

Biological and Environmental Research

Funding Profile by Subprogram

	(dollars in thousands)				
	FY 2005 Current Appropriation	FY 2006 Original Appropriation	FY 2006 Adjustments	FY 2006 Current Appropriation	FY 2007 Request
Biological and Environmental Research					
Life Sciences	198,643	204,035	-2,040 ^a	201,995	264,158
Climate Change Research.....	135,535	142,959	-1,430 ^a	141,529	134,909
Environmental Remediation	100,575	94,694	-950 ^a	93,744	97,196
Medical Applications and Measurement Science	121,924	144,000	-1,437 ^a	142,563	14,000
Subtotal, Biological and Environmental Research.....	556,677	585,688	-5,857	579,831	510,263
Construction	9,920	—	—	—	—
Total, Biological and Environmental Research.....	566,597 ^b	585,688	-5,857	579,831	510,263

Public Law Authorization:

Public Law 95-91, “Department of Energy Organization Act”

Public Law 109-58, “Energy Policy Act of 2005”

Mission

The mission of the Biological and Environmental Research (BER) program is to advance environmental and biomedical knowledge that promotes national security through improved energy production, development, and use; international scientific leadership that underpins our Nation’s technological advances; knowledge needed to support the President’s National Energy Plan; and research that improves the quality of life for all Americans. BER supports these vital national missions through competitive and peer-reviewed research at national laboratories, universities, and private institutions.

Benefits

BER supports DOE’s mission of protecting our national and economic security by providing world-class scientific research capacity and advancing scientific knowledge by supporting world-class, peer-reviewed scientific results in biology and environmental science whose results are published in the scientific literature. Basic biological and environmental research has broad impacts on our health, our environment, and our energy future. An ability to predict long-range and regional climate enables effective planning for future needs in energy, agriculture, and land and water use. Biotechnology solutions are possible for DOE energy, environmental, and national security challenges by understanding complex biological systems and developing computational tools to model and predict their behavior. Understanding the global carbon cycle and the associated role and capabilities of microbes and plants

^a Reflects a rescission in accordance with P.L. 109-148, the Emergency Supplemental Appropriations Act to Address Hurricanes in the Gulf of Mexico and Pandemic Influenza, 2006.

^b Total is reduced by \$4,678,000 for a rescission in accordance with P.L. 108-447, the Consolidated Appropriations Act, 2005; \$13,674,000, which was transferred to the SBIR program; and \$1,641,000, which was transferred to the STTR program.

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. Both normal and abnormal health—from normal human development to cancer to brain function—can be understood and improved using radiotracers, advanced imaging instruments, and novel biomedical devices. 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.

Strategic and Program Goals

The Department's Strategic Plan identifies four strategic goals (one each for defense, energy, science, and environmental aspects of the mission) plus seven general goals that tie to the strategic goals. The BER program supports the following goal:

Science Strategic Goal

General Goal 5, World-Class Scientific Research Capacity: Provide world-class scientific research capacity needed to: ensure the success of Department missions in national and energy security; advance the frontiers of knowledge in physical sciences and areas of biological, medical, environmental, and computational sciences; or provide world-class research facilities for the Nation's science enterprise. The BER program has one program goal which contributes to General Goal 5 in the "goal cascade": Program Goal 05.21.00.00: Harness the Power of Our Living World – Provide the biological and environmental discoveries necessary to clean and protect our environment, offer new energy alternatives, and facilitate the entrainment of physical sciences advances in the biomedical field.

Contribution to Program Goal 05.21.00.00 (Harness the Power of Our Living World)

BER contributes to Program Goal 05.21.00.00 by advancing fundamental research in climate change, environmental remediation, genomics, proteomics, radiation biology, and medical applications. BER supports leading research programs that provide world-class, merit-reviewed research results. Discoveries at these scientific frontiers will bring revolutionary and unconventional solutions to some of our most pressing and expensive challenges in energy and the environment.

We will understand how living organisms interact with and respond to their environments to be able to use biology to produce clean energy, remove excess carbon dioxide from the atmosphere, and help clean up the environment. Our understanding of global climate change and our ability to predict climate over decades to centuries will enable us to develop science-based solutions to minimize the impacts of climate change and to better plan for our Nation's future energy needs. Understanding the biological effects of low doses of radiation will lead to the development of science-based health risk policy to better protect workers and citizens. Understanding the fate and transport of environmental contaminants will lead the way to discovering innovative approaches for cleaning up the environment.

BER research leads to the development of advanced medical imaging technology, including radiopharmaceuticals for imaging to be used for diagnosis and treatment of disease. BER research also advances the development of a broad range of intelligent biomimetic electronics that can both sense and correctly stimulate the nervous system, e.g., an artificial retina that will enable the blind to see, and that will lead to development of intelligent micro machines that interface with the brain and spinal cord to overcome disabilities. This research capitalizes on the national laboratories' unique resources and expertise in biological, chemical, physical, and computational sciences for technological advances related to human health, and on their sophisticated instrumentation (neutron and light sources, mass spectroscopy, and high field magnets), lasers and supercomputers. This research is coordinated with other complementary Federal programs.

In addition, BER plans, constructs, and operates reliable, world-class scientific facilities to serve thousands of researchers at universities, national laboratories, and private institutions from all over the world. Activities include structural biology research beam lines at the synchrotron light sources and neutron sources; the operation of the William R. Wiley Environmental Molecular Sciences Laboratory (EMSL) (including the Molecular Sciences Computing Facility) where research activities underpin long-term environmental remediation and other DOE missions in energy and national security; the Production Genomics Facility (PGF); the Laboratory for Comparative and Functional Genomics (“Mouse House”); and the climate change research facilities – the Atmospheric Radiation Measurement (ARM) and the Free-Air Carbon Dioxide Enrichment (FACE) facilities.

The following indicators establish specific long-term goals in Scientific Advancement that the BER program is committed to, and progress can be measured against.

- **Life Sciences:** Characterize the multi-protein complexes (or the lack thereof) involving a scientifically significant fraction of a microbe’s proteins. Develop computational models to direct the use and design of microbial communities to clean up waste, sequester carbon, or produce hydrogen.
- **Climate Change Research:** Deliver improved climate data and models for policy makers to determine safe levels of greenhouse gases for the earth’s system. By 2013, substantially reduce differences between observed temperature and model simulations at subcontinental scales using several decades of recent data.
- **Environmental Remediation:** By 2015, provide sufficient scientific understanding to allow a significant fraction of DOE sites to incorporate coupled biological, chemical and physical processes for decision making for environmental remediation and long-term stewardship.
- **Medical Applications and Measurement Science:** Develop intelligent biomimetic electronics that can both sense and correctly stimulate the nervous system.^a
- **Facilities:** Manage facilities operations to the highest standards of overall performance using merit evaluation with independent peer review.

Funding by General and Program Goal

	(dollars in thousands)		
	FY 2005	FY 2006	FY 2007
General Goal 5, World-Class Scientific Research Capacity			
Program Goal 05.21.00.00 Harness the Power of Our Living World (Biological and Environmental Research).....	566,597	579,831	510,263

^a This indicator is not a PART measure.

Annual Performance Results and Targets

	FY 2002 Results	FY 2003 Results	FY 2004 Results	FY 2005 Results	FY 2006 Targets	FY 2007 Targets
Program Goal 05.21.00.00 (Harness the Power of Our Living World)						
Life Sciences						
Increase the rate of DNA sequencing; Produce at least 12.7 billion base pairs of high quality DNA microbial and model organism genome sequence. [Met Goal]	Increase the rate of DNA sequencing: Produce at least 14 billion base pairs of high quality DNA microbial and model organism genome sequence. [Met Goal]	Increase the rate of DNA sequencing: Produce at least 20 billion base pairs of high quality DNA microbial and model organism genome sequence. [Met Goal]	Increase the rate of DNA sequencing: Number (in billions) of base pairs of high quality (less than one error in 10,000 bases) DNA microbial and model organism genome sequence produced annually. FY 2005 at least 28 billion base pairs will be sequenced. [Met Goal]	Increase the rate of DNA sequencing: Number (in billions) of base pairs of high quality (less than one error in 10,000 bases) DNA microbial and model organism genome sequence produced annually. FY 2006 at least 30 billion base pairs will be sequenced. [Met Goal]	Increase the rate of DNA sequencing: Number (in billions) of base pairs of high quality (less than one error in 10,000 bases) DNA microbial and model organism genome sequence produced annually. FY 2006 target of 582 base pairs per dollar to 781 base pairs per dollar.	Increase the rate and decrease the cost of DNA sequencing – Cost reductions will increase the number of high quality base pairs determined (less than one error in 10,000 bases) by 25% from the FY 2006 target of 582 base pairs per dollar to 781 base pairs per dollar.
Climate Change Research						
Improve climate models: Released a new coupled climate model with a horizontal resolution of 2.8 degrees (longitude and latitude) in the atmosphere and 0.7 degrees in the ocean and sea ice components, compared to the previous version with a resolution of 2.8 degrees in the atmosphere and 2.0 degrees in the ocean. Executed an 800-year equilibrium climate simulation with the new model. [Met Goal]	Improve climate models: Constructed a climate model for the next round of IPCC Working Group 1 Assessment simulations. This model increased the realism of the coupled atmosphere-ocean-land surface-sea ice system through improvements in the physical parameterizations, particularly the cloud sub models. The standard model increased the horizontal resolution to 1.4 degrees in the atmosphere and maintained the 0.7 degree resolution in the ocean and sea ice components. More objective and systematic methods to test (evaluate) the performance of both the model components (i.e., atmosphere, ocean, land surface, and sea ice sub models) as well as the fully coupled model, were applied. [Met Goal]	Improve climate models: Implement a model test bed system to incorporate climate data rapidly into climate models to allow testing of the performance of sub-models (e.g., cloud resolving module) and model parameters by comparing model simulations with real world data from the ARM sites and satellites. [Met Goal]	Improve climate models: Implement three separate component submodels (an interactive carbon cycle submodel, a secondary sulfur aerosol submodel, and an interactive terrestrial biosphere submodel) within a climate model and conduct 3–4 year duration climate simulation using the fully coupled model. [Met Goal]	Improve climate models: Produce a new continuous time series of retrieved cloud properties at each ARM site and evaluate the extent of agreement between climate model simulations and observations for cloud properties in the arctic.	Improve climate models: Provide new mixed-phase cloud parameterization for incorporation in atmospheric GCMs and evaluate extent of agreement between climate model simulations and observations for cloud properties in the arctic.	

	FY 2002 Results	FY 2003 Results	FY 2004 Results	FY 2005 Results	FY 2006 Targets	FY 2007 Targets
Environmental Remediation						
	Determine scalability of laboratory results in field environments: Using genomic sequencing data of key bioremediation microbes, such as Geobacter, Deinococcus, and Shewanella, determined that common soil microbes produce organic compounds that interact with radionuclides, such as plutonium, providing the molecular understanding for the detection and transformation of radionuclides in subsurface environments. [Met Goal]	Determine scalability of laboratory results in field environments: Identified naturally occurring microbial populations responsible for transformation of metals and radionuclides at DOE contaminated sites. [Met Goal]	Perform combined field/laboratory/modeling to determine how to interpret data at widely differing scales: Quantify contaminant immobilization and renobilization by different factors: 1. natural microbial mechanisms; 2. chemical reactions with minerals; and 3. colloid formation. [Met Goal]	Determine scalability of laboratory results in field experiments - Conduct two sets of field experiments to evaluate biological reduction of chromium and uranium by microorganisms and compare the results to laboratory studies to understand the long term fate and transport of these elements in field settings. [Met Goal]	Develop predictive model for contaminant transport that incorporates complex biology, hydrology, and chemistry of the subsurface. Validate model through field tests.	Implement a field-oriented, integrated experimental research program to quantify coupled processes that control reactive transport of at least one key DOE contaminant.
	Medical Applications and Measurement Science ^a	Advance blind patient sight: Developed and tested materials for platform and sealants for a prototype artificial retina- a microelectronic array to be used for the treatment of blindness. [Met Goal]	Advance blind patient sight: Complete fabrication of 60 microelectrode array for use as an artificial retina and tested in an animal subject. [Met Goal]	Advance blind patient sight: Complete testing on a 60 microelectrode array artificial retina and insert prototype device into a blind patient. [Met Goal]	Advance blind patient sight: Begin testing of prototypes for 256 microelectrode array artificial retina.	Advanced blind patient sight: complete design and construction of final 256 electrode array. Begin in vitro testing and non-stimulating testing in animals.
	All BER Facilities	Maintain and operate BER facilities such that achieved operation time is on average greater than 90% of the total scheduled annual operation time. [Met Goal]	Maintain and operate BER facilities such that achieved operation time is on average greater than 90% of the total scheduled annual operation time. [Met Goal]	Maintain and operate BER facilities such that achieved operation time is on average greater than 90% of the total scheduled annual operation time. [Met Goal]	Maintain and operate BER facilities (Life Science – PGF and the Mouse facility; Climate Change Research – ARM and FACE; and Environmental Remediation – EMSL) such that achieved operation time is on average greater than 90% of the total scheduled annual operation time for each group of facilities. [Met Goal]	Maintain and operate BER facilities (Life Science – PGF and the Mouse facility; Climate Change Research – ARM and FACE; and Environmental Remediation – EMSL) such that achieved operation time is on average greater than 98% of the total scheduled annual operation time for each group of facilities.

^a This is not a PART measure.

Means and Strategies

The BER program will use various means and strategies to achieve its program goals. However, various external factors may impact the ability to achieve these goals.

The BER program will continue its investments in core fundamental science and technologies needed to address the interfaces between scientific disciplines such as biology, physics, chemistry, engineering, and information science. Of highest priority will be the development of a new research infrastructure needed to understand fundamental biological principles underlying the function and control of biological systems, the heart of the Genomics: GTL program. This new research infrastructure of well-integrated, interdisciplinary research teams will form the basis of a new approach for studying complex biological systems and for using those systems to solve critical problems in energy and environmental cleanup.

