Science

Proposed Appropriation Language

For expenses of the Department of Energy activities including the purchase, construction and acquisition of plant and capital equipment and other expenses necessary for science activities in carrying out the purposes of the Department of Energy Organization Act (42 U.S.C. 7101 et seq.), including the acquisition or condemnation of any real property or facility or for plant or facility acquisition, construction, or expansion, and purchase of not to exceed [5] *6* passenger motor vehicles for replacement only, [$2,682,860,000] *$2,835,393,000*, to remain available until expended[: *Provided*, That $7,600,000 of the unobligated balances originally available for Superconducting Super Collider termination activities shall be made available for other activities under this heading]. *(Energy and Water Development Appropriations Act, 1999.)*

[An additional amount of $15,000,000, to remain available until expended, for Department of Energy—Energy Programs, “Science”, is hereby appropriated.] *(Omnibus Consolidated and Emergency Supplemental Appropriations Act, 1999, Public Law 105-277, Division A, Section 109.)*

Office of Science

Executive Budget Summary

The Office of Science (SC) requests $2,844 Million for Fiscal Year 2000, an increase of $138M over FY 1999, to invest in thousands of individual research projects at hundreds of research facilities across the U.S., primarily in our national laboratories and research universities. The FY 2000 request will allow for continued construction of the Spallation Neutron Source, the first world class neutron source built by the U.S. in over 30 years; a new Scientific Simulation Initiative that will revolutionize our ability to solve scientific problems of extraordinary complexity and enable us to apply these new resources toward advancing DOE missions; participation in the Next Generation Internet effort with a focus on R&D and implementation of the technologies and tools that help meet mission requirements and contribute to the Scientific Simulation Initiative.

A History of Success:

Past successes from the SC research program and scientific user facilities have produced a rich history of contributions to science and society.

- Supported the work of 66 Nobel Laureates, from Enrico Fermi and E.O. Lawrence to Richard Smalley and Paul Boyer.
- SC's High Energy Physics program Supported *Science Magazine's* "1998 Breakthrough of the Year - *The Accelerating Universe*"

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- Developed the original prototype for positron emission tomography (PET) and the most widely used radio-pharmaceuticals used in nuclear medicine, provided the knowledge base for the nation's, and world's, radiation exposure standards, established the first Human Genome Program and the first global climate change research program.
- Advanced our understanding of the subatomic world and the fundamental forces and particles of nature through forefront research and research facilities, including the world's first super-conducting accelerator. These facilities offer a window into the most elusive particles and interactions at the very heart of matter illuminating the origin of the universe.
- Building on the advances of accelerator physics, synchrotron light sources were first conceived, constructed and utilized by SC scientists for research that enabled the discovery of new materials, advanced chip technologies, and breakthroughs in structural biology.
- Provided the first scientific investigation of multi-megawatts of fusion power produced in laboratory plasmas.

A Notable Change:

During FY 1999 budget deliberations, in recognition of more than 50 years of contributions to science and basic research, Congress changed the name of the Office of Energy Research to the Office of Science. With the FY 2000 budget request, we begin a new era as the Office of Science and, looking ahead to the challenges and opportunities of the twenty-first century, we are building a new SC strategic plan for the future research needs of the Department.

Our Mission Hasn't Changed:

Our mission remains to: produce the scientific and technical knowledge needed to develop energy technology options; understand the health and environmental implications of energy production and use; maintain U.S. leadership in understanding the fundamental nature of energy and matter; provide and operate the large-scale facilities required in the natural sciences; ensure U.S. leadership in the search for scientific knowledge; and support the availability of scientific talent for the next generation.

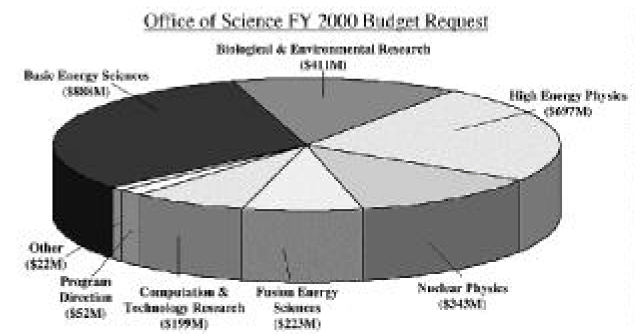

Figure 1

The FY 2000 budget request, depicted in Figure 1 and Table 1, has a program structure, that meets our mission consistent with Department goals and strategies. The major programs of the Office of Science are: High Energy and Nuclear Physics, Basic Energy Sciences, Biological and Environmental Research, Computational and Technology Research, and Fusion Energy Sciences.

The Department of Energy is a science agency because its mission and goals require technologies and scientific knowledge far beyond that which is currently available. From safeguarding the nuclear stockpile to ensuring our nation's energy supply for the next century, DOE continues to challenge the frontiers of science and technology.

The DOE Strategic Plan outlines the vision, goals and strategic objectives that will, through leadership in science and technology, help the DOE to meet those challenges. In keeping with the Government Performance and Results Act (GPRA), the Office of Science FY 2000 budget request includes program specific goals, strategies, and measures that focus our research activities and ensure continuity with Departmental plans and national goals.

Rethinking Our Goals and Strategies:

In the past year, the Department has begun to characterize the whole of our R&D efforts across business lines. The purpose and scope of this effort are to extend the work of the new SC strategic plan in terms of the R&D investments that enable us to meet our objectives and goals, and to assemble key information for improving our analysis and management of these investments.

The Office of Science's basic research supports and enables the R&D of the other business lines. A Science Portfolio has been developed with this fact in mind so as to clarify and improve integration of our program results throughout the Department. This Portfolio accompanies the release of the FY 2000 budget request.

As the Department builds R&D portfolios for its other business lines, the Office of Science will continue to integrate basic research with the applied R&D in the other business lines' portfolios so that there are strong linkages between technology needs and science.

The revised Strategic Plan of the Office of Science, to be published in Spring 1999, will articulate the long-range vision, goals, strategies, and objectives for our programs. The Science Portfolio complements and supports the strategic plan by providing a near-term "snapshot" of our investments against the new strategic framework.

