of Science and supports the ITER request of $160,000,000 from new funds in the FES budget request.

FES supports the operation of a set of experimental facilities. These facilities provide scientists with the means to test and extend our theoretical understanding and computer models—leading ultimately to improved predictive capabilities for fusion science. Research and facility operations support for the three major facilities is maintained in fiscal year 2008. Experimental research on tokamaks is continued with emphasis on physics issues of interest to the ITER project. The DIII–D tokamak at General Atomics will operate for 15 weeks in fiscal year 2008 to conduct research relevant to burning plasma issues and topics of interest to the ITER project as well as maintain the broad scientific scope of the program. The Alcator C-Mod at the Massachusetts Institute of Technology will operate for 15 weeks and the National Spherical Torus Experiment (NSTX) at the Princeton Plasma Physics Laboratory (PPPL) will operate for 12 weeks. Fabrication of the major components of the National Compact Stellarator Experiment (NCSX) at PPPL continues and assembly of the entire device will be completed in fiscal year 2009.

Funding for the FES SciDAC program continues in fiscal year 2008 for the development of tools that facilitate international fusion collaborations and initiate development of an integrated software environment that can accommodate the wide range of space and time scales and the multiple phenomena that are encountered in simulations of fusion systems. Within SciDAC, the Fusion Simulation Project is a major initiative involving plasma physicists, applied mathematicians, and computer scientists to create a comprehensive set of models of fusion systems, combined with the algorithms required to implement the models and the computational infrastructure to enable them to work together.

FES will issue a joint solicitation in fiscal year 2008, with the National Nuclear Security Administration (NNSA), focused on academic research in high energy density laboratory plasmas, which supports the Department's programmatic goals in inertial confinement fusion science.

Workforce Development for Teachers and Scientists

Fiscal Year 2007 Request—$10.9 Million; Fiscal Year 2008 Request—$11.0 Million

The Department of Energy has played a role in training America's scientists and engineers for more than 50 years, making contributions to U.S. economic and scientific pre-eminence. The Nation's current and future energy and environmental challenges may be solved in part through scientific and technological innovation and a highly skilled scientific and technical workforce. The Workforce Development for Teachers and Scientists (WDTS) program acts as a catalyst within the DOE for the training of the next generation of scientists. WDTS programs create a foundation for DOE's national laboratories to provide a wide range of educational opportunities to more than 280,000 educators and students on an annual basis. WDTS's mission is to provide a continuum of educational opportunities to the Nation's students and teachers of science, technology, engineering, and mathematics (STEM).

WDTS supports experiential learning opportunities that compliment curriculum taught in the classroom and: (1) build links between the national laboratories and the science education community by providing funding, guidelines, and evaluation of mentored research experiences at the national laboratories to K–12 teachers and college faculty to enhance their content knowledge and research capabilities; (2) provide mentor-intensive research experiences at the national laboratories for undergraduate and graduate students to inspire commitments to the technical disciplines and to pursue careers in science, technology, engineering, and mathematics, thereby helping our national laboratories and the Nation meet the demand for a well-trained scientific/technical workforce; and (3) encourage and reward middle and high school students across the Nation to share, demonstrate, and excel in math and the sciences, and introduce these students to the national laboratories and the opportunities available to them when they go to college.

In fiscal year 2008, the DOE Academies Creating Teacher Scientists (DOE ACTS) program, formerly the Laboratory Science Teacher Professional Development (LSTPD) program, will support the participation of approximately 300 teachers. All 17 of DOE's national laboratories will participate in this program. Each national laboratory can elect to implement either or both of the two types of teacher professional development models in DOE ACTS: (1) Teachers as Investigators (TAI) is geared towards novice teachers typically in the elementary to intermediate grade levels; and (2) Teachers as Research Associates (TARA) for teachers with a stronger background in science, mathematics, and engineering.

The Science Undergraduate Laboratory Internship (SULI) program, which provides mentor intensive research experiences for undergraduates at the national laboratories, will support approximately 340 students in fiscal year 2008. The Albert Einstein Distinguished Educator Fellowships, the College Institute of Science and Technology (CCI) program, the Pre-Service Teacher activity for students preparing for teaching careers in a STEM discipline, and the National and Middle School Science Bowls will all continue in fiscal year 2008.

Science Laboratories Infrastructure

Fiscal Year 2007 Request—$50.9 Million; Fiscal Year 2008 Request—$79.0 Million

The mission of the Science Laboratories Infrastructure (SLI) program is to enable the conduct of DOE research missions at the Office of Science laboratories by funding line item construction projects and the clean up for reuse or removal of excess facilities to maintain the general purpose infrastructure. The program also supports Office of Science landlord responsibilities for the 24,000 acre Oak Ridge Reservation and provides Payments in Lieu of Taxes (PILT) to local communities around ANL, BNL, and ORNL.

In fiscal year 2008, SLI will fund four construction subprojects: Seismic Safety Upgrade of Buildings, Phase I, at the Lawrence Berkeley National Laboratory (LBNL); Modernization of Building 4500N, Wing 4, Phase I, at ORNL; Building Electrical Services Upgrade, Phase II, at ANL; and Renovate Science Laboratory, Phase I, at BNL. Funding for fiscal year 2008 includes $35,000,000 held in reserve pending resolution of issues related to capability replacement and renovation at PNNL. If the issues are resolved, DOE will initiate a reprogramming request to use these funds to replace and/or upgrade mission-critical facilities currently located in the Hanford Site 300 Area. The SLI program continues funding for demolition of the Bevatron at LBNL in fiscal year 2008, and funding is also provided for the demolition of several small buildings and trailers at ORNL.

Science Program Direction

Fiscal Year 2007 Request—$170.9 Million; Fiscal Year 2008 Request—$184.9 Million

Science Program Direction (SCPD) enables a skilled, highly motivated Federal workforce to manage the Office of Science's basic and applied research portfolio, programs, projects, and facilities in support of new and improved energy, environmental, and health technologies. SCPD consists of two subprograms: Program Direction and Field Operations.

The Program Direction subprogram is the single funding source for the Office of Science Federal staff in headquarters responsible for managing, directing, administering, and supporting the broad spectrum of Office of Science disciplines. This subprogram includes planning and analysis activities, providing the capabilities needed to plan, evaluate, and communicate the scientific excellence, relevance, and performance of the Office of Science basic research programs. Additionally, Program Direction includes funding for the Office of Scientific and Technical Information (OSTI) which collects, preserves, and disseminates DOE research and development (R&D) information for use by DOE, the scientific community, academia, U.S. industry, and the public to expand the knowledge base of science and technology. The Field Operations subprogram is the funding source for the Federal workforce in the Field responsible for management and administrative functions performed within the Chicago and Oak Ridge Operations Offices, and site offices supporting the Office of Science laboratories and facilities.

In fiscal year 2008, Program Direction funding increases by 8.2 percent from the fiscal year 2007 request. Most of the increase will support an additional 29 FTEs, to mange the increase in the SC research investment that is a key component of the President's American Competitiveness Initiative; four new FTEs to support NSLS–II, and ITER project office activities; and 35 FTEs—the staff of the New Brunswick Laboratory—transferring from the Office of Security and Safety Performance Assurance. Twenty-four FTEs are reduced across the SC complex in fiscal year 2008 consistent with SC's corporate workforce planning strategy. The SCPD fiscal year 2008 increase also supports a 2.2 percent pay raise; an increased cap for SES basic pay; other pay related costs such as the Government's contributions for employee health insurance and Federal Employees' Retirement System (FERS); escalation of non-pay categories, such as travel, training, and contracts; and increased e-Gov assessments and other fixed operating requirements across the Office of Science complex.

Safeguards and Security

Fiscal Year 2007 Request—$71.0 Million; Fiscal Year 2008 Request—$71.0 Million

The Safeguards and Security (S&S) program ensures appropriate levels of protection against unauthorized access, theft, diversion, loss of custody, or destruction of DOE assets and hostile acts that may cause adverse impacts on fundamental science, national security, or the health and safety of DOE and contractor employees, the public, or the environment. The Office of Science's Integrated Safeguards and Security Management strategy uses a tailored approach to safeguards and security. As such, each site has a specific protection program that is analyzed and defined in its individual Security Plan. This approach allows each site to design varying degrees of protection commensurate with the risks and consequences described in their site-specific threat scenarios. The fiscal year 2008 budget includes funding necessary to protect people and property at the 2003 Design Basis Threat (DBT) level. In fiscal year 2008, funding for the Cyber Security program element addresses the promulgation of new National Institute of Standards and Technology (NIST) requirements that are statutorily required by the Federal Information Security Management Act (FISMA) to improve the Federal and Office of Science laboratory cyber security posture.

CONCLUSION

I want to thank you, Mr. Chairman, for providing this opportunity to discuss the Office of Science research programs and our contributions to the Nation's scientific enterprise and U.S. competitiveness. On behalf of DOE, I am pleased to present this fiscal year 2008 budget request for the Office of Science.

This concludes my testimony. I would be pleased to answer any questions you might have.

SCIENTIFIC RESEARCH AT NREL

Senator DORGAN. Dr. Orbach, thank you very much. I want to ask a series of questions and then I will turn to my colleagues.

First and foremost, my colleague from Colorado mentioned that NREL, I had the opportunity to be in Golden, Colorado recently, is also working on issues like cellulosic ethanol. Tell me what the relationship is between your Office of Science and the three facilities you're going to designate, how that relates to NREL, what the coordination is, and so on?

Dr. ORBACH. We work very closely, Mr. Chairman, with NREL, and, in fact, we fund research at NREL. And, very generally, we support the basic end of the research continuum that leads to market placement of these new technologies. NREL focuses on the applied research, the step needed to take the basic ideas and convert them to the market. It's not a sharp division. In order to communicate, we need to understand the applied sector and they also do basic research, so that we can communicate most effectively. So, our relationship with NREL is a very close one, we work very closely with the program in the Department, Energy Efficiency and Renewable Energy for joint workshops and joint enterprises.

Senator DORGAN. So the significant difference here is applied versus basic?

Dr. ORBACH. That's correct.

ADVANCED SCIENTIFIC COMPUTING RESEARCH

Senator DORGAN. In 2008 the budget proposes $340 million for advanced scientific computing research. These funds will help complete the acquisition of a 250 teraflop system at Oak Ridge. What's the relationship between the computing facility at Oak Ridge, when it's completed, with the computing facility at Argonne or at Berkeley, for example?

Dr. ORBACH. Well, the one at Berkeley is what we call a capacity machine, which services about 2,500 users. The machine at Oak Ridge is what we call a capability machine. We reserve it for a smaller number so they can get larger amounts of time. There are only about 400 users at Oak Ridge.

Also, the architectures are different. We're exploring speeds that have never been achieved before. Nobody knows which scientific problems are most efficient on which architecture. So, at Oak Ridge, you'll find an architecture which is a Cray architecture. At Argonne, you'll find a Blue GeneP architecture and you'll find a Power5 architecture at NERSC at Berkeley. We believe that different science problems will be solved more efficiently on different machines. We don't know. So, we want to have the opportunity to explore which machine is best for which class of scientific problems.

CARBON SEQUESTRATION

Senator DORGAN. Let me also ask you about the role of the Office of Science in carbon sequestration. You're doing research in those areas?

Dr. ORBACH. Yes, we are.

Senator DORGAN. Again, basic research as opposed to applied research?

Dr. ORBACH. That's correct, sir. We have it in two of our programs: biological and environmental research and basic energy sciences. The latter focuses on the geologic issues associated with carbon storage. The former talks about the earth and the ability to store carbon in roots, in the surface, also with biological microbes, for example, that will absorb carbon dioxide. It looks at the biological side for sequestration.

TRANSITION OF RESEARCH INTO THE MARKETPLACE

Senator DORGAN. You know, there's a phrase that people refer to. I was unaware of it, but it is called the DOE's valley of death. Have you heard of that?

Dr. ORBACH. Yes.

Senator DORGAN. And, it's a phrase that people use to describe, I guess, how too little research really translates into new technologies that move to the marketplace. And, therefore, the valley of death. There seems to me to be a fair question about how effectively we translate the product of research into practical applications in the marketplace. Tell us a little about your view of that.