Our ability to predict climate on global and regional scales and to develop strategies for the removal of excess carbon dioxide, suspected to adversely impact global climate, from the atmosphere will depend on the continued development of novel research tools and a close integration of experimental and computational research.

BER also plays a key role in constructing and operating a wide array of biological and environmental user facilities for the Nation's researchers, such as the Environmental Molecular Sciences Laboratory (EMSL), the Production Genomics facility, the Laboratory for Functional and Comparative Genomics, Atmospheric Radiation Measurement (ARM) facilities, and Free Air Carbon Dioxide Enrichment (FACE) facilities.

All BER-supported research projects undergo regular peer review and merit evaluation based on procedures set down in 10 CFR 605 for the extramural grant program, and under a similar process for the laboratory programs and scientific user facilities. All new projects are selected through peer review and merit evaluation.

External factors that affect the programs and performance include: (1) mission needs as described by the DOE and SC mission statements and strategic plans; (2) evolving scientific opportunities that sometimes emerge in ways that revolutionize disciplines; (3) results of external program reviews and international benchmarking activities of entire fields or subfields, such as those performed by the National Academies of Science; (4) unanticipated failures, for example, in critical components of scientific user facilities that cannot be mitigated in a timely manner; and (5) strategic and programmatic decisions made by other (non-DOE) Federal agencies and by international entities.

The BER program is closely coordinated with the activities of other federal agencies (e.g., National Institutes of Health [NIH], National Science Foundation [NSF], National Aeronautics and Space Administration [NASA], Department of Commerce/National Oceanic and Atmospheric Administration [NOAA], Environmental Protection Administration [EPA], Department of Agriculture [USDA], and Department of Defense [DOD]). BER Climate Change Research is coordinated with the U.S. Global Change Research Program, an interagency program codified by Public Law 101-606 and involving thirteen federal agencies and departments.

BER also promotes the transfer of the results of its basic research to contribute to DOE missions in areas of future energy sources, improved use of fossil fuels (carbon sequestration), reduced environmental impacts of energy production and use, and environmental cleanup.

Validation and Verification

Progress against established plans is evaluated by periodic internal and external performance reviews. These reviews provide an opportunity to verify and validate performance. Quarterly, semiannual, and

annual reviews consistent with specific program management plans are held to ensure technical progress, cost and schedule adherence, and responsiveness to program requirements.

Program Assessment Rating Tool (PART) Assessment

The Department implemented a tool to evaluate selected programs. PART was developed by OMB to provide a standardized way to assess the effectiveness of the Federal Government's portfolio of programs. The structured framework of the PART provides a means through which programs can assess their activities differently than through traditional reviews. The Biological and Environmental Research Program has incorporated feedback from OMB into the FY 2007 Budget Request and has taken or will take the necessary steps to continue to improve performance.

The Biological and Environmental Research (BER) Program last completed PART in support of the FY 2005 Budget Request. At that time, the program was rated as "Effective."

In the FY 2004 PART, OMB recommended that BER form Committees of Visitors (COVs) to review management of the BER research portfolio. The FY 2005 PART Summary Sheet Recommended that the Department develop an appropriate action plan in response to the findings and recommendations of the Committee of Visitors within 30 days of receipt of the report. Two BER COVs have been formed. The first COV was charged on July 23, 2003, to look at the Climate Change Research Division. This COV met on March 1–3, 2004, and reported to the Biological and Environmental Research Advisory Committee (BERAC) in November 2004. The Department responded to this report in December 2004. The Second COV was charged on April 21, 2004, to look at the Environmental Remediation Sciences Division. This COV met on October 5–7, 2004, and reported to BERAC in November 2004. The Department responded to this report in December 2004. In the FY 2006 PART Summary Sheet, OMB found the timely BER responses to both reports to be thoughtful and thorough.

For the FY 2004 PART, BER worked with OMB to develop more meaningful long-term performance goals for the program. BER then worked with BERAC to ensure that these measures were ambitious yet realistic and to define for each what would be required for the program to be "successful" and "minimally effective". The FY 2005 PART Summary Sheet Recommended that the Department work with its advisory committee to develop research milestones against which future outside panels may judge interim progress toward achieving the long-term goals of the program. In the FY 2006 PART Summary Sheet, OMB found that the BER program's research milestones—as expressed in the new DOE program plans—were produced and reflect the strategic goals of the program, and the BER advisory committee as a whole has provided formal comments on the milestones. Panels will be charged to review progress toward the BER long-term goals using the criteria developed by BERAC and will report to the program in FY 2006.

For the FY 2007 Budget, OMB has developed PARTWeb—a new interface for PART that facilitates collaboration between agencies and OMB. PARTWeb will link to the <http://ExpectMore.gov> website and will improve public access to PART assessments and follow up actions. For 2006 there are three actions for Biological and Environmental Research.

- Engaging the National Academies in an independent assessment of the scientific basis and business case for the program's microbial genomics research efforts.
- Implementing the recommendations of past external panel reviews of the program's research portfolio and management practices.

- Reviewing operations of user facilities, and improving discrimination in identifying open user facilities versus collaborative research facilities.

In response, BER has engaged the National Academies to review Genomics: GTL and expects a report by February 12, 2006. BER will also continue to publish responses to the COV's findings and will track improvements at <http://www.sc.doe.gov/measures/FY06.html>. The Biological and Environmental Research Advisory Committee has been reviewing the user facilities. BER will act on the results of these reviews to improve facility management.

Overview

BER supports fundamental research in genomics, proteomics, radiation biology, climate change, environmental remediation, and medical sciences. BER supports leading edge research facilities used by public and private sector scientists across the range of BER disciplines. BER works with other federal agencies to coordinate research across all of its programs. BER validates its long-range goals through its advisory committee, the Biological and Environmental Research Advisory Committee (BERAC).

The Opportunity

With the 21st Century dawns what many have called the “biological century”—an era when advances in biology, spurred by achievements in genomic research, including the sequencing of the human genome, will bring revolutionary and unconventional solutions to some of our most pressing and expensive challenges in health, energy, the environment, and national security.

We will understand how living organisms interact with and respond to their environments so well that we will be able to use biology to produce clean energy, remove excess carbon dioxide from the atmosphere, and help clean up the environment. Our understanding of global climate change and our ability to accurately predict climate over decades to centuries will enable us to develop science-based solutions to minimize the impacts of climate change and to better plan for our Nation’s future energy needs. Understanding the biological effects of low doses of radiation will lead to the development of science-based health risk policy to better protect workers and citizens. Understanding the fate and transport of environmental contaminants will lead the way to discovering innovative approaches for cleaning up the environment. Both normal and abnormal health—from normal human development to cancer to brain function—can be understood and improved using radiotracers, advanced imaging instruments, and novel biomedical devices.

The Challenges

Understanding and predicting climate – Advanced climate models are needed to describe and predict the roles of oceans, the atmosphere, sea ice, and land masses on climate. So too, the role of clouds in controlling solar and terrestrial radiation onto and away from the Earth needs to be better understood since it is the largest uncertainty in climate prediction. Moreover, the impacts of excess carbon dioxide in the atmosphere from human sources, including energy use, on Earth’s climate and ecosystems need to be determined and possible mitigation strategies developed.

A cleaner environment – Environmental sciences are undergoing a revolution, thanks in large part to the same molecular tools that have revolutionized biology in the last few decades—synchrotron radiation, advanced imaging and microscopy, and modern genomics. At the same time, the importance and roles of microbes in the environment are just beginning to be understood. How do microbes impact the geochemical cycles in the earth? How do they respond to perturbations, such as contamination? How do contaminants move through the subsurface? And how can we use nature’s own biogeochemical ‘tricks’ to help us clean up contaminated sites in the DOE weapons complex and other places?

Technology for a healthier Nation – At the crossroads of the physical and biological sciences is the promise of remarkable technology for tomorrow’s medicine. Developments in imaging technology have the potential to revolutionize all of medical imaging with increases in sensitivity, ease of use, and patient comfort. Technological wonders are on the horizon, like an artificial retina that will restore vision to the blind.

A new biology – Can we understand the workings of biological systems well enough so that we can use nature’s own principles of design to solve energy and environmental challenges? Understanding nature’s array of multi-protein molecular machines and complex microbial communities, each with exquisitely precise and efficient functions and controls, will enable us to use and even redesign these molecular machines or communities to address DOE and national needs.

The Investment Plan

All BER R&D investments are evaluated against the Administration’s R&D Investment criteria that include research and user facility relevance, quality, and performance. BER will continue its investments in core technologies and fundamental science needed to address these daunting challenges. BER believes that the most important scientific advances in the 21st century will occur at the interfaces between scientific disciplines such as biology, physics, chemistry, engineering, and information science. BER investments at these interfaces will enable: (1) the development of a new research infrastructure for understanding the function and control of biological systems that can be used to solve critical problems in energy and the environment; (2) an improved ability to predict climate on global and regional scales; (3) development of strategies to remove excess carbon dioxide from the atmosphere; (4) new science-based strategies for the remediation, and long-term monitoring of the environment; and (5) the development of unique devices and technologies for the medical community that improve our Nation’s health.

How We Work

BER uses a variety of mechanisms to conduct, coordinate, and fund biological and environmental research. BER is responsible for planning and prioritizing all aspects of supported research, for conducting ongoing assessments to ensure a comprehensive and balanced portfolio that addresses DOE and national science needs, and for coordinating its research programs with those of other federal agencies. BER regularly seeks advice on its research programs from the scientific community and from its diverse stakeholders. BER supports research at national laboratories, universities, research institutes, and private companies, and maintains a strong research infrastructure across the biological and environmental sciences most relevant to the BER program.

Advisory and Consultative Activities

To ensure that resources are allocated to the most scientifically relevant and promising research, BER actively seeks external input using a variety of advisory bodies. BER regularly compares its programs to the scientific priorities recommended by the BERAC and by the standing committees created by the Office of Science and Technology Policy (OSTP). BER staff and BERAC both interact with and receive feedback from other programs and advisory committees across the Department including Advanced Scientific Computing Research; Basic Energy Sciences; Environmental Management; Energy Efficiency and Renewable Energy; Nuclear Energy, Science and Technology; Fossil Energy; and the National Nuclear Security Administration. BER program coordination across federal agencies also benefits from international and interagency working groups such as those of the Interagency Genomics and Biotechnology working groups, the combined Climate Change Science Program and U.S. Global Change Research Program, and the National Institutes of Health Bioengineering Consortium. BER is

currently having its Genomics: GTL program, including the GTL Roadmap, reviewed by the National Academies of Science. Finally, BER consults regularly with groups like JASON, involving physicists, mathematicians, engineers, etc., to receive feedback on BER program elements such as the Atmospheric Radiation Measurement (ARM) program, climate change prediction activities, the William R. Wiley Environmental Molecular Sciences Laboratory (EMSL), and the genomics program.

Facility Operations Reviews

All BER facility operations are monitored by peer reviews and user feedback. BER facility operations have also been reviewed by BERAC and by a 1999 OSTP interagency working group evaluating structural biology user facilities. In FY 2005, the Office of Science's Construction Management Support Division has reviewed BER's Environmental Molecular Sciences Laboratory. BER manages all facilities in a manner that meets user requirements as indicated by achieving performance specifications while protecting the safety of workers and the environment. Facilities are operated reliably and according to planned schedules. Facilities are also maintained and improved to remain at the cutting edge of technology and scientific capability.

Program Reviews

Effective program review, merit review, and user feedback are critical tools for BER to measure performance of research programs, research projects, and user facilities. The quality and scientific relevance of the BER program and its individual research projects are maintained by rigorous peer reviews conducted by internationally recognized scientific experts. The criteria for determining scientific quality and relevance include scientific merit, appropriateness of the proposed approach, and reasonableness of the requested level of funding, research facilities, and qualifications of the principal investigator. BER expects the highest quality research and, when necessary, takes corrective management actions based on results of the reviews. A measure of the quality of the BER research is the sustained achievement in advancing scientific knowledge. This is demonstrated by the publication of research results in the leading refereed scientific journals pertinent to BER-related research fields, by invited participation at national and international scientific conferences and workshops, and by honors received by BER-supported researchers.

At the highest level, regular reviews of individual BER program elements and of the entire BER research program are conducted by BERAC. As noted above, BER also benefits from interagency and international reviews of programs such as the Climate Change Science Program and the structural biology research program, including reviews by Boards and Committees of the National Academies of Science.

BER goes one step further in conducting program reviews. Panels of distinguished scientists are regularly charged with evaluating the quality of individual programs and with exploring ways of introducing new ideas and research performers from different scientific fields. This strategy is based on the conviction that the most important scientific advances of the new century will occur at the interfaces between scientific disciplines, such as biology and information science. The BER program is ideally positioned to facilitate and foster interactions between the physical sciences, the computational sciences, the environmental sciences, and the life sciences, and aggressively pursues every opportunity to nurture collaborations at the interfaces between these scientific domains.