The motivations behind this planning effort are to develop a shared long-term focus for SC programs, their scientific communities and performers; to position our future scientific program content to better serve the other DOE business lines and provide a framework for cooperation and risk taking; to project future possibilities and directions for our programs based on the latest technologies and scientific advances; to better illustrate the unique and coordinated role of SC programs within the DOE mission and the federal science investment; to inspire our researchers and to better communicate our program content and successes to our sponsors and the general public.

The new SC strategic plan, and supporting Science Portfolio, is structured around five high-level goals with twelve strategic objectives, listed in Figure 2. These goals were developed through a series of planning activities and workshops that drew on the experience and knowledge of our research scientists and stakeholders to capture both what is necessary and what is possible for our science as we look to the next century.

The first goal, **Fueling the Future**, is centered on science for affordable and clean energy options for the future. Some of the questions that motivate this goal are: *How can we tap and harness affordable, clean fuels? What clean new electric power systems will fuel the future?* and *How can energy systems be made more efficient and environmentally sound?* Development of this goal has been closely connected with the development of the Energy R&D portfolio and the objectives directly map onto the energy portfolio.

The second goal, **Protecting our Living Planet**, is centered on understanding energy impacts on people and the biosphere. Some of the questions that motivate this theme are: *What are the sources and fate of energy-related by-products? What factors affect global climate and how can they be controlled?* and *How do complex biological and environmental systems respond to our energy use?* This goal also contributes to both the Energy R&D portfolio and the Environmental R&D portfolio.

- **Fueling the Future**
  - **New Fuels**
  - **Clean and Affordable Power**
  - **Efficient Energy Use**
- **Protecting Our Living Planet**
  - **Sources and Fate of Energy By-Products**
  - **Impacts on People and the Environment**
  - **Prevention and Protection**
- **Exploring Energy and Matter**
  - **Components of Matter**
  - **Origin and Fate of the Universe**
  - **Complex Systems**
- **Extraordinary Tools for Extraordinary Science**
  - **Instrumentation for the Frontiers of Science**
  - **Scientific Simulation**
  - **Institutional Capacity**
- **Enabling World Class Science**

Figure 2

The third goal, **Exploring Energy and Matter**, is centered on discovering the building blocks of atoms and life. Some of the questions that motivate this theme are: *What are the fundamental components of matter? How can the origin and fate of the Universe reveal the secrets of energy, matter and life?* and *How do atoms and molecules combine to form complex dynamic systems?* This goal captures the most fundamental research in the Office of Science. The complex systems question links to R&D efforts in all of the DOE business lines.

The fourth goal, **Extraordinary Tools for Extraordinary Science**, is centered on the national assets that DOE provides for forefront, multidisciplinary research. This goal builds on the unique role of the Office of Science in providing the nation with forefront research facilities such as the National Laboratories, and an array of research accelerators, reactors and other unique facilities. The Office of Science will continue to ensure that these critical research tools remain accessible to peer reviewed researchers from all across the nation and meet the technical challenges of forefront scientific investigation. This goal looks to the future and to training and educating the next generation of scientists and engineers.

Some of the questions that motivate this goal are: *How can we explore the frontiers of the natural sciences? How can we predict the behavior of complex systems?* and *How can we strengthen the nation's capacity for multidisciplinary science?* This goal enables research in all of the DOE business lines. By organizing future facilities needs, as identified by the scientific community, this theme ensures that America's research capability will remain both accessible and state of the art.

The fifth goal, **Enabling World Class Science**, conveys the commitment of DOE and National Laboratory staff to continuously improve their operational processes. Of paramount importance is the selection and conduct of excellent, productive science that is carried out safely and with care for the environment and involvement of local communities.

Implementing the New Strategies - Initiatives for FY 2000:

These five goals provide a framework for current programs and a platform for future efforts. FY 2000 initiatives and priorities are detailed below. Figure 3 lists these initiatives and identifies linkages to the SC goals.

Scientific Simulation Initiative - It is now possible to obtain computational capabilities 100 times faster than currently in common use through the application of technologies developed for the Accelerated Strategic Computing Initiative (ASCI). Therefore the Department of Energy, in coordination with the National Science Foundation and other federal science programs, has developed a Scientific Simulation Initiative

	Fuel the Future	Protect Our Living Planet	Explore Energy & Matter	Extraordinary Tools for Extraordinary Science
Scientific Simulation Initiative	✓	✓	✓	✓
Spallation Neutron Source	✓			✓
Large Hadron Collider			✓	✓
Scientific User Facilities	✓	✓	✓	✓
Next Generation Internet				✓
Climate Change Technology Initiative	✓	✓		
Genome	✓	✓	✓	✓

Figure 3

(SSI) in support of the President's Information Technology Initiative. The mission of the SSI is to further develop and employ the emerging generation of very high performance computers as major tools for scientific inquiry. These resources will revolutionize our approach to solving complex problems in *energy, environment, and fundamental research* and will stimulate our national system of innovation.

Portions of the program will be directed by a joint SC/Defense Programs ASCI research management committee. Within the Office of Science, the SSI will be an integrated effort with the Computational and Technology Research (CTR) program coordinating and overseeing competitive, peer reviewed selections of sites and applications. CTR, with Basic Energy Sciences (BES) and Biological and Environmental Research (BER), will manage the basic research applications.

Combustion - Currently, eighty-five percent of U.S. energy use is derived from the combustion of fossil fuels and this dependence on combustion is not likely to change in the coming decades. Combustion remains one of the primary causes of lowered air quality in urban environments. At present, engineers have neither sufficient knowledge nor the computational tools to understand and predict the chemical outcome of combustion processes with any degree of practical reliability. Existing models that guide the design process are of very limited usefulness because of the extraordinary complexity of the combustion process. With very high end computing resources and a concerted research program in combustion modeling, we can develop the next generation of combustion modeling tools for accelerated design of combustion devices meeting national goals of emission reduction and energy conservation.

Global Systems -Unlike many disciplinary areas of research, the complex workings of the global environmental system cannot be studied in a laboratory setting. The integration of knowledge from the many disciplines that together describe the global system can only be performed in computer simulation models. It is only through such general circulation models that it is possible to understand current climate and climate variability and to predict future climate and climate variability, including prediction of the possible effects of human activities on the global system. Advances in scientific understanding are therefore predicated upon the successful development of modeling tools to keep pace with the rapid advances in the quality and quantity of data available. These tools will lead to the development of detailed fully coupled global system models that accurately reproduce, and ultimately predict, the behavior of the interacting components of the system, i.e. the global atmosphere, the world ocean, the terrestrial land surface and both glacial and sea ice.