Dr. ORBACH. Well, it's very difficult. We're not the only country that struggles with that transition. The applied programs, in fact, are charged with that responsibility, but we're trying something new. The bioenergy research centers are a construct where we hope that the private sector will join with us in the basic research. The Federal money buys down the risk for the private capital so they can invest smaller amounts with this very high risk, as it is basic research. But, what we're hoping is that with the private sector as a partner, that when basic research pays off, they will then transfer that to the marketplace. So, we're looking at new methods. The Energy Policy Act gave us the Other Transactions Authority, so we have new funding structures now, that we can use with the private sector. We are attempting to come up with innovative ways to cross the "valley of death."

Senator DORGAN. Mr. Orbach, sometimes those of us without strong science backgrounds have difficulty visiting with scientists because we don't always understand exactly what they're saying. We have great respect for those that work in the sciences, obviously, but would you do me a favor? Would you send the committee a list, with an analysis, of a dozen or so of the most interesting, promising, perhaps some controversial, but breathtaking research projects that you see in your agency and in the future of your agency so that we can try to understand? If you can translate all that into the kind of thing that those of us who are non-scientists can understand I think it would give us a better idea of what you are doing and what you see ahead of you. But, I for one, appreciate your being here and appreciate especially the importance of this office. It is not the highest profile office in the Federal Government, but in many ways it holds the key to tomorrow's opportunities for our country.

[The information follows:]

INTERESTING AND PROMISING RESEARCH PROJECTS IN DOE AND IN THE FUTURE OF DOE

We are very grateful to the chairman for giving us this opportunity to explain the significance of what we do in terms that non-scientists can understand. Before we describe some of the projects we view as most promising, just a few words to put our answer into context:

To describe the far-reaching impact of DOE Office of Science-supported research on our economy, our technology, and our national life over the past five decades—and to predict the potential of Office of Science-supported research to transform Americans' lives for the better in the decades ahead—is an exciting task. Numbers only begin to tell the story. Forty-five Nobel laureates. Scores of fundamental discoveries in a wide array of fields from high energy physics, to biological research, to high-speed computing (the Office of Science website lists just a "top 100"). Countless new products, technologies, and even whole industries owe their existence to scientific research first supported by the Office of Science. But lists alone barely convey the true scope of the transformation we have generated, or the potential for new discoveries to transform our Nation's future.

Our lives have been fundamentally reshaped by Office of Science-supported discoveries. The entire field of nuclear medicine arose largely as an outgrowth of "accelerator science" spearheaded by the Office of Science and its predecessor agencies to support research in high energy and nuclear physics. At the core of MRIs are superconducting magnets, a technology first successfully developed by Office of Science-supported scientists at Fermilab to build the atom-smashing Tevatron. PET Scans grew out of pioneering advances by the Office of Science and predecessor agencies in particle accelerators, biological radiotracer molecules, photodetectors, and high-speed computers. Today particle accelerators producing X-rays, protons, neutrons, or heavy ions—once built mainly as research tools for physicists—provide advanced cancer treatment for millions of patients and are found at every major medical center in the United States.

The Information Age itself would have been impossible without the fundamental breakthroughs produced by research supported by the Office of Science—including key discoveries essential to the development of the Standard Model of high energy physics. Our world of "smart" cellular phones, cameras, music players, and appliances rely on the utilization of such phenomena and tools as the giant magnetoresistive effect and plasma chambers first investigated by Office of Science-sponsored researchers.

In short, Office of Science-sponsored discoveries are part of the very fabric of our contemporary high-tech world—a legacy of its historic role as the primary Federal sponsor of basic research in the physical sciences.

Here are some of the most promising major areas of research we are pursuing today:

Harnessing Nature for New Sources of Energy.—Since initiating the Human Genome Project in 1986, DOE has played a leading role in advancing modern biotechnology. We are applying these advances and sophisticated new tools to the task of probing microbes for solutions to energy production, carbon capture, and environmental cleanup. One of the most promising potential applications of biotechnology today lies in bioenergy production. Microbes are experts at harvesting energy from almost any form, from solar radiation to photosynthesis-generated organic chemicals to minerals in the deep subsurface. For example, there are some 200 microbes in the hindgut of the termite. They contribute to the termite's super-efficiency in breaking down cellulose into sugars that can be fermented into fuel. We now have at our disposal the tools and insights for cracking nature's code for accomplishing these marvels. Developing cost-effective ways of producing ethanol from cellulose is the key to making ethanol truly commercially viable, and biotech likely holds the solution to this challenge; biofuels also are one major means of reducing net carbon dioxide emissions into the atmosphere.

Our Joint Genome Institute is already sequencing the DNA in these microbes to identify the metabolic pathways by which these micro-organisms accomplish their mission. To seize upon these and other scientific opportunities, the Office of Science is establishing three new Bioenergy Research Centers, funded at $25 million each per year for 5 years, to bring together multidisciplinary teams of top scientists to accelerate the breakthroughs necessary for the development of cost-effective production of cellulosic ethanol and other biofuels. Universities, national laboratories, non-profit organizations, and private firms have been invited to compete for these grants, singly or in partnerships. Proposals were due on February 1, 2007; awards will be announced this June; and Centers will be underway by early in fiscal year 2008. We estimate biofuels can replace 30 percent of the transportation fuels we currently consume, reducing our dependence on imported oil, and providing energy security for our Nation.

Making Fusion Power a Reality.—Fusion powers the sun and the stars. Through our participation in ITER, a major international fusion research project, we are seeking to overcome the technical barriers to bringing fusion energy to the electric grid. In November 2006, the United States signed an agreement with 6 other partners. Scientists supported by the DOE Office of Science will be working side by side with counterparts from China, the European Union, India, Japan, the Republic of Korea and the Russian Federation to build and operate a reactor that demonstrates the scientific and technological feasibility of fusion energy.

The fusion process occurs in the sun or stars when lighter elements, hydrogen for example, fuse together under incredibly high temperatures (10–100 million degrees Celsius) to make heavier elements, thereby releasing energy and forming a stew of charged subatomic particles known as plasma. The key challenge is containing this plasma on earth. ITER will contain the plasma through use of extremely powerful magnetic fields. ITER, if successful, will put the world one step away from construction of a commercial fusion power plant. Fusion has the potential to provide abundant, clean, carbon-free energy for the world's growing electricity needs.

Extending the Frontiers of Science with the World's Fastest Computers.—The supercomputer is science's newest and most powerful tool, enabling researchers to model and simulate experiments that could never be performed in a laboratory. Some see computer modeling and simulation as a new "third pillar" of scientific discovery, side by side with scientific experiment and scientific theory. Supercomputing has enormous implications for U.S. competitiveness, for it holds out the promise of enabling U.S. industry to perform "virtual prototyping" of complex systems and products, substantially reducing development costs and shortening time to market. The Office of Science has been leading the way in developing the Nation's civilian supercomputing capabilities, acquiring ever-faster machines, nurturing the complex software development knowledge necessary to take advantage these unprecedented processing capabilities, and helping to bootstrap the U.S. supercomputer industry. Thousands of scientists from DOE labs and universities are taking advantage of these capabilities. Two private firms, Pratt & Whitney and Boeing, won time on the Office of Science fastest computer as part of the INCITE competition—in which national laboratory, university, and corporate researchers vie for time on Office of Science machines—and are performing important simulations of turbine operation and aerodynamic design. This has reduced their cost of production and time to market, giving them more of a competitive edge over their rivals on the international scene.

The Office of Science is building the world's most powerful supercomputing centers for open science. The Oak Ridge National Laboratory Leadership Computing Facility includes a Cray XT4 system that will be upgraded to 250 teraflop (trillions of calculations per second) peak capability. The Argonne National Laboratory Leadership Computing Facility will acquire an IBM Blue Gene/P this year with a peak capability of 100 teraflops. We are exploring these two different computer system architectures because we believe that different architectures will be better suited for different types of scientific problems. The National Energy Research Computing Center will reach 100–150 teraflop peak capacity this year and will serve over 2,500 scientists from DOE laboratories, universities, and companies, nationwide. Office of Science computing capabilities are expected to reach a petaflop (1,000 teraflops) by the end of 2008, far ahead of any foreign competition.

Leading the Nanotech Revolution.—The Office of Science is positioning the United States as the global leader of the nanotechnology revolution, perhaps the most economically promising technological revolution of our era. Our five Office of Science-supported Nanoscale Science Research Centers (four of which are now operational, with a fifth coming on line this year) provide our Nation's research community with the world's most advanced tools for exploring and manipulating matter at the nanoscale. Coupled with the world-leading high-intensity light sources at our National Laboratories, which enable scientists to image matter at the molecular level, these capabilities will have a dramatic impact on our national economy and energy security in the coming years. Fundamental research at the nanoscale may lead to methods to split water with sunlight for hydrogen production; technologies for harvesting solar energy with greater power efficiency and lower costs; super-strong lightweight materials to improve efficiency of vehicles; "smart materials" that respond dynamically to their environment; and low-cost fuel cells, batteries, supercapacitors, and thermoelectronics.

Manipulating matter at the atomic scale takes us into the realm where the chemical, physical, optical, and mechanical properties of materials can be dramatically different, creating the potential for the basis of new technologies. For example, both diamonds and graphite found in pencil lead are made of the same element—carbon. Their vastly different properties arise from differences in the arrangement of carbon atoms at the atomic scale. Carbon nanotubes (where the carbon atoms are arranged in a tube shape, a nanometer in diameter and with walls a single atom thick) have the right properties to be the building blocks for a range of novel energy technologies and electronic devices: they are incredibly tiny, stronger than steel, can withstand high temperatures, and have a range of controllable electronic properties. Nanotubes are already finding applications in energy technologies such as novel Lithium-ion batteries and supercapacitors; but realizing the full potential of nanotubes will require addressing challenges associated with fabricating and manipulating these molecular scale objects.

The Big Bang Machine.—Researchers at Brookhaven National Laboratory's Relativistic Heavy Ion Collider (RHIC) are pushing the frontiers of human knowledge by using a powerful particle accelerator to recreate conditions as they existed in the universe just microseconds after the Big Bang. In a headline-making development, RHIC has identified a new and entirely unexpected form of matter, a "perfect liquid" composed of quarks and gluons, the tiny components that make up the core of atoms. Work at RHIC will provide scientists with a deeper fundamental understanding of nuclear matter and its interactions, knowledge that is likely to prove invaluable not only to research in nuclear physics, but also to research in energy, materials science, astrophysics, and national security.

RHIC accelerates two beams of gold nuclei to high energies and brings them into head-on collisions inside state-of-the-art detectors designed to observe the particles that emerge. The collision disintegrates the nuclei and momentarily produces the unimaginably hot and dense matter called the quark-gluon plasma.

Understanding our Climate.—The Office of Science leads Federal agencies in the field of climate modeling. Office of Science-supported researchers are advancing climate models through the use of sophisticated field measurement tools as well as the Office of Science's supercomputing resources, the fastest in the world available for civilian research. Ultimately we need to be able to understand the factors that determine the Earth's climate well enough to predict climate and climate impacts decades or even centuries in the future. Advanced climate and Earth system models are needed to describe and predict the roles of oceans, the atmosphere, sea ice, and land masses on climate, including the interactions and feedbacks between the various components of the climate system. The role of clouds and aerosols in controlling solar and terrestrial radiation onto and away from the Earth also needs to be better understood if we are to reduce uncertainty in climate prediction. The Office of Science is addressing this need through the Atmospheric Radiation Measurement (ARM) program which is providing scientists new insights into the effect of aerosols from air pollution on clouds and the consequent heating and cooling of the atmosphere.

Restoring Sight to the Blind.—Diseases of the retina are the leading cause of blindness in the United States. The Artificial Retina Project, involving six DOE national laboratories, three universities, and an industrial partner, is utilizing the DOE labs' unique expertise in materials science, advanced microelectronics, and micro-fabrication to design and construct the most advanced device to restore sight to the blind. The pliable, biocompatible 60-electrode artificial retina has been approved by the FDA for human trials. Plans call for 30 patients to receive artificial retinas this year.

The artificial retina captures visual signals and sends them to the brain in the form of electrical impulses. The device is a miniature disc that contains an array of electrodes that can be implanted in the back of the eye to replace the damaged retina. Visual signals are captured by a small video camera located in eyeglasses worn by the blind person and processed through a microcomputer worn on a belt. The signals are transferred to the electrode array in the eye. The array stimulates the optical nerves which then carry a signal to the brain. The Office of Science goal for the project is to develop the technology to fabricate a 1000-electrode device that should allow a blind person to read large print and recognize faces. Technologies developed for this project may also be applicable to the general field of neuron prostheses.