Planning and Priority Setting

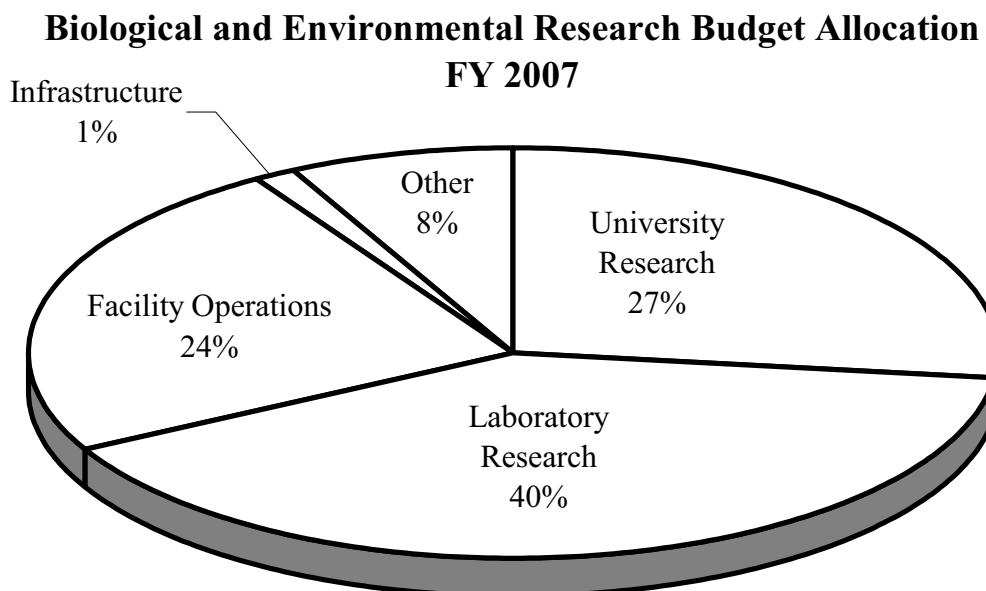
BER prides itself on supporting research and developing new research initiatives that lead the way across many fields of science and that effectively bring together many different disciplines, including

biology, chemistry, engineering, computing, and the physical sciences. Merit reviews and user feedback are incorporated as BER anticipates and plans for the future needs of DOE research in the life and environmental sciences. This includes planning for future directions, opportunities, and initiatives within the BER research portfolio; maintaining the flexibility to quickly move into promising new areas; contributing to the health of the educational pipeline in critical subfields and disciplines; planning for upgrades at existing facilities to expand the research capabilities or operational capacity; ensuring the proper balance between facilities and research; and planning for future facilities necessary to advance the science in areas relevant to BER's mission with strong involvement of the research community.

BER planning and priority setting are also key BERAC activities and part of BER's interagency coordination. Individual BER program elements, e.g., human genome, low dose radiation research, Genomics: GTL, bioremediation research, global climate change, and medical applications develop long-range program plans through coordinated efforts with BERAC and other federal agencies.

How We Spend Our Budget

The BER budget has three major components: basic research at universities (27%); basic research at national laboratories (40%); and user facility support (24%). The remaining 9% includes general plant projects and equipment that supports the research infrastructure at the National Laboratories (1%) and all other research activities (primarily other federal agencies and industry (8%)). Research at national laboratories also includes Unmanned Aerial Vehicles and other elements that represent a research infrastructure for the scientific community that includes both university and laboratory scientists. BER's user facilities include the infrastructure at synchrotron and neutron sources for structural biology and the environmental sciences, operation and equipment for the Environmental Molecular Sciences Laboratory (EMSL), support for high-throughput DNA sequencing at the Joint Genome Institute, Atmospheric Radiation Measurement Infrastructure, Free-Air CO₂ Enrichment (FACE) experimental facilities, and for the Laboratory for Cooperative and Functional Genomics ("Mouse House").



Research

In FY 2007, the BER program will support fundamental research in climate change, environmental remediation, genomics, proteomics, radiation biology, and medical sciences at over 200 public and private research institutions in over 40 states, and at 14 DOE laboratories in 10 states. This research will be conducted in over 1,000 different research projects by over 2,500 researchers and students. In addition to the principal investigator for each research project funded by BER, individual projects typically have between 1 and 20 additional Ph.D.-level scientists who are funded collaborators. Information on scientific collaborators is not routinely tracked.

- ***University Research:*** University researchers play a critical role in the BER program, conducting fundamental research and developing the next generation of scientists for the nation's biological and environmental research efforts. BER will continue its commitment to and dependence on scientists at the Nation's universities. In general, BER-supported research at universities and research institutions are single investigator projects. Approximately half of BER basic research funding supports university-based activities directly and indirectly. University scientists are the major scientific users at BER facilities that include the ARM program, DNA sequencing, structural biology, FACE, EMSL, and the Laboratory for Comparative and Functional Genomics.

All research projects supported by the BER program undergo regular merit review and evaluation based on the procedures set down in 10 CFR Part 605 for the extramural grant program (<http://www.science.doe.gov/grants/merit.html>). Peer review of BER projects is performed to provide an independent assessment of the scientific and/or technical merit of the research by peers having knowledge and expertise equal to that of the researchers whose work they review.

- ***National Laboratory Research:*** Research projects at national laboratories are most often multi-investigator team projects that take advantage of unique resources, capabilities, or facilities found at the national laboratories. Researchers at the national laboratories collaborate extensively with academic researchers supported by BER as well as with academic users of the BER facilities infrastructure including the EMSL, ARM, FACE, Environmental Remediation Sciences Research Field Research Center (FRC), the Joint Genome Institute (JGI), and the structural biology and environmental user facilities at the synchrotron.

All DOE laboratory research projects supported by the BER program undergo regular merit review and evaluation. BER research at the DOE Laboratories and scientific user facilities undergoes peer review and evaluation in a similar procedure to that used for university-based research.

BER Leadership and Unique Roles

The BER program has a broad range of unique roles for the Department and the national and international scientific communities including:

- Manage research on microbes for energy and the environment, and work with the Advanced Scientific Computing Research program to develop the computational methods and capabilities needed to advance understanding of complex biological systems, predict their behavior, and use that information to address DOE needs;
- Provide the research infrastructure needed to (1) characterize the multi-protein complexes that result in microbial products and processes of use to DOE, and (2) determine the functional repertoire of complex microbial communities that can be used to address DOE needs;
- Provide world-class structural biology user facilities;

- Provide cutting edge technologies, facilities (including high-throughput community DNA sequencing capabilities), and resources, including animal models, for genomics research;
- Provide world-class scientific user facilities for environmental and climate change research;
- Provide world leadership in low dose radiation research;
- Provide world leadership in the understanding of how metal and radionuclide contaminants interact with the environment and how environments respond to their presence;
- Provide world leadership in ground-based measurement of clouds and atmospheric properties to resolve key uncertainties in climate change, through the ARM program;
- Develop advanced predictive capabilities using coupled climate models on the Nation's premier computers for decade-to-century long simulations of climate change;
- Support fundamental research on carbon sequestration to develop technologies that enhance the uptake of carbon in terrestrial and ocean ecosystems;
- Provide the scientific knowledge and enabling discoveries to reduce the risks and costs associated with the cleanup of the DOE weapons complex and provide a basis for similar mission needs related to energy, water, and the disposal and storage of waste;
- Provide world leadership in support of science at the interface of physics, chemistry, materials, and computation to develop an artificial retina; and
- Ensure that the rights and welfare of human research subjects at the Department are protected while advances in biomedical, environmental, nuclear, and other research lead to discoveries that benefit humanity.

Significant Program Shifts

- BER will focus research activities on higher priorities, especially GTL, in support of Departmental goals and objectives. Funding reductions are initiated in the Environmental Remediation Research and in the Climate Change Research Subprograms. High level waste (including waste in storage tanks), ocean sciences, and carbon sequestration research are terminated within these two subprograms.

Genomics: GTL Research

The FY 2007 budget includes funds for the continued expansion of the Genomics: GTL program—a program at the forefront of the biological revolution. This program employs a systems approach to biology at the interface of the biological, physical, and computational sciences to address DOE's energy, environment, and national security mission needs. This research will continue to more fully characterize the inventory of multi-protein molecular machines found in selected DOE-relevant microbes and higher organisms. It will determine the diverse biochemical capabilities of microbes and microbial communities, especially as they relate to potential biological solutions to DOE needs, found in populations of microbes isolated from DOE-relevant sites. GTL research will provide the scientific community with knowledge, resources, and tools that benefit large numbers of research projects with positive impacts on more scientists and students than are negatively impacted by the initial reduction.

Development of a global biotechnology based energy infrastructure requires a science base that will enable scientists to redesign specific proteins, biochemical pathways, and even entire plants or microbes. 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 communities of microbes and engineered nanostructures. Within the Genomics: GTL program, BER will develop the understanding needed to advance biotechnology-based strategies for biofuel production, focusing on biohydrogen and bioethanol.

Biological Production of Hydrogen—Some microorganisms produce hydrogen naturally, and biotechnologies based on these microbial systems will lead to the development of clean, renewable sources of hydrogen. Under certain conditions, green algae and a type of bacteria known as cyanobacteria can use energy from the sun to split water and generate hydrogen. This process, known as biophotolysis, has the potential to produce hydrogen on the scale necessary for meeting future energy demand. This approach to hydrogen production is promising because it uses water as a source of hydrogen—a clean, renewable, carbon-free (i.e., non-fossil fuel based), substrate available in virtually inexhaustible quantities. Another advantage of biophotolysis, compared to engineered systems that capture and use sunlight, is the more efficient conversion of solar energy to hydrogen. Using and improving microbial systems to directly produce hydrogen from water eliminates inefficiencies associated with hydrogen production from biomass, such as producing and harvesting the biomass itself. Theoretically, the maximum energetic efficiency for direct biophotolysis is 40% compared with a maximum of about 1% for hydrogen production from biomass (Critical Reviews in Microbiology 31, 19-31, 2005). Fundamental research will be supported to understand biophotolysis, and other processes, well enough that predictive models of hydrogenase (the enzyme that cleaves water to produce hydrogen) structure and function, genetic regulatory and biochemical networks, and eventually entire microbes can be developed. Research will include investigations on a range of hydrogen-producing enzymes and organisms, understanding how hydrogenases work, the inhibition of hydrogenase activity by oxygen, and genetic regulatory and biochemical processes that influence hydrogen production. This new knowledge will be used to engineer the ideal microbe to use in hydrogen bioreactors or the ideal enzyme-catalyst to use in bioinspired nanostructures for hydrogen production.

Cellulose to Ethanol—Advanced Biological Production of Ethanol—Ethanol produced from corn starch is currently the most widely consumed biofuel in the United States, used as a substitute or octane booster for gasoline. A gallon of ethanol has about two-thirds the energy content of a gallon of gasoline. The production of cellulosic ethanol from biomass has promise for meeting a significantly larger portion of U.S. gasoline demand. A recent report (“Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply,” available from Oak Ridge National Laboratory, Oak Ridge, TN 37831; ORNL/TM-2005/66) has projected that relatively modest changes in the use of farmlands and forests could produce more than 1.3 billion dry tons of biomass per year, enough to reduce current oil demand by at least one-third given conservative estimates of conversion efficiencies. Research will be supported that provides a systems-level understanding of biological processes for developing and deploying large-scale, environmentally sound biotechnologies to produce ethanol from plant cell walls, primarily cellulose. Currently, a biochemical conversion of biomass to ethanol involves three basic steps: (1) breakdown of raw biomass using heat and chemicals, (2) use of enzymes to breakdown plant cell wall materials into simple sugars, and (3) conversion of the sugars into ethanol using microbes. The long-term goal is to integrate the bioprocessing into a single step. Accomplishing this requires the development of genetically modified, multifunctional microbes or a stable mixed culture of microbes capable of carrying out all biologically mediated transformations needed for the complete conversion of biomass to ethanol. Research will be supported on a variety of enzymes and microbes that contribute (individually and together) to the conversion of cellulose to ethanol; analysis of enzymes to understand how they interact with and breakdown cellulose; a determination of the factors, such as temperature and different combinations of sugars, that influence

biomass degradation or ethanol production; strategies for producing and maintaining stable mixed cultures of microbes; and improved capabilities for genetically engineering microbes that produce bioethanol. This research will lead to increased understanding of microbe-based production of cellulosic ethanol, increased production efficiencies, and reduced costs that will make cellulosic ethanol a cost-competitive alternative to gasoline in the coming decades.

Climate Change Science Program

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 causes and consequences, is possible over the next five years. The CCRI was then combined with the existing U.S. Global Change Research Program (USGCRP) to form a combined USGCRP/CCRI managed as the Climate Change Science Program (CCSP) by the cabinet-level Committee on Climate Change Science and Technology Integration. (The BER request for CCSP for FY 2007 is \$126,187,000.) DOE, in conjunction with its interagency partners, including NSF, NASA, NOAA, USDA, Interior, and EPA, will continue to focus its Climate Change Research in CCSP priority areas. These areas include advanced climate modeling, critical climate processes (including effects of clouds and water vapor on the atmospheric radiation balance), carbon cycling, atmospheric composition (with a focus on both greenhouse gas concentrations and effects of various aerosols on climate), effects of climate change on important terrestrial ecosystems, and the development and evaluation of tools for assessing the economic costs and benefits of climate change and the different potential options for mitigation and adaptation to such change. The deliverables from this BER research will be highlighted by information useful to policy makers.

In FY 2007, BER will contribute to the CCRI from four programs: Terrestrial Carbon Processes, Climate Change Prediction, ARM, and Integrated Assessment. Activities will be focused 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 Cloud and Radiation Testbed facility to provide data on the effects of clouds and aerosols on the atmospheric radiation budget in regions and locations of opportunity where data is 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; and (4) developing and evaluating assessment tools needed to study costs and benefits of potential strategies for reducing net carbon dioxide emissions.

Scientific Discovery through Advanced Computing (SciDAC)

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 achieving breakthrough scientific advances via computer simulation that are impossible using theoretical or laboratory studies alone. The power of computers and networks is increasing exponentially. Advances in high-end computing technology, together with innovative algorithms and software, are being exploited as intrinsic tools for scientific discovery. SciDAC has also pioneered an effective new model of multidisciplinary collaboration among discipline-specific scientists, computer scientists, computational scientists, and mathematicians. The product of this collaborative approach is a new generation of scientific simulation codes that can productively exploit terascale computing and networking resources. The program is bringing computation and simulation to parity with experiments and theory in the scientific research enterprise as demonstrated by major advances in climate modeling and prediction, plasma physics, particle physics, accelerator design, astrophysics, chemically reacting flows, and computational nanoscience.