Fundamental Research - Whereas the scientific accomplishments of this century have resulted in seeking and understanding the fundamental laws that govern our physical universe, the science of the coming century will be characterized by synthesis of this knowledge into predictive capabilities for understanding and solving a wide range of scientific problems, many with practical consequences. In this endeavor, the computer will be a primary instrument of scientific discovery. Many areas of scientific inquiry, critical to the department's mission, will be advanced dramatically with access to high-end computation - including, but not limited to, materials sciences, structural genomics, high energy and nuclear physics, subsurface flow, and fusion energy research.

The **Spallation Neutron Source** (SNS) - The importance of neutron science for fundamental discoveries and technological development has been enumerated in all of the major materials science studies over the past two decades, including a major study by the National Research Council entitled “Major Facilities for Materials Research and Related Disciplines” (Seitz-Eastman Report)

As the needs of our high-technology society have changed, so has the way in which we conduct the R&D that helps us to meet those needs. It has become increasingly important to develop new materials that perform under severe conditions and yet are stronger, lighter, and cheaper. Major research facilities are used to understand and “engineer” materials at the atomic level so that they have improved macroscopic properties and perform better in new, demanding applications.

The SNS is a next-generation facility for these types of applications. Neutron scattering will play a major role in all forms of materials design and understanding. This research will lead to the development of advances such as: smaller and faster electronic devices; lightweight alloys, plastics and polymers for transportation and other applications; magnetic materials for more efficient motors and for improved magnetic storage capacity; improved understanding of form and function in biological structures and the development of new drugs for medical care.

Upon completion, the SNS will be the world's most powerful neutron source, accommodating more than 1,000 researchers and 30 to 40 special purpose instruments.

The SNS Total Project Cost (TPC) is estimated to be $1,360 million over a 7.25-year schedule. The original TPC of $1,333 million (7-year schedule) was independently validated to within 1%. Throughout the life of the project, semi-annual reviews will track cost and management. FY 1999 funding provided for the start of Title I design activities, initiation of subcontracts and long-lead procurement, and continued R&D to reduce technical and schedule risks. FY 2000 funding of $214M will support Title II (detailed) design for the technical components and control systems. Construction will begin in FY 2000 on some of the conventional facilities as will the procurement of key technical equipment.

The SNS project is an example of DOE's commitment to use the DOE laboratories as a system. Under DOE leadership, Oak Ridge National Laboratory is responsible for the project with participation from Lawrence Berkeley National Laboratory, Los Alamos National Laboratory, Brookhaven National Laboratory, and Argonne National Laboratory. The laboratories have been working together most effectively and R&D is proceeding smoothly.

Scientific Facilities Utilization - This FY 2000 budget request continues to strongly support Scientific Facilities Utilization in the following programs: Basic Energy Sciences, High Energy Physics, Nuclear Physics, Fusion Energy Sciences, Biological and Environmental Research, and Computational and Technology Research. Each year, over 15,000 university, industry, and government sponsored scientists conduct cutting edge experiments at these particle accelerators, high-flux neutron sources, synchrotron radiation light sources, and other specialized facilities, such as the Combustion Research Facility (CRF) at Sandia National Laboratories, Livermore, California. The CRF is an internationally recognized facility for the study of combustion science and technology, which will begin its first year of operation after its Phase II development project.

The user community continues to be pleased with the results of the Science Facilities Initiative as evidenced by their many letters of support and by the positive results of surveys conducted at the facilities

The **Large Hadron Collider** - The foremost high energy physics research facility of the next decade will be the Large Hadron Collider (LHC) at CERN, the European Center for Particle Physics. The primary physics goals of the LHC will impact our understanding of the relation of mass, fundamental forces, and the structure and origin of the universe. U.S. participation in the LHC is required to provide U.S. access to the high energy frontier in order to maintain the U.S. as a world leader in this fundamental area of science.

The LHC is an outstanding example of international cooperation in large scientific projects, as well as interagency and inter-laboratory cooperation. An International Cooperation Agreement has been negotiated between CERN, DOE and NSF. The Agreement provides for U.S. participation in the construction of the accelerator, and of the two very large detectors, ATLAS and CMS. Carefully defined lists of deliverables and costs have been agreed upon for each of these areas of participation. U.S. costs are capped at $531M ($450M DOE and $81M NSF), consistent with Congressional guidance. In return, participating U.S. universities and laboratories will join, as full partners, in LHC experiments. In addition, a Memorandum of Understanding (MOU) has been executed between DOE and NSF that defines the relationship between the agencies relative to programmatic coordination of U.S. LHC activities include joint oversight and execution of the U.S. LHC Construction Program.

Under the terms of this MOU, Fermilab is the Lead Laboratory for the accelerator portion of the program, which it will execute in cooperation with Brookhaven (BNL) and Lawrence Berkeley (LBNL) National Laboratories. BNL is the host laboratory for the ATLAS portion of the program, which also involves Argonne National Laboratory (ANL) and LBNL along with 28 university groups. Similarly, Fermilab is the host laboratory for the CMS detector portion of the program, including BNL and Los Alamos National Laboratory (LANL) along with 33 university groups. Cost and schedule baselines have been reviewed and validated for each of the three programs and management systems are in place to monitor progress against baselines.

The **Next Generation Internet** (NGI) - The program is creating the foundation for more powerful and versatile networks of the 21st century, just as previous federal investments in information technology R&D created the foundation for today's Internet. This program is critical to DOE's science and technology missions because enhancements to today's Internet from commercial R&D will not be sufficient to enable effective use of: petabyte/year High Energy and Nuclear Physics facilities such as the Relativistic Heavy Ion Collider (RHIC); to provide remote visualization of terabyte to petabye data sets from computational simulation; to develop advanced collaboratories; and to enable effective remote access to tomorrow's advanced scientific computers.

For example, typical RHIC experimental collaborations involve thousands of scientists at hundreds of institutions across the country and the world. Using the current Internet, it would take about 2,500 hours to transmit one day's data from RHIC to one remote site for analysis. Using NGI it would take 25 hours.