The Elusive Higgs . . . Solving the Mystery of Mass.—The Standard Model of particle physics, developed with the contributions of numerous Office of Science-supported scientists and Office of Science experimental facilities over many years, is an extraordinarily powerful, accurate, and far-reaching physical theory that explains the behavior of matter down to the level of tiny quarks. Yet a critical piece of this theory—the so-called Higgs particle—has never been observed. According to the Standard Model, the Higgs particle and its associated field are actually responsible for giving all matter its mass. Yet the Higgs remains the only particle predicted by the Standard Model that has not yet been detected. Discovery of the Higgs and its properties—or discovery of some tantalizing alternative possibilities instead of the Higgs—would open new vistas in particle physics and provide new clues to some of the deepest mysteries of space, time, and matter. Recently, work at the Tevatron at Fermilab in Illinois—currently the world's most powerful particle accelerator—zeroed in on a lower range for the Higgs mass that suggest it might conceivably be detected at the energies achieved at the Tevatron. This would be the crowning discovery of the Standard Model and would mark the birth of a "new physics" with the potential to transform our basic understanding of the physical universe.

Using Microbes to Clean-up the Environment.—The Office of Science is looking at ways microbes can be used to degrade or transform contaminants such as toxic metals and radionuclides. Microbes have evolved over 3.5 billion years as masters at living in almost every environment. Thriving in some of the harshest environments on the planet, these single-celled organisms have developed powerful and diverse capabilities that, if harnessed through biotechnology, may provide cost-effective restoration strategies for many of the contaminated sites DOE is committed to cleaning up. Through research in areas such as genomics, geochemistry, imaging, and modeling and simulation, Office of Science-sponsored scientists are studying the complex interactions of microbes with contaminants in the subsurface environment and exploring remediation methods that rely on naturally occurring microbes. Several potential candidates are already being tested in the field. Geobacter species, for example, can transform uranium from a soluble form to an insoluble form, effectively removing it from groundwater and preventing its further mobility. A Shewanella species commonly found in soils is capable of reducing a wide range of organic compounds, metal ions, and radionuclides to less toxic forms or forms that are immobilized in the soil.

Building New Tools for Basic Science.—The world-leading large scale instruments designed, built, and operated by the Office of Science and its predecessor agencies—synchrotron light sources, neutron scattering facilities, and particle colliders—have not only driven entire fields like high energy and nuclear physics, but have also become essential tools for studying and understanding the arrangement of atoms in biological molecules, pharmaceuticals, and materials from metals to ceramics to plastics. Particle accelerators have been the primary sources of light and other forms of radiation for these facilities. Critical to development of the next generation of scientific user facilities—ones that will allow researchers to observe matter (and its components) at increasingly smaller scales and follow atomic motions and chemical reactions in real time—are advances in accelerator sciences such as superconducting radiofrequency (SCRF) technology.

The Office of Science is leading a national effort at several national laboratories and universities aimed at developing SCRF accelerator technology. This technology utilizes the remarkable properties of superconducting materials to greatly reduce the size and cost of accelerators while increasing their efficiency. These advances are being driven, in part, by the scientific opportunities at the very highest energies—SCRF is critical to realizing the proposed International Linear Collider, a thirty kilometer long particle collider which will be capable of exploring fundamental physics questions such as the physics responsible for the origin of mass as well as the nature of dark matter. However, the impact of this technology will be far wider, enabling next generation accelerator-based facilities such as free electron lasers (FELs), which will provide world-leading tools for transformational basic science in areas such as materials, nanotechnology, and biotechnology in the coming decades. The many applications of FELs include industrial processes such as laser penning to toughen ship propellers, high power laser weapons systems for naval defense, laser surgery, as well as imaging fundamental chemical and biological processes.

Basic research in science pursues the frontiers of discovery. While we expect discoveries to follow our instincts, we are often surprised, sometimes with wonderful consequences. What we have listed above is our present understanding of things to come, but there will be more—opportunities that we did not anticipate. With sufficient investment and consistent support, we can discover, apply, and improve the quality of our lives.

Senator DORGAN. Senator Domenici.

CLIMATE CHANGE RESEARCH

Senator DOMENICI. Let me just echo what you just said. You will find within the Federal Government and outside the Federal Government are gigantic research institutions and researchers that will be knocking at your door and trying to become part of the success that is, what they hope it's going to be because of what you have and what we have made available to you and what we're going to give you and the challenge we are going to place upon you. We wish you very, very much success.

Climate research, which is being spoken of very, very heavily by many, many people. The Department has requested $138 million to support climate change research. It is my understanding that this supports DOE's role in the administration's multi-agency climate change research initiative. It appears, from budget documents, that the Department has primary responsibility for carbon science cycle and the climate impacts. That doesn't mean you're in charge of the whole program, but obviously this does give you a very big role in climate change research by the United States and on behalf of the Department of Energy.

We very much want to help you with that as the source of your money, the source of your policy direction. There are so many things that one would ask, but this is not the time. This is, sort of, an opening round here. Staff will initiate a number of other ones and many will be submitted on behalf of both sides of the isle. So, we won't be trying for one-side to get up on, take over from the other. This is going to be a very wonderful venture together. And, I look forward to it and I hope you do. We have some great laboratories that you are going to be working with and when they see the relationship that is given to them in this legislation, in this funding, they will be very, very surprised.

Mr. Chairman, thank you for yielding to me and I appreciate the opportunity to work with you on this committee with him and other people in these areas.

Senator DORGAN. Senator Craig.

IMPORTANCE OF NEUTRON SOURCES

Senator CRAIG. Thank you very much, Mr. Chairman. And, again, Mr. Secretary, we thank you for being here. As you can hear by our chairman and ranking member, there are tremendously high levels of expectation and we're all very excited about getting more heavily involved in both basic research and then its application.

I had mentioned earlier, you were at the National Lab in Idaho. You visited and you saw, it's my understanding, the Advanced Test Reactor. It's a valuable national asset and the question is, how to make the ATR a successful national user facility. You manage many user facilities successfully and because of your experience in this area, I would like to ask that you work very closely with DOE NE too, and Assistant Secretary Dennis Spurgeon, in an effort to make the ATR a world-class user facility.

You know and I'm told that all neutrons are not created equally. The Office of Science uses HFIR at Oak Ridge for basic neutron physics research, while Navy DOE NE uses the ATR for nuclear energy research. How important is it for science that you have access to these complementary neutron sources for varying fluxes and energies?

Dr. ORBACH. It's extraordinarily important because the excitations we look at, in various structures, have different energies.

And they also are sometimes very difficult to see with low fluxes. The power of the ATR is exceptional and it's an exceptional resource in that regard.

Senator CRAIG. Well, I look forward to working with you and you working with the lab. As I say, we have these marvelous resources at hand, and now we're in the business of transforming them into plow shares. And that's an exciting opportunity for us and for the world and we thank you.

Senator DORGAN. Senator Allard.

Senator ALLARD. Thank you, Mr. Chairman.

EARMARKS

Senator ALLARD. I want to cover the renewable energy lab there in Colorado at Golden. They do basic research and as well as applied research. And one of the criticisms I've gotten from the lab is that they begin to count on a certain amount of money and then all of sudden earmarks come in and take away from what they were counting on in the budget process. What portion of your budget is dispersed based on earmarks and what portion is given out in grants?

Dr. ORBACH. Well, I can only give you the fiscal year 2006 numbers, because the fiscal year 2007 grants are still underway.

In 2006, we had $129 million that were congressionally directed out of a total budget of $3.6 billion.

Senator ALLARD. Three-point-six billion dollars?

Dr. ORBACH. Yes.

Senator ALLARD. Okay. All right. And, how much of your proposed funding will be directed to programs—well, let me see, no—and how has that split changed over the last 5 to 10 years?

Dr. ORBACH. It's increased quite substantially. In previous years it was around $60 million, but it more than doubled in fiscal year 2006.

Senator ALLARD. So, you're saying from fiscal year 2005 to fiscal year 2006 that earmarks doubled?

Dr. ORBACH. Yes.

Senator ALLARD. Really. That is a very significant increase. And, then in the bill that we had last year I think there was a lot of earmarks in that again. So, that trend was continuing. It started out that way at least, didn't it?

Dr. ORBACH. The fiscal year——

Senator ALLARD. It never made it to the floor, maybe, did it?

Dr. ORBACH. I'm sorry.

Senator ALLARD. Did it make it to the floor? I was trying to remember, on the Energy Bill. I don't think it did.

Dr. ORBACH. Well, the Senate bill did not make it to the floor. The House bill passed.

What we are doing is that I sent out a letter, actually today and tomorrow, to all those who received congressionally directed funds in fiscal year 2006 and gave them the opportunity to apply through our normal process of peer review in fiscal year 2007.

Senator ALLARD. Based on ability to do the research?

Dr. ORBACH. Based on the mission of the Department and the quality of the research that will be determined through peer review.

Senator ALLARD. Research institutions in Colorado and agencies seem very comfortable with the grant process where you're rewarded the grant based on your ability to do the research and your proven record of performance. And so, I'm very comfortable with that grant process. And, you know, we'll be looking at ways with what we can do to make sure we sustain the grant process.

Dr. ORBACH. Thank you.

Senator ALLARD. Now, as I mentioned, renewable energy and energy efficiency are important to me and the chairman has a specific interest in that too. How much of your proposed funding will be directed to programs that involve research in renewable energies and conservation?

Dr. ORBACH. I can give you some specific numbers, but it's a very complex calculation. And the reason is that many of our research programs support renewable research, but indirectly. For example, our light sources for structures for biological systems, the Joint Genome Institute. I would prefer to answer that for the record, if I could, in detail, but also to go into the richness of the way in which we support renewable energy. The AEI, the Advanced Energy Initiative, that's one crosscut that we've done, is around $700 million. That includes fusion energy. And so, part of this depends on how you define renewables. And, I would prefer that, so as not to mislead you, to give you the numbers for the record, but the numbers in our biology and environmental research exceed $100 million in the 2008 budget, $75 million of which are the three bioenergy centers that we'll be funding in fiscal year 2008.

Senator ALLARD. Well, I'm interested in how much goes toward renewable energy. I assume maybe the chairman of the committee might be too. So, I would get those figures to me and I think the committee——

Dr. ORBACH. It's a very significant fraction, but I would urge you to include the resources that we use for the purposes of renewable energy.

[The information follows:]

PROPOSED FUNDING FOR RESEARCH PROGRAMS IN RENEWABLE ENERGIES AND CONSERVATION

The DOE Office of Science supports an enormous range of basic scientific research relevant to renewable energy and energy efficiency. To convey the full scope of this research and the relevant funding, I would like to take a moment to explain the complex process by which basic research ultimately informs, shapes, and transforms our energy economy by providing new technologies, approaches, and products.

Basic research differs from applied research in a key respect: in basic research there is often no one-to-one correspondence between a discovery or breakthrough, on the one hand, and an application, on the other. Breakthroughs often lead to multiple applications. Applications often rely on multiple breakthroughs. The relationship between the explicit goal of a basic research program and its ultimate impact on the energy economy may be quite unexpected and surprising.

For example, as I pointed out in my opening remarks, one of the major breakthroughs needed to make intermittent renewable energy sources such as solar and wind power part of electrical baseload is a major improvement in our methods of electrical storage. A major breakthrough in electrical storage would likely change the entire technological and economic calculus affecting solar and wind power. It could bring solar and wind into their own.

But, for budget purposes, analysts would not tend to classify funding for research in electrical storage as research in renewable energy—even though it could have a far more profound effect on the technological and commercial viability of these renewables than some of the research that is focused more explicitly on solar and wind technologies themselves.

There is a second and related point. Basic research in the physical sciences today is critically dependent on advanced facilities and instruments. The materials research sponsored by our Basic Energy Sciences (BES) program—which has enormous implications for both energy efficiency and the development of more effective solar and other renewable energy sources—relies on a set of advanced, high-intensity light and neutron sources. These light sources—and we own and are building the very best in the world—are expensive to create, and a large portion of BES's budget goes to the construction and operation of these facilities. Yet they provide the critical tools our scientists need to push the boundaries in such areas of research. BES's four Nanoscale Science Research Centers (soon to become five) provide tools that will revolutionize materials, create vast new energy efficiencies throughout the economy, and also enable us to overcome at the nanoscale many of the barriers that prevent solar and other renewable energy sources from being truly efficient. Our Joint Genome Institute (JGI), built and operated by our Biological and Environmental Research (BER) program, is playing a critical role in the biofuels revolution. JGI is using its high-throughput capabilities to sequence the genomes of key bioenergy crops such as the poplar tree and key organisms, such as the 200 microbes in the hindgut of the termite, which hold Nature's secret to the super-efficient breakdown of cellulose, a critical step in producing cellulosic ethanol.