In FY 2007, BER will continue to advance the science of climate modeling by coupling models of different components of the earth system related to climate and by significantly increasing the spatial resolution of global climate models. These SciDAC-enabled activities will allow climate scientists to gain unprecedented insights into potential effects of energy production and use on the global climate system.

BER will 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 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. The intent is to explore potential advantages that high-end computing can bring to the understanding of optimal model complexity, the scalability of biogeochemical reactions, model abstraction methods, sources of uncertainty, parameter estimation and characterization measurements as input in subsurface reactive transport modeling.

Scientific Facilities Utilization

The BER request includes funds to maintain support of the Department’s major scientific user facilities. BER has expanded the definition of a scientific user facility to include facilities such as structural biology research beam lines at the synchrotron light sources and neutron sources; the operation of the William R. Wiley Environmental Molecular Sciences Laboratory where research activities underpin long-term environmental remediation and other DOE missions in energy and national security; the Production Genomics Facility; the Laboratory for Comparative and Functional Genomics (“Mouse House”); and the ARM and FACE facilities. With this funding, BER will provide for the operation of the facilities, assuring access for scientists in universities, federal laboratories, and industry. BER will also leverage both federally and privately sponsored research to maintain support for and operation of these facilities.

BER will maintain and operate its user facilities so that the achieved operation time will be greater than 98%, on average, of total scheduled annual operation.

User Statistics

	FY 2005	FY 2006	FY 2007
	Actual	Estimated	

EMSL

Optimal hours	4,365	4,365	4,365
Scheduled hours	4,365	4,365	4,365
Operation Time	95%	95%	>98%
Users ^a	1400	1600	1700

^a EMSL users are both onsite and remote. Individual users are counted once per proposal in a reporting period regardless of the number of visits or accesses but individual scientists could be counted as more than one user if they are part of independently merit reviewed proposals.

	FY 2005	FY 2006	FY 2007
	Actual	Estimated	
Production Genomics Facility (PGF)			
Optimal hours	8,400	8,400	8,400
Scheduled hours	8,400	8,400	8,400
Operation Time	>98%	>98%	>98%
Users ^a	50	80	120
Laboratory for Comparative and Functional Genomics (“Mouse House”)			
Optimal hours	3,536	3,536	3,536
Scheduled hours	3,536	3,536	3,536
Operation Time	>99%	>99%	>99%
Users ^b	20	20	20
Atmospheric Radiation Measurement (ARM)			
Optimal hours	7,884	7,884	7,884
Scheduled hours	7,884	7,884	7,884
Operation Time	>98%	>98%	>98%
Users ^c	800	800	850
Free Air Carbon Dioxide Enrichment (FACE)			
Optimal hours	3,865	3,865	3,865
Scheduled hours	3,865	3,865	3,865
Operation Time ^d	>95%	>95%	>96%
Users	150	150	195

User statistics for BER structural biology user facilities at DOE neutron and light sources are included as part of the user statistics collected and reported by the Basic Energy Sciences (BES) program and are not repeated here.

Construction and Infrastructure

BER will meet the cost and schedule milestones for construction of facilities and major items of equipment within 10% of baseline estimates.

For BER activities the capital equipment is held approximately at near the FY 2006 level.

^a All users are remote. Primary users are individuals associated with approved projects being conducted at the PGF in a reporting period. Each user is counted once per year regardless of how many proposals their name may be associated with.

^b Users are both remote and onsite. A user is defined as a research group with a project that uses the facility. Each group is counted only once regardless of how many visits or individual staff in the group use the facility.

^c ARM users are both onsite and remote. A user is an individual who accesses or uses equipment or computers at an ARM site. Individuals are only counted once per reporting period at an individual site but may be counted at different ARM sites if they are a user at more than one site.

^d FACE users are both onsite and remote. Individuals are counted once per proposal in a reporting period regardless of the number of visits or accesses but individual scientists could be counted as more than one user if they are part of independently merit reviewed proposals. An onsite user who uses more than one FACE site is counted once for each of the sites used to carry out the research unless the research is to compare results between multiple FACE sites.

The BER program, as part of its responsibilities as landlord for the Pacific Northwest National Laboratory (PNNL) and the Oak Ridge Institute for Science and Education (ORISE), provides funding for the general plant projects (GPP) and general purpose equipment (GPE). In addition to the general-purpose line item projects funded out of the Science Laboratories Infrastructure program, GPP and GPE represent the capital investment funding provided by the Department for the general laboratory infrastructure. This ensures that the PNNL and ORISE infrastructures will continue to enable the Department's mission activities at these sites.

Workforce Development

Workforce development is an integral and essential element of the BER mission to help ensure a science-trained workforce, including researchers, engineers, science educators, and technicians. The research programs and projects at the National Laboratories, universities, and research institutes actively integrate undergraduate and graduate students and post-doctoral investigators into their work. This "hands-on" approach is essential for the development of the next generation of scientists, engineers, and science educators. Specific fellowship programs are also sponsored by BER to target emerging areas of need in global change research. About 1,400 graduate students and post-doctoral investigators will be supported at universities and at National Laboratories in FY 2007, including those conducting research at BER user facilities with BER or other funds. BER will continue its support for graduate students and post-doctoral investigators in FY 2007.

Office of Science user facilities are playing an increasingly important role in workforce development. Graduate and postdoctoral students from many different disciplines use Office of Science user facilities. For example, researchers in the environmental, biological, and physical sciences use the instruments at EMSL and the synchrotron light sources. The unique capabilities at these facilities provide graduate and postdoctoral students the opportunity to participate in leading-edge research. Approximately half of all DOE facility users are graduate or postdoctoral fellows, for example some 600 to 700 students will conduct research at EMSL in FY 2007. Students who use EMSL receive their funding from a number of sources including the EMSL user (operating) budget, other BER projects, other DOE programs, other federal agencies, international sponsors, and private industry.

The fastest growing user community at the synchrotron light sources is environmental researchers. BER is working with BES, and BER provides funding to each of the synchrotron light sources for environmental researchers. This funding provides user support for BER sponsored scientists as well as maintenance and upgrade of environmental user stations. In addition, BER is working with scientists in the environmental research community who receive funding from DOE and other agencies to develop more environmental science user stations at the synchrotron light sources. This will further increase the impact of SC facilities on workforce development in important research fields, such as the environmental sciences.

BER will continue its commitment to and dependence on research scientists at the Nation's universities. Approximately half of BER basic research funding directly or indirectly supports university-based activities. University scientists are the major users at BER facilities and other enabling research infrastructure. University-based scientists are an integral part of research programs across the entire range of the BER portfolio. These scientists are funded through individual peer-reviewed grants and as members of peer-reviewed research teams involving both national laboratory and university scientists.

University-based scientists are the principal users of BER user facilities. University scientists also form the core of the science teams in the Climate Change Research Programs that network with the broader academic community as well as with scientists at DOE laboratories and other agencies, such as the

National Aeronautics and Space Administration and the National Oceanic and Atmospheric Administration. In addition, university-based scientists are funded through Requests for Applications across the entire BER program including genomics, structural biology, low dose radiation research, climate change research, bioremediation research, medical imaging, and radiopharmaceutical development. Furthermore, university scientists work in close partnership with scientists at National Laboratories in many other BER programs including genomics, and carbon sequestration research.

	FY 2005	FY 2006 est.	FY 2007 est.
# University Grants.....	855	700	700
Average Size per year	\$300,000	\$250,000	\$250,000
# Laboratory Projects.....	400	375	350
# Permanent Ph.D.s ^a (FTEs)....	1,540	1,321	1,291
# Postdoctoral Associates ^b (FTEs).....	400	299	297
# Graduate Students ^k (FTEs)....	500	436	423
# Ph.D.s awarded ^c	125	100	105

External Independent Reviews

Beginning in FY 2005, the costs of conducting External Independent Reviews (EIRs) for Capital Asset Projects greater than \$5,000,000 within SC have been funded by SC. Examples of EIRs include conducting Performance Baseline EIRs prior to Critical Decision-2 (CD-2) to verify the accuracy of cost and schedule baseline estimates and conducting Construction/Execution Readiness EIRs, which are done for all Major System projects prior to CD-3. These funds, which are managed by the Office of Engineering and Construction Management, are exclusively used for EIRs directly related to these projects funded within SC. Beginning in FY 2007, the EIR business line will be financed via the Working Capital Fund to achieve parity on how EIRs are funded and to standardize the administration of these critical activities.

^a Estimated. Information is not readily available on the total number of permanent Ph.D. scientists associated with each research project. In addition to the principal investigator for each research project funded by BER, individual projects typically have between 1 and 20 additional Ph.D.-level scientists who are funded collaborators. Information on scientific collaborators is not routinely tracked.

^b Estimated for national laboratory projects.

^c Information is not available on the number of Ph.D.s awarded as a result of BER funded research at universities or national laboratories. Data is estimated.

Life Sciences

Funding Schedule by Activity

	(dollars in thousands)		
	FY 2005	FY 2006	FY 2007
Life Sciences			
Structural Biology.....	21,859	15,084	15,300
Molecular and Cellular Biology	103,669	109,670	159,942
Human Genome.....	62,941	62,885	74,575
Health Effects	10,174	8,808	7,321
SBIR/STTR	—	5,548	7,020
Total, Life Sciences.....	198,643	201,995	264,158

Description

The mission of the Life Sciences subprogram is to foster fundamental research in the biological and life sciences that will provide new insights and advance knowledge to underpin the Department of Energy's mission needs. Biotechnology offers the promise of revolutionary solutions to energy and environmental challenges facing DOE and the Nation. Fundamental Life Sciences research will deliver a new knowledge base for cost effective cleanup of environmental contamination, design of new strategies for enhanced capture of atmospheric carbon dioxide, and increased bio-based sources of fuel or electricity. The program will also deliver new knowledge underpinning rigorous, cost-effective standards to protect the health of DOE cleanup workers and the public, and for science-based decisions on DOE site cleanup.

Benefits

Fundamental research is supported in genomics and the health effects of low dose radiation. DNA sequencing is used to understand the genetic and environmental basis of normal and abnormal biological function, from genes that make some people more sensitive to the adverse effects of low doses of radiation to the biochemical capabilities of complex microbial communities that could be used to produce clean energy, clean up or stabilize wastes *in situ*, or sequester excess atmospheric carbon dioxide. Resources are developed and made widely available for determining protein structures at DOE synchrotron, for high-throughput genetic studies using mice, and for high-throughput genomic DNA sequencing. New capabilities are developed in the Genomics: GTL program for understanding the structure, function, and regulation of multi-protein complexes from DOE-relevant organisms and of complex, DOE-relevant microbial communities – information needed to develop biotechnological solutions for DOE needs.

Supporting Information

BER Life Sciences supports research in the following areas:

- Biological effects of low doses of ionizing radiation. The program works closely with scientists, regulators, and the public to ensure that the research results are available to develop a better scientific basis for adequately protecting people from the adverse effects of ionizing radiation.
- Genomics: GTL research, developing, together with the Advanced Scientific Computing Research program, experimental and computational resources, tools, and technologies to understand the

complex behavior of biological systems – from single microbes to communities of multiple microbial species. This information can be used to develop innovative biotechnology solutions for energy production, waste cleanup, and carbon management.

- A high-throughput DNA sequencing user resource to meet DNA sequencing needs of the scientific community.
- Resources, tools, and technologies to understand the function of human genes identified as part of the International Human Genome Project using the mouse.

Periodic retrospective analysis will be employed to evaluate the accumulation of knowledge and validate specific outcomes. This subprogram was reviewed as part of a BERAC review of the entire BER program in FY 2001 and by a BERAC Committee of Visitors (COV) in FY 2005. The next scheduled review of the Life Sciences subprogram by a BERAC COV will likely be in FY 2009.

FY 2005 Accomplishments

- Getting a Sense of Community: For the first time, both genomic and proteomic approaches have been used on a naturally occurring microbial community from an acid mine drainage site to characterize the “community genome” as well as the “community proteome” and promising insights into potential biotechnology strategies for remediation of toxic materials.
- Microbial Genome Clearinghouse—You May Have Already Won: DOE’s Joint Genome Institute has developed a new clearinghouse (<http://img.jgi.doe.gov/v1.0/main.cgi>) that will help researchers analyze the deluge of DNA data on microorganisms. The site currently stores nearly 300 draft or completed genome sequences from archaea, bacteria, and other microbes, along with tools for sifting through the data. Besides basic information about the gene, its protein, and its function, visitors can summon diagrams illustrating which biochemical pathways the gene influences. Browsing tools make it easy to pinpoint similar genes in different organisms and compare them side by side.
- Spotlighting Cellular Processes: The ability to insert fiber-optic probes into living cells to watch cellular processes unfold has been developed. Biological probes, such as antibody molecules, are mounted on the tip of small fibers and pushed through a cell’s outer membrane. When the probe encounters its target it triggers a detectable fluorescence signal. This system has been used to detect DNA damage from chemical carcinogen exposure and, for the first time, has enabled scientists to witness the onset of apoptosis, or programmed cell death, in real time. This exciting technology will now be adapted to monitor reactive oxygen species produced in live cells in response to low doses of ionizing radiation.
- Fixing Radiation Damage—It’s When, Not What: The extreme radiation resistance of the microbe *Deinococcus radiodurans* has been shown to not be due to unusual or extra genes that less resistant bacteria lack, but rather that is due to regulatory alterations that permit them to use their repair mechanisms much more efficiently. This discovery may lead to the identification of ways to increase the radiation resistance of cells prior to radiation exposures.
- A Hypothetically Speaking, It’s in the Genes: New approach for identifying “hypothetical genes” has been developed that combines experimental and computational analyses. Integrative approaches such as this offer valuable strategies for undertaking the enormous challenge of characterizing the rapidly growing number of “hypothetical” proteins that are found in each newly sequenced genome.
- Microbes Exchange Information to Clean Up Our Act: The genome of a microbe that can be used to clean up pollution by chlorinated solvents – a major category of groundwater contaminants that are

often left as byproducts of dry cleaning or industrial production has been determined. The newly determined DNA sequence provided evidence that the soil bacterium may have developed the metabolic capability to consume chlorinated solvents fairly recently, possibly by acquiring genes from a neighboring microbe in order to survive the increased prevalence of the pollutants. This proposed lateral gene transfer is part of a rapidly growing body of evidence that will dramatically change our understanding of distant and recent microbial evolution.