Thus, DOE's NGI research program is focused on discovering, understanding, developing, testing and validating the networking technologies needed to enable wide area, data intensive and collaborative computing. The DOE applications share two important characteristics. They all involve extremely large data sets and they all require that scientists be able to interact with the data in (nearly) real time. Current network technology limitations significantly limit our ability to address these characteristics.

The DOE program includes research in advanced protocols, special operating system services for very high speed, and very advanced network control, the components needed to enable wide area, data intensive and collaborative computing. In addition the DOE program addresses issues that result from the many different kinds of network devices, network-attached devices, and services that need to be integrated together. Examples of the components and services that need to be integrated include: network resources, data archives on tape, high performance disk caches, visualization and data analysis servers, authentication and security services, and the computer on a scientist's desk. This type of integration, as well as the issues of improving the performance of the individual components, all require significant research because the issues are currently not well understood. Indeed, the first identification of many of these issues is the result of previous work in collaboratories and visualization supported by DOE.

Thus, DOE's participation in the NGI builds on previous DOE research and its over two decades of success in using advanced networks as tools for science. Furthermore, the differences between the requirements of commercial networks and networks for scientific research require DOE to conduct this research because these tools and technologies will not be developed by commercial R&D. However, the results and "spinoffs" of this research, after testing and prototyping by the scientific community, will impact broad commercial use of networks. DOE's FY 2000 NGI program will build on the results of the competitive research solicitations conducted in FY 1999.

Climate Change Technology Initiative (CCTI)- Eighty-five percent of our Nation's energy results from the burning of fossil fuels, a process that adds carbon to the atmosphere. Because of the potential environmental impacts of increases in atmospheric carbon dioxide, carbon management has become an international concern and is a focus of the CCTI.

The Office of Science is well positioned to make significant contributions to the many solutions needed to address this problem. SC can build on the fundamental discoveries of core research programs in carbon and non-carbon energy sources, carbon sequestration, and carbon recycling, extending them to the new discoveries needed to make carbon management practical and efficient.

Activities in both Basic Energy Sciences and Biological and Environmental Research support the DOE and Administration CCTI efforts in: *science for efficient technologies, fundamental science underpinning advances in all low/no carbon energy sources, and sequestration science.*

The SC portion of the CCTI leverages the foundation of excellent research already underway. The additional SC effort will also have a major impact on many scientific disciplines by advancing the state of knowledge in such fields as genome science, molecular, cellular and structural biology, biochemistry, chemical dynamics, solid state chemistry, photochemistry, ecology, nano- and meso-phase materials science, condensed matter physics, engineering, theoretical chemistry and physics.

For example, the BER microbial genome program has made significant investments in the technology that enables genome sequencing at rates previously unattainable. Capitalizing on these investments, the genomes of microbes that produce methane and hydrogen from carbonaceous sources will be sequenced as part of the first awards under CCTI. This will enable identification of key genetic components of the organisms that regulate the production of these gases. The carbon sequestration research program will focus on understanding the natural terrestrial sequestration cycle and the natural oceanic sequestration cycle as part of the first awards under the CCTI. The ultimate goal is to enhance the natural carbon cycle in both the terrestrial and oceanic systems. The search for new fuel sources and carbon sequestration research are key elements of the carbon management program.

CCTI research and related activities within the Office of Science will continue to be coordinated with the Office of Fossil Energy. FY 1999 integration efforts include the coordination of new CCTI proposal solicitations and preparation of a detailed carbon dioxide sequestration roadmap.

Genome - In only its first full year of operation, the DOE Joint Genome Institute (JGI) became the second leading public producer of high quality human DNA among U.S. sequencing centers. The JGI is boldly scaling up its sequencing capacity from 21 million finished bases in FY 1998 to 30 million finished bases and 40 million high quality draft bases in FY 1999. In total, SC will complete sequencing of 50 million finished and 70 million high quality draft subunits of human DNA to submit to publicly accessible databases in FY 2000. In addition, SC will complete the full genetic sequencing of more than 10 microbes that have significant potential for waste cleanup and energy production.

Improvements in high throughput human DNA sequencing technology and sequence data management are needed to complete the first human genome by 2003 and to efficiently and cost effectively use that sequence information for future medical diagnoses and scientific discovery. The Joint Genome Institute, in which the National Laboratories work as a system, are primarily focused on high throughput sequencing. FY 2000 is the third year of a major 3-5 year scale-up in DNA sequencing capability for this virtual institute. DOE will continue to work with the private sector, where appropriate, to accelerate progress and reduce cost in the Human Genome project.

The SC program is actively involved with other federal agencies funding, human, plant and microbial research to encourage effective and efficient management of the total federal genome research portfolio.

Recent Successes of the Office of Science:

Fueling the Future:

- Identified a major error in current models of combustion process
- Provided a realistic picture of corrosion resistance to advance protection coatings
- Created electrically conducting nano-scale ropes, 50-100 times more conductive than copper

Protecting our Living Planet:

- Research on "Conan the Bacterium" (D. Radiodurans) helps in clean-up
- Two of the 1997 "11 hottest papers in biology" were for microbial genomic sequences funded by SC
- Discovered gene for kidney disease

Exploring Energy and Matter:

- Launched the Alpha Magnetic Spectrometer experiment on the Space Shuttle to explore the mysteries of missing anti-matter and dark matter
- Established the 3-D, atom-by-atom structure of the enzyme system responsible for DNA replication
- Demonstrated that the supposedly massless neutrino must, in fact, have a non-zero rest mass.

Extraordinary Tools:

- Signed the Large Hadron Collider agreement opening the frontier of high energy physics to American researchers
- New scientific research facilities on-line: the William R. Wiley Environmental Molecular Sciences Laboratory; the Jefferson Lab's Large Acceptance Spectrometer; SLAC's B-Factory, the Oak Ridge Free-Air CO_2 Enrichment Facility and the JGI Production (DNA) Sequencing Facility.
- Projects on time and budget: Fermilab's Main Injector, the Relativistic Heavy Ion Collider, the Combustion Research Facility Phase II, and the SNS.

SC Program Direction:

- Hammer award for Environmental Management Science Program
- Jointly developed the third DOE-NIH Human Genome Five Year Plan with accelerated sequencing goals
- Acknowledged as model for facilities management by the National Academy of Public Administrators (NAPA).