Yet if a conventional budget analyst were asked to identify our funding for renewable energy and energy efficiency, none of these facilities might show up in the analyst's total, because they are not classified in that way—even though they are playing a critical role in our ability to make progress in these fields.

A third point is that many of the breakthroughs we achieve in the search for more efficient materials and motors, or more effective conversion of solar energy to fuels, will have multiple applications throughout the economy, improving quality of life for Americans and strengthening U.S. global economic competitiveness. The National Energy Policy noted that the U.S. economy grew by 126 percent since 1973, but energy use increased by only 30 percent. Half to two-thirds of these energy savings came from technological improvements throughout the American economy, but of course these technological improvements also had a major effect on the strength of the U.S. economy and Americans' quality of life.

So I want to encourage the committee to view this basic research and its relevance in its totality.

With that preface, here is a programmatic profile of where our transformational basic research relevant to renewable energy and energy efficiency is to be found.

Basic Energy Sciences ($1.5 billion under the fiscal year 2008 request). BES is our largest "use-inspired" energy-related research program. Virtually every research program under BES's Materials Science and Engineering Division is pursuing research relevant to increased efficiency in energy production and use through the development of lighter-weight, stronger materials, more efficient engines, and more effective transmission and storage of electrical power, to name only a few examples. The Chemical Sciences, Geosciences, and Biosciences Division is also providing transformational research aimed at efficiencies through improved catalysis and combustion. In addition, within the BES program, $94.6 million is specifically directed toward research in renewable energy, including solar, biomass, hydrogen, and wind.

Biological and Environmental Research (Genomics: GTL Program: $154.8 million under the fiscal year 2008 request; Joint Genome Institute: $60 million under the fiscal year 2008 request). BER's GTL program is devoted to basic research aimed primarily at discoveries relevant to renewable energy, providing the Nation's major thrust toward basic science breakthroughs leading to the development of cost-effective commercially viable cellulosic ethanol and other forms of biofuels. GTL is the heir to the Human Genome Project, which the DOE Office of Science (then known as Energy Research) initiated in 1986. GTL has been applying the major advances in biotechnology that have grown out of that monumental effort to the advanced study of microbes and plants for energy production, environmental remediation, and carbon sequestration. This includes $75 million for the establishment of three new Bioenergy Research Centers, for which proposals have been received; results of this competition will be announced in June. In addition, as mentioned, BER's Joint Genome Institute is playing a critical role by providing high throughput sequencing of the plants and microbes for biofuels.

Fusion Energy Sciences (FES) ($427.9 million under the fiscal year 2008 request). Fusion is not usually classified as a renewable energy source, but it offers essentially the same benefits: a theoretically almost limitless supply of energy with minimal impact on the environment. Fusion holds out the promise of delivering plentiful, clean, carbon-free energy using elements that are available in abundant quantities on earth with virtually no adverse environmental impact. As the planet's consumption of energy rapidly increases, fusion holds out one of the most formidable potential solutions to growing global energy demand; and, like renewables, fusion will produce energy that is carbon dioxide and greenhouse gas free. Side by side with renewables and greater energy efficiencies throughout our economy, fusion in all likelihood will play a major role in our energy portfolio of the future. The request includes $160 million for the U.S. contribution to ITER, the major international fusion reactor that the United States has joined with the European Union, Japan, China, the Russian Federation, South Korea, and India to build, starting this year.

Advanced Scientific Computing Research (ASCR) (approximately 25 percent of the $340.2 requested for the program in fiscal year 2008). Finally, though the amounts are difficult to quantify because of the in-kind nature of the contribution, the Advanced Scientific Computing Research program contributes substantially to Office of Science efforts on renewable energy, energy efficiency, and fusion energy by providing computer time, resources, and technical assistance at its supercomputing facilities. ASCR provides a very small amount (a few million dollars) of direct support for renewables research but provides a significant amount for relevant research (about 25 percent of the program) through partnerships with BES, BER, and FES. These partnerships include the Fusion Simulation Project, computational chemistry, materials simulations, computational biology, and supporting efforts in computer science and applied mathematics. In addition, the National Energy Research Scientific Computing (NERSC) facility provides computing time to researchers supported by the Office of Science. Over 60 percent of the fiscal year 2007 allocations at NERSC are to BES (chemistry, materials, geosciences, and engineering), FES, or BER researchers. The ASCR Innovative and Novel Computational Impact on Theory and Experiment (INCITE) program provides access and computing time to the best research from academe, industry, and government labs without regard to source of support. In 2007, nearly half of the INCITE projects are in fusion, materials, chemistry, engineering, or biology representing over 35 million hours of computer time for research in these areas.

This answer necessarily excludes crucial areas of basic science research for which the Office of Science is steward, including climate modeling, research toward environmental remediation of DOE sites, and fundamental research in nuclear and high energy physics, among others. Furthermore, it is reasonable to expect some of the fundamental research in nuclear and high energy physics to also have energy implications, but on a much longer time scale. This very fundamental research provides the broader scientific foundation for our "use-inspired" basic research related to energy.

Senator ALLARD. That would be fine.

Dr. ORBACH. Good.

Senator ALLARD. Thank you, Mr. Chairman.

Senator DORGAN. Senator Murray.

300 AREA AT PNNL

Senator MURRAY. Thank you, Mr. Chairman. And, we'd love to have you come out and visit PNNL and see some of those great research projects. It really is amazing what they're doing. And, going back to my questioning. You know that the replacement of the 300 Area is top priority for PNNL, and as I said, it's apparently hung up over this third party financing that OMB is demanding. If you can share with this committee how you're dealing with that, I would really appreciate it.

Dr. ORBACH. Well, it's important to us too. What we have done, and thanks to you for the help you have given us in fiscal year 2007, is to steer $10 million in 2007, which would complete the $20 million that fits the profile for the physical sciences facility and the 325 building. The replacement process is a package and it relies on the third party financing of two buildings. We have worked very closely with the laboratory and we believe we now have a package that will meet the requirements for third party financing. We have had to take into account market prices. It's really a good value for the taxpayer and we believe that we now have a package which the taxpayer will find valuable.

Senator MURRAY. And will OMB approve it?

Dr. ORBACH. We will be submitting it to OMB. We hope to have final release from our department by the end of this week and then submit it to OMB. We have an understanding with them that within a month we will get a response. So that we can release those funds, hopefully, by the end of April or beginning of May.

Senator MURRAY. Okay. Do you have a contingency plan if they say no?

Dr. ORBACH. We would probably go back to the drawing board and try and fix the third party financing. We think this will work, but third party financing of two parts is essential to successful departure from the 300 Area. And, I'd hate to give them up. We have both a biology and a computational facility. PNNL's role in computation is going to be very important in the future and that building is a stand alone building, which primarily will be Department of Homeland Security, large data sets. I think that's essential for the future of the laboratory. So, I'm going to do the best I can to get those third party packages approved.

Senator MURRAY. Okay. Well, so within 1 month we should hear from OMB on——

Dr. ORBACH. Yes. My best estimate is that it will leave the Department, hopefully, by the end of this week and then we have an understanding with OMB that we'll get a response within roughly 1 month.

Senator MURRAY. Well, there are two other Federal partners, NNSA and DHS, DHS you mentioned. Neither of them have any funds in the fiscal year 2008 budget request, and I was told that if funds were added by Congress to the Department of Homeland Security budget in 2007, which I was able to do, that they would include funds in 2008. We added $2 million, yet there are no funds in the budget request. Are you working with NNSA and DHS to ensure adequate funds are included?

Dr. ORBACH. Yes. We're working very closely with them. We have an MOU that you're aware of. The funding in 2007 has $7.9 million from NNSA and $2 million from DHS in addition to our $10 million. The $2 million is set, so is the $7.9 million, so I think we can deliver on the 2007 committment. We're sort of taking one year at a time. In 2008, for the reasons you understand——

Senator MURRAY. They did not include any money in the 2008 request.

Dr. ORBACH. Yes. I have spoken with Admiral Cohen about that and we hope that some resolution will be found.

Senator MURRAY. Will be found. Okay, that's not a very definitive answer. I hope that as a steward of the PNNL and all the laboratories that you really take a leadership role and push them in coming together with us on that.

Dr. ORBACH. I will promise you that. I have been doing it and I will continue to do that.

5-YEAR PLAN

Senator MURRAY. Okay. I also was disconcerted that the 5-year plan made no mention of this project either. And I was curious if this is a priority and we're all moving toward, why it wasn't part of the 5-year plan?

Dr. ORBACH. Well, the 5-year plan came to us at a bizarre time. We didn't have a 2007 budget and we were trying to put together the 5-year plan. So we didn't know how the 2007 budget would fit into the 2008 and then, from then on. It's not a one-year-at-a-time, but a continuum. And, frankly, we had no time to go through the review process with OMB that we normally would in a 5-year plan. So, what you have, as you noted, is really just a simple extrapolation of the 2008 budget out for 5 years on a proportional basis. It's not a 5-year plan, it's 2008——

Senator MURRAY. It's a budget based on current numbers and it's not a plan.

Dr. ORBACH. That's correct. It's based on the President's request for 2008 and then extrapolated out.

Senator MURRAY. It's disconcerting to see that because we need that kind of leadership in the 5-year plan to make sure we're all——

Dr. ORBACH. Absolutely, and in the previous year, in fiscal year 2007, we had a 2006 budget so we could put a 5-year plan together. But, the budget process this year just didn't give us the opportunity to do that.

Senator MURRAY. Thank you, Mr. Chairman.

[The statement follows:]

PREPARED STATEMENT OF SENATOR PATTY MURRAY

Thank you Chairman Dorgan for holding this hearing today and giving us the opportunity to discuss these important DOE programs.

I'm very pleased the Administration is continuing to increase funding for basic and physical sciences. It is vital to build robust research and development budgets and to maintain a healthy level of investment in our national laboratory system in order to attract the best and brightest minds in the sciences.

If the United States is to remain on the cutting edge of research and development, the work of the Office of Science is a resource we can not afford to under fund. As a long time advocate of increased funding for the Office of Science, I'm pleased to see the administration has requested $4.4 billion for fiscal year 2008. These investments are necessary to keep us on track as leaders in discovery and technology advancements.

I also take great pleasure in representing one of our national laboratories. The Pacific Northwest National Laboratory does cutting edge work that is an integral part of the future growth of Washington State and our Nation. It's important to make full use of all our resources to advance science, and the national lab system should play a key role.

One critical project the PNNL has been working on in Washington State is the capability replacement project. I look forward to getting the opportunity to ask you several questions on that project shortly and other matters vital to the Hanford cleanup project.

Thank you for coming today to testify, Dr. Orbach.

Senator DORGAN. Senator Murray, thank you very much.

RENEWABLE ENERGY

Secretary Orbach, my colleague Senator Allard is absolutely correct that many of us will be interested in the issue of renewable energy and the work that you're doing in those areas and will want to keep abreast of the relationship with the other parts of the Energy Department that are doing research in those areas as well.

Senator Domenici, did you have additional questions?

Senator DOMENICI. Mr. Chairman, I believe that if we do, and I would prefer to submit them through my staff to the Secretary if you don't mind and then back to the committee. I would wrap it up from my standpoint by saying, while your office has been kind of put in the limelight, by the President's remarks in his State of the Union Address and some that followed. For many of us, we now know that you have a very broad charter. You are not limited to one thing or another. You have a very broad base of activities that come within your jurisdiction and in your power. And, I hope, and from what I can see, I think I'm right, that our chairman is going to be looking for places where we can make a real contribution to America's energy unpreparedness, in terms of our being too heavily committed and too big a user of petroleum products for our lifestyle, which carries with it significant negative baggage. And, you have been given an opportunity to do, to lead a research effort in a number of areas to change that situation that exists and is not doing us a bit of good as a people.

That's a fun situation to be in, if in fact you are given some tools.

Dr. ORBACH. Senator, thank you. We have an opportunity here that I think we have not had before. The scientific community understands exactly your words and has made decisions, personal decisions to get involved in energy research. What we are going to do is the best basic research in the world that, as I said in my opening remarks, will make renewables contribute in a significant fashion, not at the 1 and 2 percent, but at the 30 percent level in our economy.