- Big Science Successes: From Sea to Mining See!: The work of BER-funded scientists was identified as two of the top science stories of 2004. Research on the Sargasso Sea, resulted in the discovery of more than a million new genes that had never been seen before including the startling result that a gene whose product had previously been thought of as a light receptor may be used by many marine bacteria to process carbon. Environmental genomics research focuses on a small microbial community inside an abandoned mine where the pH is extremely acidic. This research spotlights the value and potential of environmental genomics using advanced genome sequencing technologies to study the genomes of entire communities, research made possible by pioneering DOE investments in the genomic sequencing complex community DNA samples.
- Bringing Science Ethics to your Living Room: The TV documentary “Bloodlines: Technology Hits Home,” (<http://www.pbs.org/bloodlines/>) won the top broadcast award of the National Association of Science Writers (NASW), the top science journalism award in the U.S. The topic of Bloodlines is the ethical, legal, and societal challenges emerging from the Human Genome Project and some of the difficulties and dilemmas caused by the interaction of cutting edge science and the law. “Bloodlines” was originally funded by the Ethical, Legal, and Social Issues element of the BER Human Genome Program.
- Stretching a Visual Point with DNA: Optical mapping is a technology to directly image a “stretched-out” molecule of genomic DNA using the unique locations of restriction enzyme cut sites as orientation markers along the length of the DNA. This technique has now been used to directly compare single genomic DNA molecules from a series of different microbes to identify and annotate DNA alterations between bacterial strains represented by several species, including a microbe whose genome has not yet been sequenced. The results suggest that genomic rearrangements and chromosomal breakpoints of an unsequenced microbe can be readily identified and annotated against a previously sequenced strain using optical mapping. This will speed the analysis of microbial genomes by comparative genomics by using information from previously sequenced microbial species.
- Performance Art by Diatoms: Diatoms are simple single-celled algae, covered with elegant and often very beautiful casings sculpted from silica. They share biochemical features of both plants and animals and are related to the organisms that make up the well known White Cliffs of Dover in England. Scientists have taken a big step toward resolving the paradoxical nature of these odd microbes by sequencing the genome of the marine diatom *Thalassiosira pseudonana*. Analyses of these genes and the proteins they encode confirm that diatoms, in their evolutionary history, apparently acquired new genes by engulfing microbial neighbors including, possibly, genes that provided the diatom with all the machinery necessary for photosynthesis. Diatoms occupy vast swaths of ocean and fresh water, where they play a key role in the global carbon cycle. Diatom photosynthesis yields 19 billion tons of organic carbon, about 40% of the marine carbon produced each year, and thus represent one of nature’s key defenses against global warming. Progress in analyzing the diatom genome is also shedding light on how a diatom constructs its intricately patterned glass shell, progress that could benefit both materials and climate change scientists.

- Some Archaea Eat Their Dessert First: Scientists describe the use of genome based analyses of methane-oxidizing *Archaea* (evolutionarily ancient microorganisms) from deep-sea sediments to study the biological mechanisms controlling anaerobic methane oxidation. One current model suggests that relatives of methane-producing *Archaea* developed the capacity to consume methane to produce cellular carbon and energy. The new results show that nearly all of the genes typically associated with methane production are present in one specific group of these methane-consuming organisms, but appear to be “run backwards” so that they consume rather than generate methane. Importantly, the sequencing of this microbe was completed without a requirement for individual growth and culturing of each organism in the sediments, a capability that is becoming increasingly valuable since most microbes are not readily culturable. These genome-based observations provide a foundation for metabolic modeling of methane oxidation in the absence of oxygen in the deep ocean. This will lead to a better understanding of the role these organisms play in the flux of greenhouse gases from ocean to atmosphere, information that may illuminate how oceanic microbes participate in global carbon cycling and climate processes.

Detailed Justification

(dollars in thousands)

	FY 2005	FY 2006	FY 2007
Structural Biology	21,859	15,084	15,300
▪ Basic Research	6,559	—	—
Basic Structural Biology research is terminated to support Genomics: GTL research. Support for characterization, including imaging, of multiprotein complexes and of gene regulatory networks is transferred to Genomics: GTL.			
▪ Infrastructure Development	15,300	15,084	15,300
BER develops and supports access to beam lines and instrumentation at DOE’s national user facilities for the Nation’s structural biologists. BER coordinates, with the NIH and the NSF, the management of experimental stations at DOE synchrotrons (Advanced Photon Source [APS], Advanced Light Source [ALS], and Stanford Synchrotron Radiation Laboratory [SSRL]). User statistics for all BER structural biology user facilities are included in the BES facility user reports. BER continually assesses the quality of the instrumentation at its experimental stations and supports upgrades to install the most effective instrumentation for taking full advantage of the facility capabilities as they are improved by DOE.			
Molecular and Cellular Biology	103,669	109,670	159,942
▪ Microbial Genomics	8,276	—	—
Microbial genomics is consolidated within Genomics: GTL.			
▪ Carbon Sequestration Research	5,581	7,106	7,127
Microbes and plants play substantial roles in the cycling of carbon through the environment. Carbon sequestration research seeks to understand how plants and microbes work together to sequester atmospheric carbon dioxide. The program continues to leverage the genomic DNA sequence of the			

(dollars in thousands)

	FY 2005	FY 2006	FY 2007
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poplar tree, completed in FY 2004, supporting research to understand the poplar genome and proteome related to carbon utilization. Research will also focus on microbes that live in the poplar rhizosphere (root zone) to understand the role these microbes play in the transfer of carbon between the roots and the soil. The program will emphasize organisms and pathways that serve to increase long-term carbon storage to identify strategies that would lead to increased carbon storage in the poplar rhizosphere and surrounding soil, such as manipulation of the soil chemical environment to promote specific microorganisms or metabolic pathways. This research leverages BER's more fundamental microbial systems biology research in Genomics: GTL and BER's terrestrial carbon cycle research to evaluate options for molecular-based terrestrial carbon sequestration.

▪ Genomics: GTL.....	72,637	85,486	135,319
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Genomics: GTL is a microbe-based program at the forefront of the biological revolution - a systems approach to biology at the interfaces of the biological, physical, and computational sciences.

Genomics: GTL offers the possibility of biotechnology solutions that can give us abundant sources of clean energy, such as ethanol from cellulose or biohydrogen, yet control greenhouse gases such as carbon dioxide, a key factor in global climate change, and that can help us clean up contamination of the environment.

Genomics: GTL will require a mix of fundamental research and development of novel capabilities for new high-throughput biological research, e.g., for protein production, molecular imaging, small molecule production, and proteomics. Over the long-term, it will support a combination of fundamental research and technology development; development and use of facility infrastructure that will efficiently and cost effectively generate much needed data for the scientific community much like DNA sequencing was moved from the research laboratory to sequencing facilities in the human genome project; and demonstration projects developed in partnership with other DOE offices such as Energy Efficiency and Renewable Energy, Fossil Energy, and Environmental Management to "field test" potential biotechnology solutions for DOE energy and environmental needs. The program focuses on scientific challenges that can be uniquely addressed by DOE and its National Laboratories in partnership with scientists at universities and in the private sector and will focus on high-throughput genomic-scale activities (e.g., DNA sequencing, complex computational analysis, imaging, and genomic protein-expression experimentation and analysis) that are beyond the reach of individual investigators or even small teams.

(dollars in thousands)		
FY 2005	FY 2006	FY 2007

The broad goals of this research are shared with other agencies, such as the National Institutes of Health, the National Science Foundation, the Department of Agriculture, the Environmental Protection Agency, and private sector companies and will require coordination exceeding that of the Human Genome Project.

In FY 2007, the program continues to support a mix of large multidisciplinary research teams and smaller individual investigator projects to:

- develop computational models and the necessary algorithmic and computational tools needed to describe the biochemical capabilities of microbial communities; to integrate diverse data types and data sets into single models; and that accurately describe and predict the behavior of genetic regulatory networks;
- develop high-throughput approaches for isolating and characterizing microbial molecular machines;
- develop new technologies and strategies for imaging individual proteins and molecular machines inside microbes;
- develop new technologies for producing large numbers of microbial proteins and molecular tags to identify those proteins;
- develop microbe-based strategies for production of cellulosic ethanol and hydrogen; and
- determine the societal and legal implications of genomics research and technology.

In FY 2007, research will also continue the high-throughput DNA sequencing of microbes and microbial communities. This DNA sequence information will continue to serve as the core of biological information needed to understand the control and function of molecular machines and complex microbial communities.

Technology development research relevant to proposed GTL user facilities is increased in FY 2007 to address key challenges. Research will be increased to develop new methods that enable scientists to “see” individual molecular machines at work inside microbes. This capability will provide information that is needed to understand the functions, regulation, and interactions of molecular machines. Aspects of proteome analysis are now very efficient and being used for large numbers of analyses. Research will be increased to improve the efficiency of components of the proteome “pipeline,” including aspects of initial sample preparation, analysis of protein modifications, and development of capabilities of high-throughput metabolite analysis. Research will also be increased to improve methods for long-term analysis of complex microbial communities in controlled environments. Only by understanding how microbes live and work together in the environment can we take advantage of their capabilities to address DOE mission needs.

SciDAC research is initiated to develop mathematical and computational tools needed for complex biological systems modeling and for analysis of complex data sets, such as those generated by mass spectrometry.

The research activities in this subprogram are carried out at National Laboratories, universities, and private institutions and selected through competitive and merit-reviewed processes.

(dollars in thousands)

FY 2005	FY 2006	FY 2007
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The request greatly accelerates fundamental Genomics: GTL research, including SciDAC research, so that Genomics: GTL research progress will be maximized and the program is able to optimize use of potential future facility infrastructure. GTL research accelerates, including a focus on microbe-based generation of hydrogen, production of ethanol from cellulose, sequestration of carbon dioxide, and bioremediation. The program would include multiple research paths to avoid roadblocks and to optimize systems design options and would be coordinated across DOE programs (both within and outside SC), across federal agencies (including the Department of Agriculture, National Science Foundation, National Institutes of Health), and across DOE laboratories, academia, industry, and nongovernmental organizations. Increased SciDAC research would develop mathematical and computational tools needed for complex biological system modeling, for analysis of complex data sets, such as mass spectrometry, and to develop predictive models of complex microbial communities.

Within the request, \$40,000,000 is for GTL research which will contribute biotechnology solutions for two biofuels: hydrogen and ethanol. Studies have suggested that, by 2100 biotechnology-based energy use could equal all global fossil energy use today. Bioethanol is derived from plant cell walls (cellulosic ethanol) and biohydrogen is produced from water using energy from the sun (biophotolytic hydrogen). Cellulosic ethanol is a carbon-neutral fuel that can already be used within today's energy infrastructure. Microbes or microbial processes are used to produce ethanol from plant biomass such as corn plants left after a corn harvest or energy crops such as poplar trees, that are specifically raised as biomass for energy production. Hydrogen is the ultimate carbon-free energy carrier that can be converted efficiently to energy in fuel cells with water as the only chemical by-product. Microbes, the planet's dominant photosynthetic organisms, exist that can use solar energy to convert water to hydrogen and oxygen, i.e., biophotolysis.

New knowledge on biophotolysis and hydrogenases will be used to engineer the ideal microbe to use in hydrogen bioreactors or the ideal enzyme-catalyst to use in bioinspired nanostructures for hydrogen production. New knowledge on the enzymes and microbes that contribute (individually and together) to the conversion of cellulose to ethanol will be used to develop genetically modified, multifunctional microbes or a stable mixed culture of microbes capable of carrying out all biologically mediated transformations needed for the complete conversion of biomass to ethanol in a single step.

Fundamental research will be supported to understand biophotolysis, and other processes, well enough that predictive models of hydrogenase (the enzyme that cleaves water to produce hydrogen) structure and function, genetic regulatory and biochemical networks, and eventually entire microbes can be developed. Research will include investigations on a range of hydrogen-producing enzymes and organisms, understanding how hydrogenases work, the inhibition of hydrogenase activity by oxygen, and genetic regulatory and biochemical processes that influence hydrogen production.

Research will also be supported on a variety of enzymes and microbes that contribute (individually and together) to the conversion of cellulose to ethanol; analysis of enzymes to understand how they interact with and breakdown cellulose; a determination of the factors, such as temperature and different combinations of sugars, that influence biomass degradation or ethanol production; strategies for producing and maintaining stable mixed cultures of microbes; and improved capabilities for genetically engineering microbes that produce bioethanol.

	(dollars in thousands)		
	FY 2005	FY 2006	FY 2007
▪ Low Dose Radiation Research	17,175	17,078	17,496

The goal of the Low Dose Radiation Research program is to support research that will help determine health risks from exposures to low levels of ionizing radiation, information critical to adequately and appropriately protect people and to make the most effective use of our national resources. Information developed in this program will provide a better scientific basis for making decisions with regard to remediating contaminated DOE sites and for determining acceptable levels of human health protection, both for cleanup workers and the public, in the most cost-effective manner. Some research in this program is jointly funded with NASA's Office of Biological and Physical Research.

Radiation studies have traditionally been carried out using isolated cells and the responses of those cells were extrapolated to tissues and organisms. We now know that cells within tissues respond very differently to radiation than do isolated cells. This difference is greatest for very low dose exposures, or for very low dose rates, because in these situations, most of the cells in a tissue would not be irradiated at all. After these low-level exposures, the few irradiated/potentially-damaged cells in the tissue are mostly surrounded and heavily outnumbered by unirradiated/undamaged cells.