In addition, hundreds of principal investigators, funded by SC, win dozens of major prizes and awards sponsored by the President, the Department, the National Academy of Sciences, the National Academy of Engineering, and the major professional societies. These include the 1997 Nobel Prize for Chemistry, the 1997 Fermi and Lawrence awards, the National Science Foundation Career Award, eight of the 1998 R&D 100 awards, 1997 Discover Awards, the 1998 Federal Laboratory Consortium Award, and the 1997 and 1998 "Top Ten Contributions to Science," reported by *Science* Magazine.

Major Program Activities for FY 2000:

The **Basic Energy Sciences** (BES) program is a principal sponsor of fundamental research for the United States in the areas of materials sciences, chemical sciences, geosciences, biosciences, and engineering sciences. This research underpins the DOE missions in energy, the environment and national security; advances energy related basic science on a broad front; and provides unique national user facilities for the scientific community. Performance measurement, dominated by peer review, helps to determine the distribution of activities supported within BES and the individual projects supported within each activity. The program funds more than 2,400 researchers at 200 institutions nationwide. Program results continue to be recognized through the receipt of major prizes and awards from the scientific community.

BES also plays a major part in the FY 2000 Office of Science initiatives described above. BES is the sole supporter of the Spallation Neutron Source construction and a major contributor to the Scientific Simulation Initiative (Combustion and Fundamental Research portions), Scientific Facilities Utilization, and the Climate Change Technology Initiative.

BES plans, constructs, and operates 18 major scientific user facilities to serve over 6,000 researchers at universities, national laboratories, and industry. These facilities enable the acquisition of new knowledge that often cannot be obtained by any other means. These facilities have an enormous impact on science and technology, ranging from determinations of the structure of superconductors and biological molecules to the development of wear-resistant prostheses; from atomic-scale characterization of environmental samples to elucidation of geological processes; and from the production of unique isotopes for cancer therapy to the development of new medical imaging technologies. As part of its commitment to excellence, BES user facilities maintain a record of less than 10 percent unscheduled downtime, on average.

Facility enhancements and maintenance activities for BES in FY 2000 will be focused on the existing high-flux neutron sources, the Los Alamos Neutron Science Center at Los Alamos National Laboratory and the High Flux Isotope Reactor at Oak Ridge National Laboratory. These improvements, recommended by the Basic Energy Sciences Advisory Committee, will substantially increase the neutron flux and instrument capabilities available to the scientific community. BES is committed to keeping the development and upgrade of scientific user facilities, including the construction of the Spallation Neutron Source, on schedule and within cost, not to exceed 110 percent of estimates.

Within the base research effort, the program in Complex and Collective Phenomena, started in FY 1999, will continue to support work at the frontiers of basic research that hold the promise of delivering revolutionary breakthroughs. This effort is designed to obtain fundamental knowledge of increasingly complex systems in order to help bridge the gap in our understanding between the atomic and molecular properties and the bulk structural and mechanical properties of materials, for example. In addition, BES will continue its Partnership for Academic-Industrial Research (PAIR) program to facilitate research partnerships between academic researchers, their students, and industrial researchers.

The **Biological and Environmental Research** (BER) program in FY 2000 will focus on sequencing the human genome, microbial genome research, low dose exposure research, environmental processes research with an emphasis on global environmental change, environmental remediation research, and radiopharmaceutical research, structural biology, and molecular nuclear medicine.

Last year, *Science* magazine identified genomic sequencing as one of the top ten breakthroughs in science. BER's Microbial Genome Program supported the complete genomic sequencing of 6 of the 18 bacteria sequenced with at least 12 more in progress. Microbial genome research continues to sequence microbes relevant to DOE mission needs including work in three main areas: (1) microbial diversity, to identify potentially useful microbes, (2) new DNA sequencing strategies to rapidly and cost effectively determine the sequence of closely related microbes, and (3) novel strategies and tools for characterizing, manipulating, and modeling entire reaction pathways or gene regulatory networks. Microbes are used as models to understand more complex biology and to advance sequencing tools.

In FY 2000, human DNA sequencing continues to ramp up. The DOE Joint Genome Institute will sequence 50 million finished bases and 70 million high quality draft bases of human DNA.

Radiopharmaceutical research and molecular nuclear medicine will continue to develop more specific and sensitive radiopharmaceutical tracers and develop sensitive imaging technology that will impact clinical medicine. Positron Emission Tomography (PET) technology, developed previously in this program, will be used to elucidate complex biomedical problems such as the neurochemical basis of addictive and neurodegenerative diseases. Recent work has shown damage to the brain function in persons addicted to drugs, such as cocaine, that reinforces the craving for these drugs. The Boron Neutron Capture Therapy Program will complete Phase I trials to determine an effective and safe treatment dose and initiate a Phase II efficacy trial. BER will continue to exploit the unique capabilities of the National Laboratories in a national biomedical engineering program to develop novel medical technologies.

In FY 2000, The Atmospheric Radiation Measurement facility will begin operations of the third climate observatory in the Tropical Western Pacific on Christmas Island, thus completing the span of observatories across the Pacific warm pool. Valuable data will result for climate model development and improvement.

The Free Air Carbon Dioxide Enrichment (FACE) experiment will continue tree growth and physiological observations, including studies of ecosystem processes. FACE technologies have achieved international recognition, with FACE facilities developing in Europe and Panama. FACE has observed the effect of increased atmospheric concentrations of carbon dioxide on tree growth and physiology.

BER facilities in support of fundamental science to underpin environmental cleanup continue to have an impact. After its first full year of operation in 1998, the William R. Wiley Environmental Molecular Sciences Laboratory (EMSL) had already attracted nearly 600 outside users and collaborators from government laboratories, private industry, and academia. Interactions between EMSL and the Natural and Accelerated Bioremediation Research (NABIR) program will be strengthened, to provide unifying research facilities for academic and laboratory investigators in the fields contributing to bioremediation research.

BER also plays a major part in the FY 2000 Office of Science initiatives described above. BER is the primary supporter of SC Genome research, and a major contributor to SSI (Global Systems and Fundamental Research portions), Scientific Facilities Utilization, and the CCTI.

The **High Energy Physics** (HEP) program will continue to address new and exciting research at the forefront of particle physics.