Senator DOMENICI. That's your goal, you say.

Dr. ORBACH. Yes.

MAJOR CONSTRUCTION PROJECTS

Senator DORGAN. Secretary Orbach, I too am going to send you a list of questions and I'm interested in visiting some of the laboratories and to try to see some of the work, visit with the scientists, and so on. It must be almost nirvana to be able to hire scientists to operate a department like yours and just inquire what's happening in the universe. So, I imagine that you have some unbelievably bright staff, some of America's best, working on some breathtaking scientific projects. I'm also going to be asking our staff here to do some visits to the laboratories and will keep in close touch with you.

I want to ask, you don't have any major construction projects in your 2008 budget request, but we know of course that you have several projects envisioned in the longer term. The International Linear Collider, the ITER and the National Synchrotron Light Source II, apparently. Do you have the out-year cost estimates for these projects? How confident are you in the estimates? Will you be able to accommodate, you think, in future budgets, large construction projects? Are these projects or other projects, in your 20-year facilities plan or is that 20-year facilities plan being modified to accomplish these projects? So, these are, I'll let you answer that question, but these are the kind of questions we're also going to submit to you because we want to work with you to make sure that you have a funding plan for the longer term, not just 2008, a funding plan that works.

Dr. ORBACH. Yes, actually, we take pride in that. The Spallation Neutron Source was just finished last year. It was $1.4 billion. It came in slightly under budget and slightly ahead of schedule.

Project management is very, very serious to us. In terms of ITER, we can give you the explicit numbers out to 2014 when the construction is intended to end. And, we have been the primary driver for project management in the ITER construction process.

Senator DORGAN. What does ITER look like physically?

Dr. ORBACH. It's huge. It's about eight stories high. It looks like a donut. It's a way of containing a fusion plasma at 200 million degrees of sufficient density to generate half a gigawatt of power. So, it's a big donut. If you imagine a donut and you put your hand in the middle and open up your fingers, you have a d-like cross section, and that's now thought to be the appropriate geometry for stability of these plasmas at these huge temperatures. It will burn deuterium and tritium. These are two isotopes of hydrogen. It's the way the sun works. And, they will produce nothing but energy and helium gas. It's completely benign.

Senator DORGAN. You know, Secretary Orbach, your personality changes when I ask you a question that allows you to provide an answer you know I won't understand.

Dr. ORBACH. I'm sorry. I think——

ADDITIONAL COMMITTEE QUESTIONS

Senator DORGAN. But, let me tell you something. I hope I speak for Senator Domenici as well. If he understood all that, then I'm in serious trouble as a chairman. We really are very interested in these things and interested in what our scientists are doing. And, I asked the question to elicit your response. I hope that our subcommittee, all of the members of our subcommittee will be interested in working with you on these really fascinating projects.

[The following questions were not asked at the hearing, but were submitted to the Department for response subsequent to the hearing:]

QUESTIONS SUBMITTED BY SENATOR DIANNE FEINSTEIN

BIOLOGICAL AND ENVIRONMENTAL RESEARCH

Question. The Department of Energy's Office of Biological and Environmental Research (DOE–OBER) has a robust program for monitoring carbon cycles on land, but does not address ocean carbon. DOE traditionally has not examined ocean acidification in the context of global warming. Increases in atmospheric carbon dioxide make the ocean more acidic, and ocean acidification has a large impact on global carbon cycles. Please answer the following questions:

Do you believe that monitoring of oceanic carbon cycles is within the scope of the Office of Biological and Environmental Research?

Answer. The uptake of carbon dioxide by the ocean has a chemically well-understood effect on the acidity of ocean water. Since the industrial revolution, the pH of the ocean has been reduced slightly. This fact was brought to the attention of the scientific community in part through global ocean carbon cycle modeling carried out at DOE laboratories, with the support of the Biological and Environmental Research (BER) program. Changes in ocean pH may have an effect on the ocean carbon cycle in the future, and the BER climate modeling program will attempt to account for those effects in the development of the coupled climate-carbon cycle models supported by the program. The BER climate change research program conducts basic research and develops advanced climate modeling. Supported research includes studying the effects of climate change on important terrestrial ecosystems, but does not include environmental monitoring. Monitoring of the oceanic carbon cycle is outside the present scope of BER; however, it is supported by other Federal agency partners in the Climate Change Science Program (CCSP), including the National Oceanic and Atmospheric Administration (NOAA) and the National Science Foundation (NSF).

Question. If so, how much of the 17 percent increase in funding provided by the President's fiscal year 2008 budget would be needed to initiate such a program? Is more funding needed? If so, how much?

Answer. As stated above, environmental monitoring is outside the scope of the BER basic research program. Monitoring of ocean carbon cycles is supported by other Federal agencies.

Question. If not, how can other Federal agencies best take advantage of DOE's expertise in this realm? What types of programs do you envision where the Office of Biological and Environmental Research provides important support to this national need?

Answer. One of the most robust methods of studying the carbon cycle of the entire ocean, and the chemistry of ocean water, including its acidity, is through detailed, three-dimensional models of the biogeochemistry of the ocean. When such a model is coupled to a model of the atmosphere, uptake of atmospheric carbon dioxide by the ocean is accounted for. This approach is central to the BER climate modeling program, which includes leading-edge three-dimensional modeling of the coupled atmosphere-ocean system. Other Federal agencies can best take advantage of DOE's expertise in this realm by communicating their process research results to the modeling teams so that the models account for the most up-to-date scientific results.

Question. The Department of Energy's Office of Biological and Environmental Research (DOE–OBER) has developed unique capabilities to monitor and predict chemical and physical interactions between fluids and subsurface environments. This capability is essential to understanding the behavior of carbon dioxide in the deep subsurface; and the application of this knowledge to the permitting and monitoring of carbon sequestration sites. Please answer the following questions:

In addition to technology development, what efforts are you making to improve our scientific understanding of the behavior of carbon dioxide at potential sites for geologic carbon sequestration?

Answer. Within the Office of Science, the Basic Energy Sciences (BES), Biological and Environmental Research (BER), and Advanced Scientific Computing Research (ASCR) programs support research that underpins efforts to understand the behavior of carbon dioxide sequestered in deep geological formations. BES-supported research focuses on areas where improved understanding is needed to evaluate the potential for deep underground sequestration, including understanding the mechanical stability of porous and fractured reservoirs/aquifers, understanding multiphase fluid flow within the aquifers, and understanding the geochemical reactivity within the reservoirs/aquifers. BER supports research towards the development of methods or strategies to enhance carbon sequestration in long-term stable forms in plants and soils. This research includes the development of functional genomic, genetic, and proteomic approaches that may lead to improved biomass systems for carbon fixation and sequestration. ASCR leads the development of high-performance computers for related scientific applications and supports research in multiscale mathematics and computation science needed to develop optimal codes for modeling complex systems such as subsurface biogeochemical processes. ASCR has also partnered with BER to support research on groundwater reactive transport modeling and simulation through the Scientific Discovery through Advanced Computing (SciDAC) program.

Additionally, the Office of Science has led a series of workshops that engaged the broader scientific community to identify the challenges associated with terrestrial and subsurface geological carbon sequestration and promising research areas that, if pursued, could lead to further understanding of related biochemical and geochemical processes and enable the development of long-term sequestration technology options. More information on these workshops can be found in the subsequent reports: "GTL: Genomics Roadmap—Systems Biology for Energy and Environment," August 2005 (http://genomicsgtl.energy.gov/roadmap); the Basic Research Needs for Geosciences: Facilitating 21st Century Energy Systems workshop held in February 2007, (report to be released soon); and Computational Subsurface Sciences Workshop, held in January 2007 (http://subsurface2007.labworks.org/report/).

Question. At the current level of investment, how long before we have sufficient scientific knowledge to begin permitting various sites around the country in the near future?

Answer. Sufficient scientific understanding currently exists to support planned large-scale demonstrations of carbon sequestration in depleted oil and gas reservoirs. Only after these large-scale demonstrations are conducted will there be sufficient understanding of the long-term stability and environmental impacts of geological storage of carbon dioxide in such reservoirs. DOE's Office of Fossil Energy is pursuing this applied research and development path. Knowledge about deep saline aquifers is far less extensive, and many substantial issues need to be addressed through research and demonstration before it will be possible to permit sequestration in saline aquifers at a commercial scale.

Question. In addition to current efforts in carbon capture and sequestration technology; what additional programs are needed to develop carbon sequestration science to the point where we can safely permit and monitor sequestration sites? How much additional funding is needed to implement these programs?

Answer. The Office of Science, in coordination with the Office of Fossil Energy, is supporting a range of basic research activities that will provide a sound scientific basis for carbon sequestration. Such research includes the study of geophysical imaging methods needed to measure and monitor below-ground reservoirs of carbon dioxide resulting from geological sequestration, multiscale modeling to understand and visualize saline aquifers and other geological reservoirs, and studies to enhance long-term sequestration processes and the stability of stored carbon in terrestrial vegetation and soils. The recent Office of Science-led workshops on Basic Research Needs for Geosciences: Facilitating 21st Century Energy Systems, February 2007, and Computational Subsurface Sciences Workshop, January 2007, identified priority research areas needed to develop carbon sequestration science. The results of these workshops will help inform ongoing research planning and future budget requests.

Question. In fiscal year 2007, some compromises had to be made for new facility construction and for user facility operations in the synchrotron radiation/photon science area. How do you see the fiscal year 2008 budget addressing the objective of maintaining the on-time, on-budget completion of major construction projects and also achieving a level of funding for facility operations which is needed to ensure scientific accomplishment commensurate with the large investments that have been made in major scientific user facilities?

Answer. To support users and to maintain the facilities and instruments, the fiscal year 2008 budget funds facility operations generally at or near optimal levels, with the exception of Fusion Energy Sciences facilities, which would be operated at about half of optimal levels as part of a balanced fusion program, consistent with the fiscal year 2007 request and fiscal year 2006 appropriation. The fiscal year 2008 budget provides funding for the major construction projects and major items of equipment at a level that assumes full funding of construction in fiscal year 2007; i.e., the fiscal year 2008 budget was submitted to Congress prior to passage of the final fiscal year 2007 appropriation. Therefore, impacts on construction projects from the fiscal year 2007 appropriation are not addressed in the fiscal year 2008 budget.

Question. California is, and has been an R&D leader, contributing greatly to the U.S. economy through its scientific and technical talent. The challenge is sustaining this talent with increasing pressures on the Federal budget. The Nation needs to leverage its investments across agencies and throughout the U.S. scientific enterprise to effectively and synergistically apply its world-class R&D capabilities. I am interested in how the DOE plans to leverage the investments and accomplishments of the NNSA complex, such as its tremendous supercomputing capability and the fusion capability of the National Ignition Facility, to support our civilian science programs? Will you and the Office of Science be able to reap benefits from the investments made to develop NNSA's scientific capabilities to support DOE's national security mission? How do you plan to leverage the capabilities at universities, Office of Science laboratories, and the NNSA laboratories to capitalize on the strengths and capabilities across the DOE complex?

Answer. The Office of Science (SC) utilizes investments made by NNSA in the field of High Energy Density Physics (HEDP) as well as in high-performance computing in a number of ways.

Increased cooperation between these two programs will have benefits for both. The NNSA HEDP infrastructure, represented by facilities such as the National Ignition Facility (NIF) in California, OMEGA at the University of Rochester, and the Z-Pinch at Sandia, are all used by SC funded researchers to advance the field of High Energy Density Laboratory Plasmas (HEDLP), which is a subset of HEDP. These facilities will be used by SC to perform research on extreme states of matter, for example, simulating in a laboratory physical properties of phenomena that once could only be viewed from afar by telescope. These facilities may also serve to move forward research on inertial fusion energy.

Many of the facilities that NNSA uses for stockpile stewardship, including Z-Pinch, Omega, and NIF (which will begin operations in 2010), can be used for both national security and energy-related HEDP research. The joint NNSA–SC Fusion Energy Sciences (FES) HEDLP program is currently being put together. A workshop to consider integration of NNSA and FES program elements is planned for May 2007. Details of the joint HEDLP program are contained in the DOE NNSA and SC fiscal year 2008 President's Budget Request narratives.