We now know that tissues often "protect" themselves from abnormal cells—such as a cell damaged by radiation—and defective cells may be stimulated to undergo "altruistic suicide." Tissue function is the culmination of a multicellular network coordinated by soluble endocrine, autocrine, and paracrine signals, and linked through a scaffolding of extracellular matrix that dynamically maintains homeostasis by regulating tissue composition, function, and phenotype. Emerging data shows that for low dose exposures it is the networked, multicellular responses, rather than the damage *per se*, that dictate whether homeostasis is restored or if pathology ensues. High dose exposure may corrupt normal signaling and moderate chronic irradiation may persistently alter cellular phenotype compromising the surveillance of abnormal cells and allowing aberrant cells to accumulate and proliferate.

In FY 2007, the program has an increased emphasis on systems biology concepts to place radiation induced bystander effects, adaptive response, and genomic instability data into the context of irradiated system (i.e. tissues). Bystander effects result from cell-cell communication (extracellular signaling) and are a type of early multicellular programmed response that attempts to re-establish homeostasis and eliminate abnormal cells. Adaptive response and multi-generational radiation-induced genomic instability may result from persistent network perturbations following radiation exposures.

In FY 2007, the program is also emphasizing the use of genome-based technologies to learn how cells communicate with each other in tissues in response to radiation, what causes cells and tissue to undergo different biological responses to radiation at different times, and how some people may be more sensitive to radiation while others are relatively resistant.

The research activities in this subprogram are carried out at National Laboratories, universities, and private institutions and selected through competitive and merit-reviewed processes. University scientists, competing for funds in response to requests for applications, conduct a substantial fraction of the research in this subprogram.

	(dollars in thousands)		
	FY 2005	FY 2006	FY 2007
Human Genome	62,941	62,885	74,575
▪ Joint Genome Institute	51,500	51,500	62,055

The Joint Genome Institute's (JGI) high-throughput DNA sequencing factory, the Production Genomics Facility (PGF) is focused on helping to meet the growing demand for DNA sequencing in the broader scientific community. Sequencing capacity will be increased to at least 50 billion base pairs in FY 2007 to support the increasing demand and need of the DOE research programs and the scientific community. The JGI's Community Sequencing Program (CSP) devotes 60% of its sequencing capacity to the merit-reviewed sequencing needs of the broader scientific community, including the needs of other agencies. DNA sequencing targets are chosen using peer review of requests for sequencing submitted by individual scientists and other federal agencies that share some DOE missions (for example USDA for Biomass). In FY 2007, the CSP will sequence approximately 30 billion base pairs of DNA from individual microbes, microbial communities, small plants and animals, and large plants and animals that will be selected by the CSP's merit review panel in FY 2006. Any large genomes selected for sequencing through the CSP will be required to meet the additional criteria of general relevance to DOE mission needs. Forty percent of the JGI's DNA sequencing capacity is being used to address DOE sequencing needs, including BER programs such as carbon sequestration research and bioremediation research, low dose radiation research and other DOE and national needs. The substantial high-throughput DNA sequencing needs of the GTL program (\$10M) are supported at the JGI directly by the Genomics: GTL program and are not included here. These GTL funds support DNA sequencing and DNA sequencing research that present unique sequencing challenges primarily attributable to the complexity or difficulty of the environments from which the microbes or plants were isolated.

The JGI is a virtual research institute principally comprised of research programs at DOE national laboratories (LLNL, LANL, LBNL, PNNL, and ORNL). The JGI's DNA sequencing factory is located in Walnut Creek, California.

In FY 2007, the increased funding supports an increase of 15% in the DNA sequencing capacity for DOE and the scientific community.

▪ Tools for DNA Sequencing and Sequence Analysis	9,594	9,785	10,520
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BER continues to develop the tools and resources needed by the scientific, medical, and industrial sector communities to fully exploit the information contained in complete DNA sequences, including the first human genome sequence. Use of sequence information to understand human biology and disease will also require new strategies and tools capable of high-throughput, genome-wide experimental and analytic approaches. BER will continue efforts to develop high-throughput approaches for analyzing gene regulation and function.

The research activities in this subprogram are carried out at the JGI, national laboratories, universities, and private institutions and selected through competitive and peer-reviewed processes.

In FY 2007 the increased funding will support additional efforts to develop high-throughput annotation methods that keep pace with the rapidly increasing rate of DNA sequencing.

	(dollars in thousands)		
	FY 2005	FY 2006	FY 2007
▪ Ethical, Legal, and Societal Issues (ELSI).....	1,847	1,600	2,000
In FY 2007, ELSI research will increase and complete the refocusing of ELSI research on activities applicable to Office of Science issues in biotechnology and nanotechnology such as environmental or human health concerns associated with Genomics: GTL or nanotechnology research. Research with these funds will be coordinated across the Office of Science. The increased funding will support the first full year of research in the newly refocused ELSI program.			
Health Effects	10,174	8,808	7,321
Functional genomics research is a key link between human genomic sequencing, that provides a complete parts list for a genome, and the development of information (a high-tech owner's manual) that is useful, in the case of human, in understanding normal human development and disease processes. The mouse continues to be the focus of our efforts. Research at BER's Center for Comparative and Functional Genomics user facility at Oak Ridge National Laboratory serves as a national focal point for high-throughput genetic studies using mice. This facility creates and genetically characterizes new mutant strains of mice that serve as important models of human genetic diseases and for understanding gene function especially as they relate to the genetic information found on human chromosomes 5, 16, and 19 (DOE's chromosomes in the International Human Genome Project). It also develops high-throughput tools and strategies to characterize these mice. This user facility provides tools useful to the entire scientific community for decoding the functionality of the human genome.			
The research activities in this subprogram are principally carried out at National Laboratories, selected through merit-reviewed processes.			
In FY 2007, the decreased funding will reduce research on animal models for disease associated with exposures to energy-related materials.			
SBIR/STTR.....	—	5,548	7,020
In FY 2005 \$4,816,000 and \$577,000 were transferred to the SBIR and STTR programs, respectively. FY 2006 and FY 2007 amounts are the estimated requirements for continuation of the programs.			
Total, Life Sciences.....	198,643	201,995	264,158

Explanation of Funding Changes

 FY 2007 vs.
 FY 2006
 (\$000)

Structural Biology

- Structural Biology Infrastructure Development is held near FY 2006 levels..... +216

Molecular and Cellular Biology

- Carbon Sequestration Research is held near FY 2006 levels..... +21

FY 2007 vs. FY 2006 (\$000)

<ul style="list-style-type: none"> ▪ Genomics: GTL research will be increased to speed development of technologies that underpin proposed facility infrastructure including high-throughput methods for real time imaging of molecular machines inside microbial cells, for reducing current bottlenecks in high-throughput proteomics, and for improved methods for studying complex microbial communities in controlled environments. The increase also funds the following: greatly accelerates fundamental Genomics: GTL research, so that Genomics: GTL research progress will be maximized and the program is able to optimize use of potential future facility infrastructure. It also includes enhanced SciDAC Research, microbe-based generation of hydrogen and production of ethanol from cellulose, sequestration of carbon dioxide, and bioremediation. The program would include multiple research paths to avoid roadblocks and to optimize systems design options and would be coordinated across DOE programs (both within and outside SC), across federal agencies (including the Department of Agriculture, National Science Foundation, National Institutes of Health), and across DOE laboratories, academia, industry, and nongovernmental organizations. Increased SciDAC research would develop mathematical and computational tools needed for complex biological system modeling, for analysis of complex data sets, such as mass spectrometry, and to develop predictive models of complex microbial communities.... 	+49,833
▪ Low Dose Radiation Research is held near FY 2006 levels.....	+418
Total, Molecular and Cellular Biology	+50,272
Human Genome	
▪ Joint Genome Institute increases DNA sequencing capacity for DOE and the scientific community by an additional 15% to support increased scientific need for genomic DNA sequencing in BER programs and in the broader scientific community. Tools for DNA Sequencing and Sequence Analysis research increases to continue development of high-throughput approaches for analyzing gene regulation and function	+10,555
▪ Tools for DNA Sequencing and Sequence Analysis research increases to continue development of high-throughput approaches for analyzing gene regulation and function.	+735
▪ ELSI research increases to identify and understand the environmental or human health concerns of Genomics: GTL research.....	+400
Total Human Genome.....	+11,690

Health Effects

- Health Effects research decreases research on animal models for disease associated with exposures to energy-related materials. The support for the mouse user facility, the Center for Comparative and Functional Genomics, continues at FY 2006 levels....

-1,487

FY 2007 vs. FY 2006 (\$000)

SBIR/STTR

▪ Increases in SBIR/STTR due to increases in Life Sciences research funding.....	<u>+1,472</u>
Total Funding Change, Life Sciences	+62,163

Climate Change Research

Funding Schedule by Activity

	(dollars in thousands)		
	FY 2005	FY 2006	FY 2007
Climate Change Research			
Climate Forcing.....	74,346	78,980	77,831
Climate Change Modeling.....	27,507	26,680	25,175
Climate Change Response.....	25,132	24,986	23,181
Climate Change Mitigation	8,550	6,947	5,014
SBIR/STTR	—	3,936	3,708
Total, Climate Change Research.....	135,535	141,529	134,909

Description

The mission of the Climate Change Research subprogram is to deliver relevant scientific knowledge that will enable scientifically based predictions and assessments of the potential effects of greenhouse gas and aerosol emissions on climate and the environment.

Benefits

This subprogram's research will reduce and resolve key uncertainties and provide the scientific foundation needed to predict, assess, and help mitigate adverse effects of energy production and use on the environment. This will be done through research on climate forcing and processes, including factors that affect climate forcing, such as clouds and aerosols and carbon cycling, climate change modeling and simulation to develop models needed to project what the likely response of the climate system would be in the future to natural and human-induced climate forcing, the response of ecological and human systems to ongoing and projected future changes in climate and atmospheric composition associated with energy production, and climate change mitigation, specifically research that could lead to the development of strategies or technologies for modifying or managing natural carbon sequestration processes in terrestrial systems to enhance their potential.

Supporting Information

The Climate Change Research subprogram supports four contributing areas of research: Climate Forcing, including processes that affect climate forcing; Climate Change Modeling; Climate Change Responses; and Climate Change Mitigation. The research is focused on understanding the physical, chemical, and biological processes affecting the Earth's atmosphere, land, and oceans and how these processes may be affected, either directly or indirectly by changes in radiative forcing of climate resulting from energy production and use, primarily the emission of carbon dioxide from fossil fuel combustion, how the climate system would likely respond to human-induced and natural changes in radiative forcing, what the potential response would be of ecological and ecosystem systems to climatic changes, and how natural processes in terrestrial and ocean systems can be altered or managed to enhance their long-term capacity to sequester carbon dioxide emitted to the atmosphere, thereby helping to mitigate the increase in atmospheric CO₂. BER has designed and planned the research program to provide data that will enable objective assessments of the potential for, and consequences of, global

warming. It is intended to provide a scientific basis that will enable decision makers to determine a “safe level” of greenhouse gases in the Earth’s atmosphere to avoid a disruptive, human-induced interference in the climate system.

U.S. Climate Change Research is currently organized into the Climate Change Science Program (CCSP) and the Climate Change Technology Program (CCTP). The CCSP includes the interagency U.S. Global Change Research Program (USGCRP), proposed by the first President Bush in 1989 and codified by Congress in the Global Change Research Act of 1990 (P.L. 101-606), and the current Administration’s Climate Change Research Initiative (CCRI).

The BER Climate Change Research subprogram (excluding the Climate Change Mitigation element which focuses on carbon sequestration in the terrestrial biosphere) represents DOE’s contribution to the CCSP (USGCRP and CCRI). The Climate Change Mitigation/carbon sequestration element in Climate Change Research plus carbon sequestration activity in the Life Sciences subprogram are BER’s contribution to the CCTP.

The CCRI is a set of cross-agency programs in areas of high priority climate change research where substantial progress is anticipated over the next three to five years. The specific focus areas include climate forcing (atmospheric concentrations of greenhouse gases and aerosols); climate feedbacks and sensitivity; climate modeling, including enabling research; regional impacts of climate change, including environment-society interactions; and climate observations. In FY 2007, BER will continue to participate in one of the specific research areas: climate forcing, which includes modeling carbon sources and sinks, especially those in North America. In FY 2007, BER will continue to support research to quantify the magnitude and location of the North American carbon sink, a high priority need identified in the interagency Carbon Cycle Science Plan, and on climate modeling, Atmospheric Radiation Measurement (ARM), and Integrated Assessment activities (BER’s FY 2007 CCRI request is \$23,750,000).

A major emphasis of the Climate Change Research subprogram is on understanding climate forcing, especially the radiation balance from the surface of the Earth to the top of the atmosphere and how changes in this balance due to increases in the concentration of greenhouse gases in the atmosphere may alter climate. Much of the research is focused on improving the quantitative models necessary to predict possible climate change at global and regional scales. Research in the ARM program will continue to focus on resolving the greatest scientific uncertainty in climate change prediction – the role of clouds and their interactions with solar radiation. ARM seeks to develop a better quantitative understanding of how atmospheric properties, including the extent and type of cloud cover and changes in aerosols and greenhouse gas concentrations, affect the solar and infrared radiation balance that drives the climate system. It also includes support to archive and analyze climate change data, including data from the ARM sites, and data on greenhouse gas emissions and concentrations and to make such data available for use by the broader climate change research community.

The Atmospheric Science program was reconfigured in FY 2005 to focus on acquiring the data needed to understand the atmospheric processes that control the transport, transformation, and fate of energy-related aerosols emitted to the atmosphere and their radiative properties so as to enable more reliable and accurate simulations of their radiative forcing effect on climate. In FY 2007, the program will continue studies of the physical, chemical, and radiative properties of aerosols and how much they may directly or indirectly affect the radiation balance.