At Fermilab, the newly upgraded D-Zero and CDF detectors will be moved into position at the Tevatron; and they, along with the newly commissioned Main Injector, will be used for the first time for antiproton-proton collisions. The Main Injector will increase the luminosity of the Tevatron by a factor of 5. Also at Fermilab, the

NuMI/ MINOS neutrino oscillation project will be well underway with construction of conventional facilities and technical components; and the Wilson Hall Safety Improvements Project will be progressing well in its second year of physical construction with completion scheduled for 2002.

SLAC's newly commissioned B-factory, a collaboration among SLAC, Lawrence Berkeley National Laboratory, and Lawrence Livermore National Laboratory, will be in its first full year of operation with its primary goal to obtain high luminosity to begin the study of CP-violation (matter-antimatter asymmetry). Also at SLAC, physical construction on a new office building for B-factory users will begin.

As planned, the Alternating Gradient Synchrotron (AGS) at Brookhaven was transferred to the Nuclear Physics program for use as an injector for RHIC. Therefore, use of the AGS for high energy physics in FY 2000 will be on an incremental cost basis. AGS runs, necessary to achieve the precision measurement of the muon g-2 anomalous magnetic moment, will continue in FY 2000.

The fabrication of components for the LHC project continues in FY 2000. Fermilab is the host and lead laboratory for the U.S. efforts on the CMS detector as well as host and lead laboratory, with the assistance of Brookhaven and Lawrence Berkeley, on the U.S. accelerator efforts. Similarly, Brookhaven is the host and lead laboratory for the U.S. efforts on the ATLAS detector.

In addition, R&D on accelerator concepts for future large accelerator facilities will continue in FY 2000. Consistent with recent HEP Advisory Panel recommendations, modest increases are planned for high energy physics university groups in FY 2000 to allow them to exploit new facilities mentioned above.

The **Nuclear Physics** (NP) program provides primary support in the U.S. for fundamental research on the structure and fundamental forces in atomic nuclei. The Program operates large and small particle accelerator facilities located at National Laboratories and Universities which provide the microscopic probes of these structures and forces. The scope of the FY 2000 Nuclear Physics Program is broadly enhanced by operation of several new facilities. The new Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory will operate for its first full year to search for the predicted quark-gluon plasma, a heretofore unseen form of nuclear matter. The new Thomas Jefferson National Accelerator Facility in Newport News, Virginia, is fully operational, and will continue an already impressive program of research into the quark basis of the structure of nuclei. The Sudbury Neutrino Observatory (SNO) in Canada will be fully operational in FY 2000 and will be accumulating important information on the apparent low rate of neutrino flux from the sun. R&D and conceptual design development for a proposed world-class radioactive ion beam facility (ISOL) for nuclear structure and astrophysics studies, will be supported in FY 2000. A smaller radioactive ion beam facility (RIB) has recently begun to operate at Oak Ridge National Laboratory, and is prototyping new radioactive beam techniques as well as doing research.

Unique low energy heavy ion facilities at ANL and LBNL, will continue to pursue important investigations of highly deformed and exotic nuclei which require examination using very high resolution spectroscopy. The new and highly successful Gammasphere detector is being utilized at both ANL and LBNL to pursue such experiments. The MIT/Bates Linear Accelerator Center, which has been a major world center for nuclear research using electron scattering for over 25 years, will end operations in FY 2000.

The **Fusion Energy Sciences** (FES) program is completing its transition from a focus on the development of fusion as a new energy supply technology to emphasizing the science that underpins fusion energy. In FY 2000, the program will continue to make progress in understanding plasma physics, identifying and exploring innovative approaches to fusion power, and exploring the science and technology of energy producing plasmas, as a partner in the international fusion research effort.

FY 2000 will begin a three year effort, supported by FES, at the Princeton Plasma Physics Laboratory (PPPL) for the decontamination and decommissioning of the Tokamak Fusion Test Reactor (TFTR).

The program continues the move toward innovation and increased understanding of a wide range of confinement concepts. The National Spherical Torus Experiment (NSTX) facility provides strong support of the goal to explore innovative and more affordable development paths. Work on concept improvement at the exploratory level in both physics and enabling technology R&D will receive more emphasis. The inertial fusion energy element will be broadened to include research efforts on systems and related elements. This change in domestic program emphasis reflects a move away from the costly, large scale devices aimed at providing integrated plasma technology experiments operating with power plant-scale plasma parameters.

The International effort to explore the science and technology of energy producing plasmas was dramatically reduced in FY 1999 by termination of U.S. participation in the International Thermonuclear Experimental Reactor (ITER) project. The U.S. will, however, continue to pursue modest scale international collaborative activities on major international scientific facilities.

Research on high temperature toroidal plasmas will be carried out using the DIII-D facility at General Atomics, C-MOD at MIT and NSTX spherical torus at PPPL which will have its first full year of operations in FY 2000. The experimental program will be supported by broadly based theoretical, modeling and computational efforts. Technology activities supporting energy-producing plasmas will be drastically reduced as part of the shift in priorities noted above, but the long range program on low activation materials will continue. The physical and intellectual infrastructure associated with the experimental portion of energy producing plasmas will need to be re-established at an appropriate time depending upon technical advances toward lower-cost systems and/or increased urgency.

As recommended by Congress, a review of the several approaches to fusion (to be conducted by the Secretary of Energy Advisory Board) was initiated in December, 1998 and will be completed in May 1999. The National Academy of Sciences is also expected to complete a review of the fusion science program in FY 1999. Recommendations from these reviews will help to set the course for future fusion research activities.

The **Computational and Technology Research** (CTR) program supports advanced computing research — applied mathematics, high performance computing, networking, and operates supercomputer and associated facilities that are available to researchers 24 hours a day, 365 days a year. The combination of support for fundamental research, computational and networking tools development, and high-performance computing facilities provides scientists with the capabilities to analyze, model, simulate, and — most importantly — predict complex phenomena of importance to the Office of Science and the Department of Energy.

The long history of CTR accomplishments continued in FY 1999 including: the 1998 Gordon Bell Prize for Best Performance of a Supercomputing Application, the 1998 IEEE Fernbach Award for outstanding contribution in the application of high performance computers using innovative approaches and four R&D 100 Awards to CTR researchers in areas ranging from parallel numerical libraries to near frictionless coatings.

Experiments at Office of Science facilities may generate millions of gigabytes (petabytes) of data per year (which would fill the disk drives of millions of today's personal computers) presenting significant computational and communications challenges in analyzing and extracting information from the data.