In the area of computation, there has been a high level of collaboration to advance the state-of-the art in computation. NNSA is a world leader in mission-driven computation for its stockpile stewardship program. SC laboratories have assisted in the development of software codes, for instance, and have also benefited from NNSA's experience in running machines like Cray's Red Storm and the IBM BlueGene/L.

Researchers from NNSA and SC labs as well as university researchers are already reaping benefits from the array of facilities within the DOE complex. We are examining ways to increase collaboration with NNSA facilities without compromising national security or NNSA's mission. We expect this collaboration to develop further and help keep the United States at the forefront of many areas of physical science.

QUESTIONS SUBMITTED BY SENATOR PETE V. DOMENICI

LOW DOSE RADIATION EFFECTS RESEARCH

Question. Dr. Orbach, you and I have worked on understanding the effects of low dose radiation for some time. It appears that the science indicates that the linear no-threshold model theory does not hold up scientifically.

Can you tell me what the conclusions of the Department's research indicate and when you will complete this evaluation?

Answer. Until recently, biophysical models of response to radiation exposure have assumed independent action of ionization events in cells and tissues. The models assume that the single cell is the unit of function. The models also assume that every ionization event increases the probability of DNA breaks. Together, these physical/biological assumptions supported linear, no-threshold models of radiation risk and cancer. Historically, measurements of initial radiation damage such as cell death, chromosome aberrations, or micronuclei formation in cellular systems showed a fairly linear response with dose, but these experiments seldom encompassed the lower doses of interest.

New research from DOE's Low Dose Program directly challenges the old fundamental assumptions. The new findings provide compelling evidence that ionization events in cells and tissues are not completely independent and that tissues have surveillance mechanisms that dramatically affect the development of cancer and the behavior of cancer cells. The research is establishing the importance of studying a tissue's biological response to an exposure, rather than studying just the initial events within an individual cell.

This new research includes recent studies that highlight biological signaling between irradiated cells and nearby non-irradiated cells. This crosstalk cannot be explained with the older biophysical paradigms, which assume that the single cell is the unit of function. These data also show that cells within a tissue are not independent of each other in a multi-cellular organism. Indeed, the signaling from non-irradiated cells can actually eliminate damaged cells from a tissue. These and other results are consistent with the conclusions of the recent French National Academy Report "Dose-effect Relationships and Estimation of the Carcinogenic Effects of Low Doses of Ionizing Radiation" (March 2005).

We believe that investments being made to study the effects of low doses of radiation in 3 dimensional tissues, a significant advance over traditional isolated cell approaches, will provide substantial results in the next 3 to 5 years. Research to understand the variability and genetic susceptibility of individuals to low doses of radiation is much more difficult but will have significant payoffs in 5 to 7 years.

Question. How will you work to see that this information is used to make informed decisions about environmental and worker safety?

Answer. In addition to verifying and expanding research findings, we are working to communicate the new biological paradigms to the larger scientific communities in the United States and around the world. We feel that the quickest and most appropriate route to establish the need for reconsideration of risk estimate models is to gain understanding and acceptance from the scientific community first, while informing the regulating agencies and the general public along the way.

The growing body of research from the Low Dose Program now provides a scientific basis for reconsideration of models used to set regulatory standards. The Low Dose Program is supporting research to help in the development of new mechanistic models that would incorporate all aspects of radiation biology, from cellular and molecular actions within tissues, to the evolution of cancer as a multi-cellular disease. Ongoing research in the Low Dose Program and advances in systems biology hold promise in providing this modeling framework, which can facilitate moving new biological paradigms into the regulatory process.

SCIENTIFIC INTERACTION WITH CHINA

Question. I have been talking for quite some time about the need for a U.S. global climate change policy that incorporates all world economies, including the developing world. The foundation of our success will be the development of affordable technologies.

Today, the United States is the largest emitter of greenhouse gases, but China will soon overtake us in this regard. I believe it is critical that we engage China as a partner in our efforts to curb reductions in greenhouse gases. We need to launch a serious, ambitious effort to reduce greenhouse gas emissions in both of our nations through technology deployment and other coordinated efforts.

Please tell me about the current collaborative efforts between the United States and China to advance technologies that will reduce greenhouse gas emissions, including any bilateral R&D programs.

Answer. The fossil energy protocol is a bilateral agreement on energy technology cooperation that has a goal of reducing the impact of China's growing demand on global hydrocarbon markets; some of the activities in the Protocol relate to modeling and technologies for control of greenhouse gas emissions in China. Additionally, both China and the United States are charter members of the Carbon Sequestration Leadership Forum (CSLF), which is an international climate change initiative focused on development of improved cost-effective technologies for the separation and capture of carbon dioxide for its transport and long-term safe storage. The United States and China are co-sponsors of a CSLF-recognized project for "Regional Opportunities for CO_2 Capture and Storage in China".

Question. Can you please tell me what additional steps this administration plans to take to address this important issue?

Answer. The fossil energy protocol was renewed in 2006 for an additional 5 years.

WORKFORCE DEVELOPMENT FOR TEACHERS AND SCIENTISTS

Question. I am pleased to see that the fiscal year 2008 budget request would increase this account to $11 million, an increase of 57 percent over the operating plan for fiscal year 2007.

I believe the Department of Energy can make an important contribution to the quality of math and science teaching in this country, which is so critical to our Nation's continued economic competitiveness.

I understand that the Department is developing a strategic plan for the scale-up of its activities in this area.

Could you describe the main elements you are including in this strategic plan?

Answer. A strategic plan is being developed in the Office of Science for its Office of Workforce Development for Teachers and Scientists (WDTS). It is not a Departmental-wide blueprint for this program area. As the strategic plan is under development, I regret that I am unable to provide a substantive answer to your question at this time. As to a "scale-up" of our activities, I point you to recommendation number five of the just-released interagency Academic Competitiveness Council report (located at http://www.ed.gov/about/inits/ed/competitiveness/acc-mathscience/index.html), which states that "funding for Federal STEM education programs designed to improve STEM education outcomes should not increase unless a plan for rigorous, independent evaluation is in place, appropriate to the types of activities funded." We have begun working with the other members of the Council under the auspices of the National Science and Technology Council to implement the recommendation in this report. Overall, the fiscal year 2008 request to Congress of $11.0 million is an increase of 38 percent over the fiscal year 2007 appropriated level of $8.0 million.

Question. How will you ensure that the expanded program will include the widest possible cross-section of our Nation's educational system?

Answer. In January 2007, WDTS held a series of 9 focus groups designed to gather advice and information from a very wide cross-section of STEM education leaders from universities, educational associations, under-represented populations, the private sector, other Federal agencies, and other groups. These entities remain part of the planning process for WDTS and will help ensure that the program includes the widest possible cross-section of participants from our Nation's educational system.

HIGH ENERGY DENSITY PHYSICS

Question. Dr. Orbach, as you are aware, this subcommittee has carried language in the fiscal year 2006 and draft fiscal year 2007 bill directing the Department to integrate the Federal research in High Energy Density Physics among DOE's Office of Science and the NNSA and other Federal agencies.

I want to thank you for supporting the multi agency effort to establish the High Energy Density Laboratory Plasmas program, including the establishment of a multi agency advisory group to oversee the establishment of research priorities and goals.

One objective of my proposal was to expand the use of critical NNSA facilities such as the Z machine for non weapons research.

What is the DOE's plan to maintain the United State's leadership in this area of science?

Answer. As part of the new joint program on High Energy Density Laboratory Plasmas (HEDLP), SC and NNSA are initiating a series of focused workshops to engage the research community in identifying promising research opportunities that merit increased investment as the joint program is implemented. The first workshop is scheduled for this May. These workshops will examine the use of NNSA facilities for world-class HEDLP science. The workshops will be used to guide development of new research efforts in fiscal year 2009, which will be competitively solicited and peer reviewed, to ensure top-quality science for this investment.

Question. Has the Department included any funding for this scientific research as a joint program? If not, why not?

Answer. Funding will be provided from existing support for HEDLP within SC's Fusion Energy Sciences (FES) program and NNSA in fiscal year 2008. As the program matures, it is expected to compete for funding against the other programs in SC and NNSA.

Question. What is the Department's plan for stewardship of this important area of scientific research?

Answer. HEDLP will be nurtured under the joint program by NNSA and FES to steward this emerging field of physics. DOE plans to establish a new advisory committee to give technical advice and help develop a scientific roadmap for the joint program.

INTEGRATION OF SCIENCE AND THE NNSA

Question. With passage of the Energy Policy Act of 2005, your position has been elevated to the Under Secretary level. In this position, you now have responsibility for setting the scientific agenda for both the Office of Science labs as well as integrating the capabilities of the NNSA facilities, which have tremendous scientific capabilities and facilities. This budget is the first year that you would have had to integrate the research at all labs.

How has this budget request changed to integrate research of NNSA and Office of Science facilities?

Answer. The Office of Science (SC) and NNSA have always had a high level of collaboration in a number of areas, including high-performance computing and high-energy density physics (HEDP). These collaborations are being expanded, and new areas are currently being added. I think the key to any collaboration is to take advantage of both NNSA and SC strengths. Increased cooperation between these two programs will have benefits for both.

In the area of computation, there has been a high level of collaboration to advance the state-of-the-art in computation. NNSA is a world leader in mission-driven computation for its stockpile stewardship program. SC laboratories have assisted in the development of software codes, for instance, and in turn have benefited from NNSA's experience in running machines such as Cray's Red Storm and the IBM BlueGene/L.

Many of the facilities NNSA uses for stockpile stewardship, including Z–Pinch, Omega, and the National Ignition Facility (which will begin operations in 2010) can be used for HEDP and energy-related HEDP research. The joint NNSA–SC Fusion Energy Sciences (FES) program in High Energy Density Laboratory Plasmas (HEDLP) is currently being put together. A workshop to consider the integration of NNSA and FES program elements is planned for May 2007. Details of the joint HEDLP program are contained in the NNSA and SC fiscal year 2008 President's Budget Request narratives.

Question. Which NNSA research facilities do you believe offer the best opportunity to support the Science research priorities?

Answer. There are a number of ongoing collaborations between NNSA in computation and HEDLP. With the start of the joint program in HEDLP, and the workshop planned for May, we expect to learn more about how to maximize the potential for collaboration. At a minimum, I expect this cooperation will improve the effectiveness of both programs' missions and use of facilities.

HIGH PERFORMANCE COMPUTING

Question. High Performance Computing developed by the NNSA to support the weapons stockpile stewardship program, and the research within the Office of Science has enabled breakthrough advances in science and engineering in the United States. These advances contribute to the Nation's economic competitiveness. Even today, industry looks to the Department to define future computing architecture and code development.

What is the DOE long term strategy to keep the Nation at the forefront of High Performance Computing?

Answer. As a partner in the President's American Competitiveness Initiative, we are committed to keeping America at the forefront of High Performance Computing (HPC) and the computational sciences. The first petascale computer resource for open science will be operating at the Leadership Computing Facility (LCF) at Oak Ridge National Laboratory in late 2008. Experts expect that, for at least the next decade, chip transistor counts will continue to follow Moore's law, but fundamental physics will significantly limit chip speeds. Consequently, increased parallelism will be essential for continued chip performance improvement, and increased transistor counts will allow radical departures from traditional CPU designs. To prepare for future systems, we are partnering with the National Nuclear Security Administration (NNSA), the Defense Advanced Research Projects Agency (DARPA), and the National Security Agency (NSA) through the High Productivity Computer Systems program to foster development of the next generation of hardware. Further, SC and NNSA have entered into a research contract with IBM to develop the next generation of the IBM Blue Gene.

In addition, we will redirect a portion of our computer science research portfolio to address major obstacles constraining the ability of a broad range of computational scientists to use petascale computers effectively in areas important to DOE missions. Also, our Scientific Discovery through Advanced Computing (SciDAC) program has created a powerful, integrated research environment for advancing scientific understanding through modeling and simulation. Through SciDAC, applied mathematicians, computer scientists and computational scientists are working in teams to create the comprehensive, scientific computing software infrastructure needed to enable scientific discovery in the physical, biological, and environmental sciences at the petascale and to develop efficient and scalable data management and knowledge discovery tools for large data sets. Further, SciDAC–2 expanded the original program by collaborating with the NNSA and the National Science Foundation as new funding partners.

Finally, we will continue the successful Computational Science Graduate Fellowship with NNSA to develop the next generation of computational science leaders.

Question. What is the DOE doing to establish a R&D roadmap with industry and labs to support long term research of advanced computing architecture concepts, algorithms, and software in order to meet the next technological changes?