Research on the carbon cycle explores the movement of carbon on a continental scale, starting from natural and anthropogenic emissions to ultimate sinks in the terrestrial biosphere and the oceans.

Experimental and modeling efforts primarily address the net exchange of carbon between major types of terrestrial ecosystems and the atmosphere. The focus in developing an understanding and ability to model the processes controlling the exchange of carbon dioxide between terrestrial systems and the atmosphere and how these processes may affect the atmospheric concentration of carbon dioxide which contributes to climate forcing.

Climate change modeling program element develops advanced, fully coupled, atmosphere-ocean-sea ice-land surface climate models and uses premier supercomputers to simulate and predict climate and climate change, including evaluating uncertainties in climate models due to changes in atmospheric levels of greenhouse gases on decade-to-century time scales. The focus is on developing, testing, improving, and applying state-of-the art climate models for assessing the potential for future climate changes due to natural and human-induced forcing of the climate system.

Ecological Processes research is focused on experimental and modeling studies to understand and predict the effects of climate and atmospheric changes on the biological structure and functioning of terrestrial ecosystems. The research also seeks to identify the potential feedbacks from ecosystems to climate and atmospheric composition. The research emphasizes major field studies of intact ecosystems using experimental manipulations of, for example, carbon dioxide and ozone concentrations and precipitation, and using data from these experiments to develop, test, and improve models for simulating and predicting ecosystem responses to environmental changes associated with energy production and use. The research also focuses on the causal mechanisms and pathways of biological and ecological responses ranging from the proteome of individual species to the whole ecosystem and will develop advanced computational models to establish how changes in the proteomes of single species or whole systems can explain the responses and behavior of complex ecosystems.

Human Interactions research is focused on improving methods and models that can be used to assess the economic and societal costs and benefits of both human-induced climate change and possible response options or strategies for mitigating or adapting to climate change.

The carbon sequestration element under Climate Change Mitigation funds basic research that seeks to exploit the biosphere's natural processes to enhance the sequestration of atmospheric carbon dioxide in terrestrial ecosystems. It also seeks the understanding needed to assess the potential environmental implications of purposeful enhancement and/or disposal of carbon in the terrestrial biosphere. The carbon sequestration activities include research to identify and understand the environmental and biological factors or processes that limit carbon sequestration in terrestrial systems and to develop approaches for overcoming such limitations to enhance sequestration. The research includes studies on the role of terrestrial microorganisms and terrestrial higher plants in carbon sequestration.

Periodic retrospective analysis is employed to evaluate program management processes, priorities, and outcomes. A BERAC COV for the Climate Change Research Program was established in FY 2004 to provide outside expert validation of the program's merit-based review and funding decision processes that impact scientific quality, programmatic relevance, and performance. The COV found the Climate Change Research subprogram to be a credit to DOE and an example of the way that Executive agencies should operate. It also found many of the programs within the subprogram to be unique. The COV concluded that the Climate Change Research programs are productive and support high quality research that plays an important role in the DOE and especially in the interagency U.S. Climate Change Science Program. The COV found the Climate Change Research subprogram to be generally well managed, but noted the need to improve documentation of the basis for proposal funding decisions, and the

performance and outcomes of Climate Change Research programs. BER has taken action to address these findings.

The full report and the BER response are at <http://www.science.doe.gov/ober/berac.html>.

FY 2005 Accomplishments

- Release of New Version of Fully-Coupled Climate System Model: The most recent version of the Community Climate Model System, CCSM3.0, which is a fully coupled atmosphere-ocean-sea ice-land surface model, was released. Its release marks a significant milestone in the development of climate models that now incorporate the ability to simulate phenomena ranging from the effect of volcanic eruptions on temperature patterns to the impact of shifting sea ice on sunlight absorbed by the oceans. The model was developed at the National Center for Atmospheric Research in collaboration with researchers at universities and DOE laboratories, with major investments from DOE's climate modeling program. Model results and the underlying computer codes have been released to atmospheric researchers and other users worldwide. Scientists have applied the new model to generate scenarios of future potential climate change for use in preparing the Intergovernmental Panel on Climate Change's Fourth Assessment Report (IPCC AR4). Preliminary results of simulations of future climate states using CCSM3.0 indicate global temperatures could rise by 2.6 degrees Celsius (4.7 degrees Fahrenheit) in a hypothetical scenario in which atmospheric levels of carbon dioxide are suddenly doubled. That is significantly more than the 2 degree Celsius (3.6 degree Fahrenheit) increase that had been indicated by the preceding version of the model. In addition to simulating temperatures over the next century, scientists are using the model to study climate patterns of the past, such as the peak of the last ice age 21,000 years ago. It will also be used to probe chemical processes and the cycling of carbon between the atmosphere, ocean, and land, as well as the localized impacts of sulfates and other pollutants on climate.
- Climate Model Simulates Occurrence of Extreme Heat Wave Events Under Greenhouse Gas Forcing Climate Change Scenario: Results under a 'business-as-usual' scenario of future carbon dioxide emissions using a global coupled climate model indicate a distinct geographic pattern to future simulated changes in heat waves. Model results for areas of Europe and North America, associated with the severe heat waves in Chicago in 1995 and Paris in 2003, show that future heat waves in these areas will become more intense, more frequent, and longer lasting in the second half of the 21st century. Observations and the model results show that present-day heat waves over Europe and North America coincide with a specific atmospheric circulation pattern that is intensified by ongoing increases in greenhouse gases, indicating that it will produce more severe heat waves in those regions in the future. This research was jointly sponsored by BER and the National Center for Atmospheric Research.
- Regional Climate Model Simulates Global "Warming Hole" in Central United States: A local minimum warming ("warming hole") in summer over the central United States was predicted for the next few decades using a regional climate change model. Although the simulated daily maximum temperature in the "hole" increased in summer between the 1990s and 2040s, the simulated increase in the "hole" was 2.0-2.5°C (about 4°F) less than in the surrounding area. This projected "warming hole" coincides roughly with an observed "hole" in the warming of the last 25 years of the 20th century in the central United States. The simulation showed that the "hole" was associated with changes in low-level circulations that lead to replenishment of seasonally depleted soil moisture, thereby increasing late-summer evapotranspiration and suppressing daytime heating. These regional-scale feedback processes, which are unresolvable by most global climate models, may partly explain

the cooling trend in the central and eastern United States occurring in spite of global warming, and potentially could reduce the magnitude of future warming in the region due to the enhanced greenhouse effect caused by increasing carbon dioxide concentration in the atmosphere.

- ARM Mobile Facility (AMF) Completed and Deployed to Study Clouds and Aerosols: With instrumentation and data systems similar to ARM stationary sites at the North Slope of Alaska and the Tropical Western Pacific, fabrication of the AMF has been completed for deployment to sites around the world in various climatic regimes for durations of 6 to 18 months. Following a competitive peer review deployments were selected for 2005 and 2006. In 2005, researchers from the ARM Program deployed the facility at Pt. Reyes, California and in collaboration with scientists from the U.S. Office of Naval Research, NOAA, and DOE's Atmospheric Science Program began a 6-month campaign to study the interactions between marine stratus clouds and aerosols and the effect of such interactions on the absorption and scattering in incoming solar radiation and drizzle. The experiment addresses the specific effects of aerosols on the discrepancy between the measured and modeled amount of solar radiation absorbed by these clouds. In 2006, the AMF will be deployed at Niamey, Niger, Africa, as part of the field phase of the international African Monsoon Multidisciplinary Analysis (AMMA). The campaign will study meteorological conditions ranging from deep, tropical convective clouds in the humid tropical air masses prevalent in the wet season to the aerosol-laden dry air masses found during the dry season. These campaigns will provide unique opportunities for evaluating and improving the parameterization schemes used in climate models across a wide range of meteorological conditions.
- New Parameterization Improves Climate Simulations: The addition of a new ARM-developed parameterization scheme for convection to the Community Atmosphere Model (known as CAM3) has resulted in a remarkable improvement in the simulation of climate and its variability on intraseasonal timescales in the Tropics. In particular, several long-standing model biases, including the dual Intertropical Convergence Zones in the Equatorial Pacific Ocean are eliminated when the new parameterization is used in the model. The new parameterization improved simulations for precipitation in both winter and boreal summer seasons and more accurately simulates the annual cycle of the monsoon precipitation. The new convection parameterization also improves the simulation of tropical intraseasonal variability.
- Carbon Balance of Western Montane Coniferous Forest found to be Sensitive to Timing of Spring Warming: Montane forests are responsible for much of the atmospheric CO₂ assimilated by terrestrial ecosystems in the western United States. This poses challenges for accurate quantification of ecosystem carbon balance and dynamics because the current generation of CO₂ exchange measurement systems and approaches are designed to function in relatively flat, simple terrain. Using a specially designed multiple tower system, it was shown that when current measurement methods are deployed in mountainous terrain without special accommodation for the complex topography, the annual net CO₂ uptake by forests is underestimated by about 17%. When corrected for complex topography, a subalpine forest in Colorado was found to store about 100 g C m⁻² each year (5-year average). This annual net CO₂ uptake was sensitive to interannual climatic variation, with the most sensitive period being the early spring (April and May), when as much as 40% of the annual net CO₂ uptake can occur within a 30-day period. During years when spring warming occurred early, as is predicted for the future by climate models, annual net CO₂ uptake by the forest declined; this is contrary to studies in eastern deciduous forest ecosystems, where earlier spring warming is predicted to enhance annual net CO₂ uptake. This divergence may be due to differences

between the evergreen trees that dominate western forests and the winter-deciduous trees that dominate eastern forests.

- Genetic Diversity and Gene Expression of Carbon Fixation Influence Carbon Fixation and Potentially Carbon Sequestration in Gulf of Mexico area affected by Mississippi River Plume: The Mississippi River Plume strongly influences the biology, chemistry, physics, and the air-sea interactions of much of the Gulf of Mexico, including the atmospheric humidity and CO₂ levels of the southeastern United States. The biological processes occurring in this plume largely dictate whether it takes up or releases atmospheric CO₂. Using primary productivity and remote sensing analyses, it was shown that the offshore Mississippi River Plume is responsible for about 40% of the surface primary productivity in the low nutrient waters of the Gulf of Mexico. Nutrient uptake, biological productivity, and gene expression analyses revealed two alternative routes for CO₂ fixation in the Plume: (1) a cyanobacterial-driven uptake which likely leads to only short-term carbon storage in the ocean and (2) a diverse, diatom driven uptake which may contribute to longer-term carbon storage (removal from the atmosphere) in the ocean. The genetic sequence information that was collected will enable quantification of phytoplankton group-specific gene expression in the environment, providing new insights about the role of the Mississippi River Plume in controlling atmospheric CO₂ increase.
- Can Iron Fertilization of the Ocean be both Effective and Efficient at Sequestering Carbon? An investigation into the effectiveness of iron fertilization of the ocean surface as a means to increase the efficiency of the biological pump of carbon in waters of the Ross Sea, Antarctica was conducted using the CIAO ecosystem model. Results indicate that the stimulation of air-sea CO₂ exchange caused by iron fertilization depends primarily on the timing of the fertilization, regardless of the amount of iron added. Increasing the area of fertilization produced the largest response and increasing initial iron concentration produced the smallest, in the model. In all cases, as the intensity of iron fertilization increased, the fertilization efficiency (CO₂ uptake per unit iron added) dropped. Strategies that maximized the fertilization efficiency resulted in relatively little additional CO₂ being drawn out of the atmosphere. Conversely, to markedly increase oceanic uptake of atmospheric CO₂ would require the addition of large amounts of iron due to the low fertilization efficiencies associated with maximum air-sea CO₂ exchange.
- Hydrate Reactor Developed to Improve Efficiency of Deep Ocean Injection for Carbon Sequestration: A continuous-jet hydrate reactor was developed to efficiently produce dense, negatively buoyant (i.e., sinking) CO₂ hydrate particles for the purpose of carbon sequestration via direct injection of CO₂ into the deep ocean. The technical feasibility of the reactor was proven at Oak Ridge National Laboratory using a 72-liter seafloor process simulator and at the National Energy and Technology Laboratory using a high-pressure water tunnel facility. Field verification of laboratory results was demonstrated in Monterey Bay, California, using the facilities of Monterey Bay Aquarium Research Institute. Prior to this, methods for direct injection of CO₂ into the deep ocean were inefficient because the injection of liquid CO₂ alone produces buoyant droplets with the risk of returning to the ocean surface and atmosphere rather than remaining in the ocean for long periods required for effective carbon sequestration.
- Deep Ocean Injection of CO₂ harmful to deep-sea organisms: Effects of injected CO₂ on foraminiferal assemblages living at 3600 meter depth on the deep-sea floor were evaluated during the first field experiment off the coast of California. Foraminifera, commonly referred to as “forams” are single-celled protists with shells and range in size from 100 micrometers to almost 20 centimeters (cm). Most of the estimated 4,000 living species of forams are found in the world’s

oceans. Injection of CO₂ into the deep ocean has been proposed as means to sequester carbon and slow the increase in atmospheric CO₂ concentration. Results from this study imply almost complete initial mortality of forams and severe carbonate dissolution of the shells of forams in ocean sediments to depths of at least 10 cm into the sediment in close association to the point of CO₂ injection. This results in major decreases in the abundance and taxonomic diversity in both living and dead assemblages of forams on the sea floor. A second, shallower (3100 meter depth) experiment confirmed total mortality in at least the upper 1 cm of sediments and dissolution effects to even greater depths, which are still being determined. Benthic foraminifera are therefore now known to be highly vulnerable to CO₂ injection into the deep ocean.