Some of the pioneering accomplishments of this program are: development of the technologies to enable remote, interactive access to supercomputers; research and development leading to the High Performance Parallel Interface (HiPPI) standard; and research leading to the development of the slow start algorithm for the Transmission Control Protocol (TCP), which enabled the Internet to scale to today's worldwide communications infrastructure.

CTR is responsible for DOE participation in the Next Generation Internet (NGI) program to create the foundation for more powerful and versatile networks of the 21st century.

CTR also heads the Department's Scientific Simulation Initiative (SSI) as a joint program with the other program offices in SC. CTR's role in the SSI includes management of the selection process for a small number of basic science application efforts initiated in FY 2000, management of the SSI Advanced Computing and Communications Facilities, and management of the Computer Science and Enabling Technology component.

In addition to these computing related activities CTR also manages the Laboratory Technology Research (LTR) program for the Office of Science. The mission of this program is to support high risk, energy related research that advances science and technology to enable applications that could significantly impact the Nation's energy economy. LTR fosters the production of research results motivated by a practical energy payoff through cost-shared collaborations between Office of Science laboratories and industry.

The Science **Program Direction** budget funds staff and related expenses which are necessary to provide overall management direction of the Office of Science research programs. The Office of Science will strive to meet staffing levels as outlined in its Workforce Management Plan. Work will continue on piloting the transfer of management responsibility of newly generated wastes at SC sites from Environmental Management to the Office of Science. The scientific and technological challenges of the Department's missions demand an adequate supply of scientists, engineers and technicians. For over 50 years, DOE and its predecessor agencies have supported science and engineering education programs involving university faculty as well as pre-college teachers and students. Tapping the significant human and physical resources of the DOE National Laboratories is perhaps the most distinguishing feature of the agency's contribution to science education. Within the FY 2000 request for Program Direction is SC's core program for science education, supporting such activities as: the Undergraduate Research Fellowship Program, the National Science Bowl, and Albert Einstein Distinguished Educator Fellowship. In addition, two new initiatives, developed in partnership with NSF, will be supported through the five SC scientific programs. The first initiative will be focused on providing pre-college science and math teachers with research opportunities that will improve their knowledge and skills of scientific discovery and enhance their ability to apply them in their classrooms. The second initiative will allow university faculty and undergraduate student teams to participate in long-term research projects at DOE Laboratories. Historically, over two-thirds of undergraduates who have participated in DOE programs have gone on to graduate school in disciplines directly related to DOE missions. These activities will help to fulfill SC's responsibilities in developing the next generation of scientists and engineers in a responsible and focused manner.

Effective human resource management will ensure that critical staffing needs are met in support of the strategic goals of the Department. This includes, but is not limited to, the integration of diversity considerations into all human resource management activities, and effective long-term succession planning for executives and scientific/ technical positions. Enhanced business processes that are built from our Activity Based Management activities and Strategic Information Planning will enable the staff to carry out the mission and functions of the organization effectively and efficiently.

Closing:

The significant increase in the FY 2000 budget for the Office of Science recognizes the critical role that fundamental knowledge plays in achieving the DOE missions and for the general advance of the Nation's economy and the welfare of its citizens. The Scientific Simulation Initiative represents a major investment in producing the necessary scientific computation and information infrastructure for DOE science applications as part of a multi-agency initiative. This request will also provide the U.S. scientific community with increased research capability and new opportunities at the DOE scientific user facilities, including progress on SNS, a new forefront neutron source, and upgrades of existing facilities. On behalf of the Administration and the Department, I am pleased to present this budget for the Office of Science and welcome the challenge to deliver results.

Martha Krebs
Director
Office of Science

Table 1

OFFICE OF SCIENCE
FY 2000 PRESIDENT'S BUDGET REQUEST TO CONGRESS
(B/A in thousands of dollars)

	FY 1998 Current Approp.	FY 1999 Current Approp.	FY 2000 Request
Science			
Basic Energy Sciences	651,816	799,524	888,084
Computational and Technology Research	146,779	157,471	198,875
Biological and Environmental Research	395,676	436,688	411,170
Fusion Energy Sciences	224,190	222,636	222,614
High Energy Physics	668,590	695,526	697,090
Nuclear Physics	314,738	334,555	342,940
Energy Research Analyses	1,434	1,000	1,000
Multiprogram Energy Laboratories-Facilities Supp	21,247	21,260	21,260
Science Program Direction	37,600	49,800	52,360
Small Business Innovation Research and Small Business Technology Transfer	80,730	——	——
Subtotal	2,542,800	2,718,460	2,835,393
General Reduction for Use of Prior Year Balances	-15,295	-13,000	——
Superconducting Super Collider	-35,000	-7,600	——
Total	2,492,505	2,697,860	2,835,393
Energy Supply R&D			
Technical Information Management	10,100	8,600	9,100
General Reduction for Use of Prior Year Balances	-68	-191	——
Total	10,032	8,409	9,100

Table 2

OFFICE OF SCIENCE
FY 2000 PRESIDENT'S BUDGET REQUEST TO CONGRESS
(B/A in thousands of dollars)

	FY 1998 Current Approp.	FY 1999 Current Approp.	FY 2000 Request
Global Climate Change	105,780	113,865	124,838
Climate Change Technology Initiative	——	13,500	33,000
Partnership for New Generation of Vehicles	5,000	5,000	5,000
Science and Education Programs	——	4,500	14,235
Strategic Simulation Initiative	——	——	70,000

Table 3

OFFICE OF SCIENCE
FY 2000 PRESIDENT'S BUDGET REQUEST TO CONGRESS
(B/A in thousands of dollars)