Answer. The 2004 report of the Federal High-End Computing Revitalization Task Force (HECRTF) coordinated by the National Science and Technology Council (NSTC) established the R&D roadmap, which we are actively pursuing through government-wide interagency working groups. Both the Office of Science (SC) and NNSA are formal mission partners in Phase III of the DARPA High Productivity Computing Systems (HPCS) research program. Phase III of the HPCS program is focused on the generation of HPC systems that will be available from Cray and IBM in the 2011 timeframe. In addition, both SC and NNSA will participate in an NSA workshop which is intended to bring together key experts across related interdisciplinary fields to consider and define the opportunities and challenges in six technical thrusts for improving power efficiency, chip input/output (I/O), interconnect, resilience, productivity, and file system I/O.

The long term architectural strategy for system vendors is in a period of significant change. Both SC and NNSA are working with vendors to help them better understand our mission needs. Examples include working with Cray on its XMT multithreaded architecture and with IBM on the Road Runner architecture and the design of the next generation of the Blue Gene architecture.

SC and NNSA continue to work together in the area of HPC software environments. A recent example is SC participation in the NNSA workshop on its TriLab L2 petascale user environment milestone that was held after the 2007 Advanced Simulation and Computing principal investigator meeting. As a next step, SC and NNSA are co-sponsoring a workshop on petascale tools in Washington, DC this August. Results from this workshop will inform SC funding plans in petascale tool research to meet both SC and NNSA needs.

INTEGRATION OF HIGH PERFORMANCE COMPUTING AMONG SCIENCE AND NNSA

Question. Both the DOE/Office of Science (SC) and NNSA have national High Performance Computing programs for their respective missions. Both offices support acquisition plans with decidedly different goals. The Office of Science seeks to expand computing capacity to other labs, while the NNSA is seeking to reduce the number of labs with High Performance Computing from 3 to 2 labs.

What is the plan within DOE to acquire new high performance computing platforms and how is it integrated and coordinated between the Office of Science and the NNSA?

Answer. To support open scientific discovery, we must maintain our balanced high performance computing (HPC) resources portfolio that includes two types of HPC facilities. In the case of the National Energy Research Scientific Computing (NERSC) Center, we have established a mission-critical high performance production computing center. NERSC provides HPC resources for open science to support the needs of the Office of Science program offices. Currently, NERSC supports over 400 projects with 2,500 users and is predominately characterized by capacity computing. Within the current NERSC funding profile we have established a stable 3-year upgrade cycle which is consistent with the life cycle of HPC production resources.

The second priority in our "Facilities for the Future of Science: A Twenty Year Outlook" is establishment of HPC capability computing facilities. In contrast to NERSC, which supports thousands of users with small allocations of time, the high performance computing resources at the Leadership Computing Facilities (LCFs) at Oak Ridge and Argonne provide large allocations to a small number of projects with the potential for breakthrough scientific impact. Because access to capability computing is so important to our national competitiveness, we have made the HPC resources at the LCFs available to the open scientific community, including industry, through the Innovative and Novel Computational Impact on Theory and Experiment (INCITE) program. Over the past 3 years we have focused our efforts on establishing capability computing centers to provide a variety of HPC resources for open science.

In 2003, we signed a memorandum of understanding with NNSA to establish a framework for planning and coordinating research, development, engineering, and test and evaluation activities related to high-end technical computing. The acquisition of both the Red Storm (Cray XT3) computer at the LCF at Oak Ridge National Laboratory and the proposed IBM Blue Gene/P at the Argonne LCF were a result of a partnership between NNSA Advanced Simulation and Computing (ASC) and the Office of Science. More recently, Lawrence Livermore National Laboratory, Argonne National Laboratory, and IBM have entered a research and development contract to develop the next generation of Blue Gene-based products. Oak Ridge is working with Sandia National Laboratories and Cray to develop a quad-core version of the Catamount operating system. As we go forward, we will continue to rely on our close collaboration with NNSA in the area of high performance computing research and testbeds. However, NNSA's requirements for classified computing are inconsistent with the Office of Science's mission to support open science; therefore, ASCR does not share production systems with NNSA–ASC.

GENOME RESEARCH

Question. Are we making sufficient investments in the scientific underpinnings that would support our Nation's biofuels goals?

Answer. The Department recognizes the significant scientific and technological barriers that need to be overcome in order to achieve our Nation's biofuels goals, and is investing a significant portion of our research budget to support fundamental research underpinning microbial and plant research relevant to biofuels. Three GTL Bioenergy Research Centers, representing a total investment of $375 million over the next 5 years, will conduct comprehensive, multidisciplinary, and integrated basic research programs in bioenergy-related systems and synthetic biology. Research at the Centers will focus on developing the science underpinning biofuel production that will ultimately lead to technology deployable in the Nation's energy economy. The Centers will draw heavily on technology and basic science generated in the entire portfolio of Genomics: GTL activities. The Department also provides significant investments in a broad suite of scientific user facilities, such as the Production Genomics Facility and structural biology user stations at DOE synchrotrons and neutron sources, with unique instrumentation, computational capabilities, and experimental capacity to enable scientists in universities, Federal laboratories, and industry to conduct research underpinning the goals of biofuels production.

Question. With the need to support the DNA characterization of many more plants to support our biofuels goals, why has the Department reduced funding for the Joint Genome Initiative?

Answer. The DOE Joint Genome Institute (JGI) receives a significant fraction of the overall budget for Biological and Environmental Research (BER), indicating our commitment to provide genome sequencing resources supporting the Department's missions and its biofuels goals. The level of fiscal year 2008 funding has increased significantly relative to that of fiscal year 2006. The budget request for the JGI, in addition to reflecting a realistic funding balance among the entire portfolio of BER research supporting our biofuels goals, also reflects the need to replace aging sequencing equipment with more advanced instrumentation capable of greater throughput. JGI receives funds from sources other than the "operating" line in the budget. In fiscal year 2008, $10 million is requested for JGI from the Genomics: GTL Sequencing portion of the BER budget. JGI also receives funding from external sources. In fiscal year 2006, JGI received $2.9 million for sequencing from "work for others"; about $1.3 million of which was from the intelligence community and the rest from a variety of other sources.

CLIMATE RESEARCH

Question. Dr. Orbach, the Department has requested $138 million to support Climate Change Research. It is my understanding that this supports DOE's role in the Administration's multi agency Climate Change Research Initiative. It appears from budget documents, the Department has primary responsibility for carbon cycle science and climate impacts.

Can you please explain the administration's research priorities and how the Department supports those efforts?

Answer. The administration's Climate Change Research Initiative (CCRI) is a set of cross-agency activities in areas of high priority climate change research where substantial progress is anticipated over the next 2 to 4 years. The specific focus areas include: climate forcing (atmospheric concentrations of greenhouse gases and aerosols); climate observations, climate feedbacks, and sensitivity; climate modeling, including enabling research; regional impacts of climate change, including environment-society interactions; and climate observations.

In fiscal year 2008, the Biological and Environmental Research (BER) program will continue to participate in specific research areas of the CCRI. These areas include climate forcing, climate modeling, and climate change observation. Climate forcing, which includes modeling carbon sources and sinks, especially those in North America and quantifying the magnitude and location of the North American carbon sink, is a high priority need identified in the interagency Carbon Cycle Science Plan. In climate modeling, DOE's contribution to the CCRI will continue to involve the production of future potential climate scenarios for use in assessing the environmental implications of different future possible climate states. In the climate observations area of the CCRI, the DOE Atmospheric Radiation Measurement (ARM) program mobile facility will be deployed to a location where data are needed to fill gaps in understanding key atmospheric properties and processes, and their effect on the Earth's radiation balance and climate. The Integrated Assessment Research contribution to the CCRI will continue to be the development of tools for use in assessing the costs and benefits of human-induced climate change, including those associated with different policy options for mitigating such change. The requested BER budget to support these specific CCRI activities in fiscal year 2008 is $23.7 million. The remainder of BER's $138 million climate change research request supports research in the long-standing U.S. Global Change Research Program (USGCRP) and climate change mitigation research.

Question. Does the Office of Science support climate research modeling to determine what effect climate change may have on regional rainfall patterns? What does the DOE research tell us?

Answer. The BER climate modeling program supports the development and testing of coupled ocean-atmosphere-land surface climate models. Those models are used to project climatic change based on specified atmospheric greenhouse gas concentrations. Those model runs are performed at horizontal grid cell resolution of about 150 kilometers (or about 90 miles). There are systematic biases in the precipitation patterns in these model runs, particularly in the tropics due to processes like convection that are apparently not being represented accurately in the atmospheric component of the model. Researchers are working in a concerted way to address these systematic biases. Such biases notwithstanding, results such as earlier spring snowmelt over large parts of the Southwestern United States and a northward shift of storm-tracks are fairly robust results in the climate change projections so far.

CARBON SEQUESTRATION

Question. The Department plays a large role in supporting carbon research, including the possibility for long term sequestration within the Climate Change Research program.

What is your opinion of the technological potential for this country to safely sequester large amounts of carbon?

Answer. Carbon capture and storage technologies through geological storage and terrestrial sequestration provide options for reducing greenhouse gas emissions. Successful research, development, and demonstration are expected to result in widespread, safe deployment of these technologies.

Question. How long do you believe it will be before we will be able to utilize large scale carbon sequestration in this country?

Answer. Although several commercial-scale projects currently operate outside the United States, we believe it will be several years before the United States will be able to utilize large-scale carbon sequestration. Sufficient scientific understanding currently exists to support planned large-scale demonstrations of carbon sequestration in depleted oil and gas reservoirs. Only after these demonstrations are conducted, however, will there be sufficient understanding of the long-term stability and environmental impacts of geological storage of carbon dioxide in these reservoirs to proceed on a large scale. Knowledge about deep saline aquifers is far less extensive, and many substantial issues must be addressed through research and demonstration before we could consider permitting the injection of carbon dioxide into saline aquifers at a commercial scale.

Question. What does the scientific data indicate about our domestic capacity to store CO_2?

Answer. Scientific data indicate that the United States has a large number of geological formations amenable to storage of large quantities of carbon dioxide—e.g., oil and gas reservoirs, unminable coal seams, and deep saline reservoirs. Current estimates indicate that hundreds of years of total domestic carbon dioxide emissions could be stored in such formations. In a recent Department study led by the National Energy Technology Laboratory (NETL)—"Carbon Sequestration Atlas of the United States and Canada"—the DOE Regional Carbon Sequestration Partnerships identified over 3.5 trillion tons of possible carbon dioxide storage capacity in the U.S. and Canada. Again, greater scientific understanding and demonstration of feasibility are needed before use of such storage capacity on a commercial scale can be safely implemented. There is also significant potential for terrestrial carbon sequestration in soils and plants, which is an ongoing area of research for the Office of Science as well as other Federal agencies.

OFFICE OF SCIENCE—ENERGY-WATER PROGRAM

Question. The Energy Policy Act of 2007 included in section 979 an authority for the Office of Science to pursue research, development, demonstration, and commercial applications to address issues associated with the management and efficient use of water in the production of energy. As you are well aware, water plays a big role in the production of electricity, and the development of technologies to minimize water usage will be critical in areas facing drought conditions.

Unfortunately, the budget request doesn't provide any funding to support this important activity.

Can you tell me what if anything the Department is doing to carry out the direction in section 979?

Answer. The Department is undertaking activities responsive to section 979. For example, Science (SC), Energy Efficiency and Renewable Energy (EERE), and Environmental Management staff are working together to track existing DOE-wide research, development, and demonstration projects relevant to water needs in energy production. SC and EERE representatives participate in the National Science and Technology Council's Water Availability and Quality Subcommittee. SC and EERE representatives are working with the national laboratories to develop a broad-based understanding of technology and development needs that could improve water efficiency for energy production. Lastly, the Department is in the process of preparing a report to Congress responsive to section 979(f).

BIOLOGICAL AND ENVIRONMENTAL RESEARCH FUNDING

Question. I understand there has been discussions about changing the funding model for the Office of Biological and Environmental Research to adopt a block funding model that would send the bulk of research funding to a single "core lab." I believe this would discourage competition among labs to come up with creative research and discourage the development of broad multidisciplinary approach at each lab.

Is the Department considering changing the BER program to a block funding model?

Answer. BER will transition its research and technology development portfolio at the national laboratories into one with three key thrusts. First, BER will maintain its use of and reliance on rigorous merit-review for research selection. Second, it will focus on support of team-based research efforts. Third, it will fund a portfolio of laboratory research focused on one or more BER Scientific Focus Areas. There is no plan to support a Scientific Focus Area exclusively at a single "core" national laboratory. The purpose of this new funding strategy is to better align BER's approach with that used by the other major DOE Office of Science programs.

Question. Would this approach impede the other DOE labs from promoting relevant new ideas and quickly responding to emerging national problems when a single lab has been designated for funding as the lead lab?

Answer. Impeding competition is contrary to the principles in the Administration's R&D Investment Criteria, and any new approach should encourage, not impede, competition.

JOINT DARK ENERGY MISSION

Question. Over the past few years, this committee has consistently demonstrated its strong support for the Joint Dark Energy Mission. However, other priorities in the Office of Sciences 20 Year Facilities Plan are moving forward, even some ranked lower than the Joint Dark Energy Mission (JDEM). This program seems to be stuck and moving nowhere—especially in light of the Department's budget priorities.

I am specifically concerned that the Administration's fiscal year 2008 request for JDEM will hinder the Department's capacity to move forward aggressively either in partnership with NASA or as a single agency mission in 2008.

Unfortunately, this budget reduction may also discourage international collaborations interested in a near term launch.

What do you and the Office of Science plan to do in the remainder of 2007 and in 2008 to get JDEM moving? What can Congress do to help you ensure that JDEM doesn't become a missed opportunity?

Answer. The DOE fiscal year 2007 appropriation and the President's fiscal year 2008 budget request have allocated resources for continuing the dark energy program, including funding R&D for the SuperNova/Acceleration Probe (SNAP), a concept for JDEM. In addition, there is funding for mid-term or longer-term ground- or space-based dark energy R&D of approximately $3 million in fiscal year 2007 and $5.8 million requested for fiscal year 2008. This research will be competitively selected.

In fall 2006, DOE and NASA began jointly funding a National Research Council (NRC) study, to be completed by September 2007, to advise NASA on which of the 5 proposed NASA Beyond Einstein missions, including JDEM, should be developed and launched first. If the recommended top priority by the NRC study is JDEM, DOE and NASA could request to proceed jointly on this mission, leading to construction and launch during the next decade.

In response to a Congressional directive for DOE to begin planning for a single-agency dark energy mission and explore other launch options, DOE has been investigating a scenario of participation with international partners, in particular France and Russia.

There are also other international efforts towards a space-based dark energy mission. CNES is supporting an equivalent amount of R&D towards DUNE, a French dark energy concept. The European Space Agency (ESA) has recently completed a feasibility study for a dark energy mission and is planning to have a competition and decision in 2009 for its next mission.

DOE and CNES officials have discussed a possible partnership and have agreed to work together until fall 2007 to document possible cooperation on the SNAP mission. Whether CNES will eventually participate in SNAP, DUNE, or other missions depends on the results of the NRC study and other policy considerations. DOE officials have also discussed possible Russian collaboration with the Federal Agency for Science and Innovations of the Russian Federation. The Department's path forward will be determined following the results of the NRC study and we continue to support dark energy R&D.

CLIMATE MODELING

Question. The DOE plays a leadership role in the Nation's Climate Change Science Program that includes self-consistent modeling of the world's atmosphere, land, and oceans. For more than 20 years, Los Alamos National Laboratory scientist [sic] have utilized their substantial know-how and computational facilities to develop the best ocean and sea ice models, and have applied them to the coupled earth system models. This is a strong successful collaboration among the best and brightest from almost every national laboratory. What is the Office of Science program strategy for modeling and remote sensing in response to recent observations of the Greenland ice melt? Isn't there a sense of urgency to produce even more accurate sea ice predictions as Arctic ice thins, and also to build a model of Greenland glacial melting?

Answer. The BER strategy is to continue its support for the leading-edge coupled ocean-sea ice modeling (COSIM) group at LANL as part of BER's broader climate change research subprogram. DOE researchers examined Arctic sea-ice under various emission scenarios for the IPCC Fourth Assessment Report using the Community Climate System Model. Because Arctic sea-ice is already in the ocean, its melting does not directly affect sea level, though it does affect navigability of the northern ocean. Researchers at LANL are currently examining the Greenland ice melt using an interactive ice-sheet model coupled to the other components of the climate model: land surface, sea-ice, and atmosphere. Ice-sheet models need to resolve fast-flow features such as ice streams, subglacial process physics, and marine processes, and also to include stress coupling. Thus, the challenge to get all these extremely complex processes well-represented in the models is immense. For glacial melt, the increased lubrication of glacier beds by increased summer melt water that drains down crevasses and moulins to the beds needs to be represented in the land-ice models. DOE does not carry out remote sensing, but we do use the results of remote sensing supported by other Federal agencies to evaluate or test the results of our modeling activities.

COMPUTER QUESTIONS

Question. These big parallel supercomputers have always been very difficult to program and the knowledge to do so is only understood by specialists that exist in our Nation's National Laboratories and Universities. Now that computer manufacturers have started to produce multi-core processors, the technology needed for advancement in scientific understanding has become even more complicated and inaccessible.

Can you describe the complete DOE investment strategy in this area, and speak specifically to how these investments go beyond simply supporting procurement of large hardware and represent tangible investments in the specialized scientists needed to make these machines available to the country?

Answer. As a partner in the President's American Competitiveness Initiative, we are committed to keeping the United States at the forefront of High Performance Computing (HPC) and the computational sciences. In addition to acquiring large high performance computing resources that will generate millions of gigabytes per year of data, ESnet has entered into a long term partnership with Internet 2 to build the next generation optical network infrastructure needed for U.S. science. Further, SC will redirect a portion of its computer science and research portfolio to address major obstacles that would constrain the ability of a broad range of computational scientists to use petascale computers effectively in areas important to DOE's missions. Within our Applied Mathematics research program, for example, we are conducting a petascale data workshop to identify the next-generation mathematical techniques that will enable scientists to extract the scientific phenomena buried in massive complex data sets.

Through our Scientific Discovery through Advanced Computing (SciDAC) program, applied mathematicians, computer scientists, and computational scientists are working in teams to create the comprehensive, scientific computing software infrastructure needed to enable scientific discovery in the physical, biological, and environmental sciences at the petascale and to develop efficient and scalable data management and knowledge discovery tools for large data sets. In 2006, we re-competed SciDAC (SciDAC–2) and introduced the concept of SciDAC Institutes to increase the presence of the program in the academic community and to complement the efforts of the SciDAC Centers. Our SciDAC Institutes will infuse new ideas and community focus into the SciDAC program, as well as provide students with valuable computational science experiences. In addition to SciDAC Institutes, SciDAC–2 expanded the original program by collaborating with the NNSA and the National Science Foundation as new funding partners.

Finally, SC and NNSA will continue the successful Computational Science Graduate Fellowship to develop the next generation of computational science leaders.

Question. There is a trend toward managing and extracting actionable knowledge from very large amounts of data. This trend has grown faster than traditional scientific simulation and has immediate importance in national security matters.

How do you plan to ensure that your investment strategy is applicable to these new trends?

Answer. Using the NSTC High-End Computing Revitalization Task Force report as our roadmap, we are undertaking a broad investment strategy for the deployment and utilization of new HPC resources. Our Leadership Computing Facilities provide architectural diversity so that researchers have the resources they need to tackle challenging scientific questions. The first petascale computer resource for open science will be operating at the Leadership Computing Facility (LCF) at Oak Ridge National Laboratory in late 2008. Additionally, the HPC resources at NERSC have undergone a significant upgrade so that they can continue to meet SC mission-critical needs and help prepare our researchers to make optimum use of the Oak Ridge LCF, as well as the LCF at Argonne National Laboratory. Because access to capability computing is so important to our national competitiveness, we have made the HPC resources at the LCF available to the open scientific community across Federal agencies and national laboratories, in universities, and in industry, through the Innovative and Novel Computational Impact on Theory and Experiment (INCITE) program.

We are coupling our investment in hardware with a corresponding investment in our base computer science and applied mathematics research programs to develop system software and tools as well as new algorithms for analysis of multi-scale and complex data. Through our SciDAC Outreach Center we are disseminating SciDAC accomplishments to the broader HPC community.

Within DOE, NNSA and SC have entered a research and development contract with IBM to develop the next generation of Blue Gene-based products. Oak Ridge is working with Sandia National Laboratories and Cray to develop a quad-core version of the Catamount operating system. Although the two programs are managed differently because of the NNSA's requirements for classified data, SC and NNSA will continue and grow our close collaboration in high performance computing research and testbeds.

Within the broader community, we closely coordinate our activities with other Federal agencies through the Networking and Information Technology Research and Development (NITRD) subcommittee of the National Science and Technology Council (NSTC). Lastly, both SC and NNSA are formal mission partners in Phase III of the DARPA High Productivity Computing Systems (HPCS) research program. Phase III of the HPCS program is focused on the generation of HPC systems that will be available from Cray and IBM in the 2011 timeframe.

Question. DOE has two major programs in computational sciences: the Office of Science program and the NNSA ASC program. These two programs seem to be managed very differently, and I am struck by the lack of synergy between them. Further, NSF and DARPA are pushing their own computer initiatives.

Why isn't the DOE maintaining its leadership for the country in terms of a national investment strategy for technology and scientific investment for computing, computational sciences, and computer sciences for the future?

Answer. DOE continues to maintain a leadership role in computational science and high end computing systems for open science. The first petascale computer resource for open science will be operating at the Leadership Computing Facility at Oak Ridge National Laboratory in late 2008. Within SciDAC we created a powerful, integrated research environment for advancing scientific understanding through modeling and simulation. NSF and NNSA have joined SC as funding partners for SciDAC–2. Through the INCITE program, we are making 80 percent of the leadership computing facilities available to the open science community through a peer-reviewed process.

Question. It appears that there is very little mission coordination among the various agencies in order to sustain a long term R&D program that goes beyond the purchase of a faster computer.

How are you going to bring these various pieces together?

Answer. Through the American Competitiveness Initiative, we will continue to work with our partners within DOE and NITRD on a national roadmap for the future. In addition, the Office of Science has focused partnerships with the mission agencies including NNSA, NSA, DOD, and DARPA.

SUPERCONDUCTIVITY

Question. Given the fundamental science challenges inherent in superconductivity and recent successes in technology demonstration projects using second generation coated conductors, what is the Office of Science investment strategy for seizing basic and applied research opportunities in this area?

Answer. In May, 2006, SC's Office of Basic Energy Sciences sponsored a workshop entitled Basic Research Needs for Superconductivity. The workshop identified seven "priority research directions" and two "crosscutting research directions" that capture the promise of revolutionary advances in superconductivity science and technology. The first seven directions set a course for research in superconductivity that will exploit the opportunities uncovered by the workshop panels in materials, phenomena, theory, and applications. These research directions extend the reach of superconductivity to higher transition temperatures and higher current-carrying capabilities, create new families of superconducting materials with novel nanoscale structures, establish fundamental principles for understanding the rich variety of superconducting behavior within a single framework, and develop tools and materials that enable new superconducting technology for the electric power grid that will dramatically improve its capacity, reliability, and efficiency for the coming century. The seven priority research directions identified by the workshop take full advantage of the rapid advances in nanoscale science and technology of the last 5 years. Superconductivity is ultimately a nanoscale phenomenon. Its two composite building blocks—Cooper pairs mediating the superconducting state and vortices mediating its current-carrying ability—have dimensions ranging from a tenth of a nanometer to a hundred nanometers. Their nanoscale interactions among themselves and with structures of comparable size determine all of their superconducting properties.

The workshop participants found that superconducting technology for wires, power control, and power conversion had already passed the design and demonstration stages. Second generation (2G) wires have advanced rapidly; their current-carrying ability has increased by a factor of 10, and their usable length has increased to 300 meters, compared with only a few centimeters five years ago. However, while 2G superconducting wires now considerably outperform copper wires in their capacity for and efficiency in transporting current, significant gaps in their performance improvements remain. The fundamental factors that limit the current-carrying performance of 2G wires in magnetic fields must be understood and overcome to produce a five- to tenfold increase in their performance rating.

SUBCOMMITTEE RECESS

Senator DORGAN. We thank you very much for coming here today and thank you for your work.

This hearing's recessed.

[Whereupon, at 2:54 p.m., Wednesday, March 21, the subcommittee was recessed, to reconvene subject to the call of the Chair.]