Major Site Funding	FY 1998 Current Approp.	FY 1999 Current Approp.	FY 2000 Request
AMES LABORATORY			
Basic Energy Sciences	18,659	17,114	16,967
Biological and Environmental Research	766	631	500
Computational and Technology Research	2,290	1,939	1,490
High Energy Physics	—	—	219
Total Laboratory	21,715	19,684	19,176
ARGONNE NATIONAL LABORATORY			
Basic Energy Sciences	139,894	143,436	145,096
Biological and Environmental Research	11,278	9,181	13,476
Computational and Technology Research	16,869	15,430	8,187
Fusion Energy Sciences	2,835	2,540	2,135
High Energy Physics	9,512	8,825	9,040
Multiprogram Energy Labs-Facilities Support	10,892	7,089	4,980
Nuclear Physics	16,845	16,045	17,485
Total Laboratory	208,125	202,546	200,399
BROOKHAVEN NATIONAL LABORATORY			
Basic Energy Sciences	76,722	77,586	77,331
Biological and Environmental Research	26,501	22,142	19,228
Computational and Technology Research	2,843	1,457	2,589
Fusion Energy Sciences	50	—	—
High Energy Physics	86,774	62,813	32,769
Multiprogram Energy Labs-Facilities Support	568	1,349	6,881
Nuclear Physics	110,851	115,900	135,549
Total Laboratory	304,309	281,247	274,347

Table 3

OFFICE OF SCIENCE
FY 2000 PRESIDENT'S BUDGET REQUEST TO CONGRESS
(B/A in thousands of dollars)

Major Site Funding	FY 1998 Current Approp.	FY 1999 Current Approp.	FY 2000 Request
THOMAS JEFFERSON NATIONAL ACCELERATOR FACILITY			
Basic Energy Sciences	200	——	——
Computational and Technology Research	190	100	283
Nuclear Physics	68,850	70,305	73,669
Total Laboratory	69,240	70,405	73,952
FERMI NATIONAL ACCELERATOR LABORATORY			
Computational and Technology Research	100	50	332
High Energy Physics	278,873	283,301	291,788
Total Laboratory	278,973	283,351	292,120
IDAHO NATIONAL ENGINEERING LABORATORY			
Basic Energy Sciences	3,478	3,609	3,020
Biological and Environmental Research	2,158	2,034	1,736
Fusion Energy Sciences	4,120	1,740	1,000
Nuclear Physics	90	80	80
Total Laboratory	9,846	7,463	5,836
LAWRENCE BERKELEY NATIONAL LABORATORY			
Basic Energy Sciences	62,160	62,553	62,095
Biological and Environmental Research	34,358	31,587	29,003
Computational and Technology Research	57,916	53,938	49,377
Energy Research Analyses	100	——	——
Fusion Energy Sciences	3,947	5,334	5,255
High Energy Physics	26,869	24,492	35,532
Multiprogram Energy Labs-Facilities Support	2,400	4,854	6,133
Nuclear Physics	21,965	22,118	18,080
Total Laboratory	209,715	204,876	205,475

Table 3

OFFICE OF SCIENCE
FY 2000 PRESIDENT'S BUDGET REQUEST TO CONGRESS
(B/A in thousands of dollars)

Major Site Funding	FY 1998 Current Approp.	FY 1999 Current Approp.	FY 2000 Request
LAWRENCE LIVERMORE NATIONAL LABORATORY			
Basic Energy Sciences	5,933	6,044	5,236
Biological and Environmental Research	30,004	36,148	28,446
Computational and Technology Research	2,755	2,940	640
Fusion Energy Sciences	10,518	11,158	10,168
High Energy Physics	1,794	685	680
Nuclear Physics	845	660	950
Total Laboratory	51,849	57,635	46,120
LOS ALAMOS NATIONAL LABORATORY			
Basic Energy Sciences	23,613	24,673	25,906
Biological and Environmental Research	19,661	20,651	18,251
Computational and Technology Research	14,614	13,034	10,894
Fusion Energy Sciences	4,143	4,219	4,419
High Energy Physics	1,090	650	790
Nuclear Physics	10,783	9,750	10,260
Total Laboratory	73,904	72,977	70,520
OAK RIDGE NATIONAL LABORATORY			
Basic Energy Sciences	110,219	217,848	302,898
Biological and Environmental Research	25,422	21,617	19,153
Computational and Technology Research	19,434	10,415	6,876
Energy Research Analyses	665	——	400
Fusion Energy Sciences	17,870	17,480	15,866
High Energy Physics	772	240	240
Multiprogram Energy Labs-Facilities Support	7,387	6,808	2,106
Nuclear Physics	16,215	15,017	16,665
Total Laboratory	197,984	289,425	364,204

Table 3

OFFICE OF SCIENCE
FY 2000 PRESIDENT'S BUDGET REQUEST TO CONGRESS
(B/A in thousands of dollars)

Major Site Funding	FY 1998 Current Approp.	FY 1999 Current Approp.	FY 2000 Request
PACIFIC NORTHWEST NATIONAL LABORATORY			
Basic Energy Sciences	12,868	12,788	12,947
Biological and Environmental Research	77,466	73,913	70,434
Computational and Technology Research	4,188	3,238	3,584
Energy Research Analyses	——	——	250
Fusion Energy Sciences	1,415	1,410	1,430
High Energy Physics	10	10	10
Total Laboratory	95,947	91,359	88,655
NATIONAL RENEWABLE ENERGY LABORATORY			
Basic Energy Sciences	4,515	4,193	3,744
Biological and Environmental Research	250	——	——
Computational and Technology Research	498	127	——
Total Laboratory	5,263	4,320	3,744
PRINCETON PLASMA PHYSICS LABORATORY			
Basic Energy Sciences	700	675	——
Computational and Technology Research	90	121	332
Fusion Energy Sciences	49,612	50,332	58,979
High Energy Physics	80	120	534
Total Laboratory	50,482	51,248	59,845
SANDIA NATIONAL LABORATORY			
Basic Energy Sciences	28,764	26,600	22,008
Biological and Environmental Research	3,486	3,239	2,903
Computational and Technology Research	5,232	5,293	3,779
Fusion Energy Sciences	5,850	4,115	3,565
Total Laboratory	43,332	39,247	32,255

Table 3

OFFICE OF SCIENCE
FY 2000 PRESIDENT'S BUDGET REQUEST TO CONGRESS
(B/A in thousands of dollars)

Major Site Funding	FY 1998 Current Approp.	FY 1999 Current Approp.	FY 2000 Request
STANFORD LINEAR ACCELERATOR CENTER			
Basic Energy Sciences	21,684	22,686	21,968
Computational and Technology Research	980	357	782
Biological and Environmental Research	3,323	2,450	2,550
Fusion Energy Sciences	50	50	50
High Energy Physics	147,502	145,017	150,231
Nuclear Physics	9	——	——
Total Laboratory	173,548	170,560	175,581