- Forest Food Chain Dynamics Altered by Elevated Atmospheric Carbon Dioxide and Ozone Concentrations: BER constructed, maintains, and operates a large-scale field research facility in northern Wisconsin to study effects of experimentally elevated concentrations of carbon dioxide and ozone on the structure and functioning of hardwood forest ecosystems (concentrations of both gases are increasing because of energy production from fossil fuels). The forest being studied, a constructed mixture of aspen, birch, and maple trees, has been exposed to elevated carbon dioxide and ozone since 1997. Scientists recently discovered that elevated levels of these two gases can alter the feeding and reproduction of herbivorous insects, as well as their pheromone-mediated predator escape behaviors. For example, the efficacy of insect escape responses appears to increase under elevated O₃ but decrease under elevated CO₂. These results indicate that shifts in the dynamics of trees, the insects that feed on them, and the predators that feed on those insects could be altered by ongoing changes in atmospheric composition, with implications for the future health of forests.
- Enhanced Monsoon could alter Mojave Desert vegetation: Many climate models predict an enhanced monsoon in the southwestern United States, which could include additional rain in the Mojave Desert. Three years of a field experiment in the Mojave Desert, including added summer rain (three 25 millimeter events) have resulted in stimulation of growth in the dominant perennial plants. Deeper penetration into the soil of wetting fronts caused by added summer rain resulted in increased depth of root growth of several shrubs, including creosote bush. These results indicate that an enhanced future monsoon in the Southwest might change the structure and functioning of Mojave Desert scrub plant communities in favor of more deep-rooted plants capable of exploiting this additional moisture.
- Warming and increased carbon dioxide concentration accelerates succession in terrestrial ecosystem: The warmer temperatures and increased atmospheric carbon dioxide concentrations associated with urban areas, relative to upwind rural areas, was used to study effects of warming and rising carbon dioxide levels on the early stages of ecosystem secondary succession (i.e., the development of an ecosystem following a disturbance). The warming and elevated carbon dioxide levels now associated with urban Baltimore broadly reflect conditions expected about 50 years from now in rural areas. The present Baltimore conditions increased plant growth, including the growth of weedy species, and accelerated a shift from annual herbaceous species to perennial plant species, including young trees. The results indicate that warming and increasing carbon dioxide concentration may both enhance plant growth and accelerate successional processes following ecosystem disturbance in Maryland and in ecologically and climatically similar regions.
- New Ecological Research Facility Becomes Operational: A research facility at the Oak Ridge National Laboratory was established for studying the effects of atmospheric CO₂ enrichment, warming, and altered soil moisture on old-field ecosystems, which represent an important stage of recovery from disturbance in many ecosystems. Plants typical of old-field communities were

established within field chambers. Chamber air is modified to provide current or elevated (+300 ppm) CO₂ concentration in combination with near-current (+0.5 °C) or elevated (+3.2 °C) temperature. Rain is excluded from the ecosystems and water is added to maintain wet or dry soil conditions. Effects of these environmental changes on the organisms within these ecosystems, and the ecosystems themselves, will be quantified during coming years. The establishment of this research facility meets a near-term milestone of the U.S. Climate Change Science Program.

- Soil communities altered by elevated atmospheric carbon dioxide and ozone concentrations: Soil microorganisms depend on plant litter (dead plant parts) as a source of food, therefore, increases in plant litter production caused by elevated CO₂ and declines in litter production caused by elevated O₃ could alter microbial community composition and functioning. Exposure of aspen, aspen-birch, and aspen-sugar maple stands to elevated carbon dioxide resulted in greater fungal metabolism of plant litter, whereas exposure of the trees to elevated ozone eliminated this response. Molecular analysis of fungal DNA in the soils under the trees revealed that elevated carbon dioxide favored a community of litter degrading fungi that was ecologically distinct from that favored by elevated O₃; both differed from the fungal community under the present ambient atmosphere. Results indicate that fungal community composition and activity in soils (and perhaps biodiversity) will be modified as atmospheric concentrations of carbon dioxide and ozone continue to change.

Detailed Justification

	(dollars in thousands)		
	FY 2005	FY 2006	FY 2007
Climate Forcing.....	74,346	78,980	77,831
▪ Atmospheric Radiation Measurement (ARM) Research.....	12,243	13,731	14,765

In FY 2007, the principal goal of the ARM research will continue to be the development of an improved understanding of the radiative transfer processes in the atmosphere and to formulate better parameterization schemes of these processes in climate prediction models, referred to as General Circulation Models (GCMs). The increased funding will be used to support research using ARM data to develop and test cloud resolving models and other parameterization schemes and incorporate them in cloud modeling approaches such as the Multi-scale Modeling Framework. The cloud modeling approaches will then be incorporated in Atmospheric General Circulation Models to test and intercompare their performance in improving climate simulations. ARM research supports about 50 principal investigators at universities and DOE laboratories involved in studies of cloud physics and the interactions of solar and infrared radiation with water vapor, clouds, and aerosols (including black soot). University scientists form the core of the ARM science team that networks with the broader academic community, including scientists funded by NSF. Networking also occurs with the scientists at the DOE National Laboratories and with federal scientists at NASA, NOAA, and DOD. ARM scientists pursue research as individuals and as members of teams and contribute to the production of ARM data, e.g., as designers of new remote sensing instrumentation for use at ARM sites, the development and application of methods to process ARM data and produce data sets useful to researchers, as well as consumers of the data generated at the three stationary ARM sites and the new mobile ARM facility. To facilitate the knowledge transfer from the ARM program to the premier modeling centers, the ARM program also supports scientific “Fellows” at NSF’s National Center for Atmospheric Research, NOAA’s National Center for Environmental Prediction, and the

(dollars in thousands)

	FY 2005	FY 2006	FY 2007
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European Center for Medium-Range Weather Forecasting in the U.S. In addition, a model parameterization test bed that was fully implemented in FY 2004 will be continued to enable the testing and improvement of parameterization schemes and submodels by rapidly incorporating data from the ARM sites into the models to enable diagnostic tests and intercomparisons of model simulations with real world data.

Atmospheric Radiation Measurement (ARM) Infrastructure	34,343	35,214	35,174
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In FY 2007, the ARM infrastructure will continue to support and maintain three stationary ARM Cloud and Radiation Testbeds (CART) facilities and associated ground-based instrumentation. It will also support the maintenance, upgrading and deployment of the ARM mobile facility. It will also continue to support application of the ARM Unmanned Aerial Vehicle for use in field campaigns around the ARM facilities to provide sustained measurements at different altitudes of cloud and atmospheric properties and processes. BER will continue to operate over two hundred instruments for characterizing atmospheric properties and processes and measuring solar and infrared radiation at the Southern Great Plains facility. It will also continue operations at the Tropical Western Pacific ARM facility and the North Slope facility in Alaska. The ARM program will continue to provide data to the scientific community through the ARM Archive.

The ARM data streams will continue to be enhanced periodically by additional measurements at the ARM facilities during intensive field campaigns referred to as Intensive Operational Periods (IOPs). Ranging from two weeks to two months, the campaigns bring together teams of scientists to coordinate measurements with airborne and satellite observations to measure particular processes and their effects on radiation around one of the facilities. These IOPs often involve coordinating the ground-based measurements with airborne and satellite observations. The ARM facilities have become major testbeds of research on atmospheric processes, serving as scientific user facilities for hundreds of scientists from universities and government laboratories. Both NASA and DOD, for example, have used the ARM facilities to "ground truth" measurements made with some of their satellite-based instruments. The ARM program, including the ARM UAV, will conduct a major field campaign focusing on the interactions between the land surface and the life cycle of clouds. The CCRI ARM program will continue to deploy an ARM mobile facility in selected locations that are either data poor or represent locations of opportunity for measuring effects of atmospheric conditions on the radiation balance that are currently poorly understood (e.g., direct and indirect effects of aerosols and their interactions with clouds). The primary criterion for deployment of the mobile facility is to provide needed measurements to address specific modeling needs that cannot be provided by measurements from the stationary ARM facilities. In FY 2007, the ARM mobile facility will be deployed at a site in the Arctic during the International Polar Year to study the impact of clouds, aerosols and surface characteristics on the arctic climate. Activities will be coordinated with other U.S. agencies and Arctic countries, such as Canada, Russia, and Norway. Data products will continue to be developed through collaboration with model developers.

The research activities in this subprogram are carried out at National Laboratories, universities, and private institutions, and are selected through competitive, merit review processes.

	(dollars in thousands)		
	FY 2005	FY 2006	FY 2007
▪ Atmospheric Science	13,017	12,552	12,551

The CCSP 10-year Strategic Plan raised the priority of research dealing with the direct and indirect effect of atmospheric aerosols on climate. As a result, BER restructured the entire Atmospheric Science Program in FY 2005 to focus on research dealing with aerosol properties and processes and their effect on radiation and climate.

In FY 2007, the Atmospheric Science Program (ASP) will continue to characterize the physical, chemical, and optical properties of energy-related aerosols and their potential effects on climate. This will include laboratory studies and field research to understand aerosol formation and transformation processes and their effect on aerosol radiative properties, including the indirect effect on cloud properties and processes. Acquired data will be used to develop and test predictive parameterization schemes or models for aerosol properties and their effect on radiative transfer in the atmosphere. The ASP will also support the development of new instruments for measuring aerosol properties and processes of importance to climate. The ASP aerosol research will continue to be closely coupled and coordinated with other components of DOE's climate change research, especially the ARM and climate modeling programs. The ASP will also continue to be broadly coordinated with the climate change research in other agencies, including collaborations with NOAA, NASA, NSF, and EPA, and with the DOE Office of Fossil Energy's Airborne Fine Particulate Matter (PM) Research program. Much of the research will involve multi-agency collaboration, and university scientists will play key roles. The information is essential for improving the scientific basis for assessing the effects of energy-related emissions on climate and will contribute to the evaluation of science-base options for minimizing the impacts of energy production on climate change.

The ASP will conduct a major collaborative field campaign in FY 2007 aimed at determining the sources, chemical and physical properties and radiative properties of aerosols derived from a major urban area. In addition, data collection from the field campaign conducted downwind of Mexico City, Mexico in 2006 will be analyzed and results will be used to develop and test new schemes for modeling aerosol transformation processes, including the chemical, physical, and optical properties of aerosols and aerosol precursors emitted from this large urban area.

Research activities in this subprogram are carried out by scientists at National Laboratories, universities and private institutions and are selected through competitive and merit-review processes.

▪ Terrestrial Carbon Processes	11,254	12,480	13,332
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In FY 2007, BER will continue support of the AmeriFlux program, a network of research sites that measure the net exchange of carbon dioxide, energy, and water between the atmosphere and major terrestrial ecosystems in North America. These measurements are linked to field measurement campaigns across major regions of North America that are designed to test how well point measurements of fluxes represent fluxes observed over larger areas within the same region and allow the estimate of carbon sources and sinks on a regional and eventually a national or continental basis.

The research supports the interagency Carbon Cycle Science Plan which is focused in the near term on the North American Carbon Plan that is designed to quantify the magnitude and location of the North American carbon sink. The increased funding in FY 2007 will be used to support additional

(dollars in thousands)

FY 2005	FY 2006	FY 2007
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process studies that are needed to interpret the observed variation in carbon fluxes at some of the AmeriFlux sites.

BER will also continue research to refine and test terrestrial carbon cycle models based on mechanistic representation of important carbon cycle processes and carbon accounting. The models will be used to estimate the magnitude of potential carbon sinks and sources in response to changes in environmental factors, including climate variation.

In FY 2007, BER's terrestrial carbon cycle research, as a partner in the interagency North American Carbon Program (NACP) will provide data, modeling, and analysis products from field measurements and campaigns. Data on net exchange of carbon dioxide will be produced by about 15-20 of the AmeriFlux Network sites, and these data along with information from research on fundamental mechanisms and processes will help in testing remote sensing observations and model calculations of terrestrial sources and sinks of carbon for specific region of North America.

Research activities in this subprogram are carried out at National Laboratories, universities, and private institutions and are selected through competitive and merit-review processes.

▪ **Ocean Sciences** **1,622** **3,130** **136**

Ocean sciences research is concluded. DOE has met its commitment to the scientific community to support the analysis of ocean carbon data. Analysis of ocean carbon data and modeling of ocean carbon cycling is being done by other agencies (e.g., NSF, NOAA, and NASA) eliminating the need for continuing DOE investments in these areas. Funding will be used to support one investigator to write and publish a summary article describing the major results and accomplishments of BER's ocean carbon cycle research.

▪ **Information and Integration.....** **1,867** **1,873** **1,873**

The Information and Integration element of Climate Forcing research will continue to store, evaluate, quality assure and disseminate a broad range of climate change related data, especially data on atmospheric concentrations of greenhouse gases, industrial emissions of greenhouse gases, greenhouse gas fluxes from terrestrial systems, ocean pCO₂ data, and air quality data. Disseminating such data to the climate change research community for use in assessing changes in climate forcing due to increasing concentrations and emissions of greenhouse gases, for example, is an important function served by the Information and Integration element of BER's Climate Forcing research. The Carbon Dioxide Information and Analysis Center funded through BER's Information and Integration element, for example, is recognized as a World Data Center for accessing information on greenhouse gas emissions and concentrations. The Center serves a diverse set of users, including academic and laboratory scientists and policy makers globally. BER will also continue the Quality Systems Science Center for the tri-lateral (US, Mexico, Canada) NARSTO (formerly known as the North American Strategy for Tropospheric Ozone), a public partnership for atmospheric research in support of both air quality management and research on the effects of air quality on climate forcing and climate change. This Center also serves a diverse set of users, especially across North America, including both scientists and policy makers.

	(dollars in thousands)		
	FY 2005	FY 2006	FY 2007
Climate Change Modeling.....	27,507	26,680	25,175

Model-based climate prediction provides the most scientifically valid way of predicting the response of the climate system to current and future changes in natural and human-induced forcing of the climate system over decade to century time scales. BER will continue to develop, improve, evaluate, and apply the best coupled atmosphere-ocean-sea ice-land surface models (GCMs) that simulate climate variability and over these time scales. The goal is to achieve statistically accurate forecasts of climate over regions as small as river basins using ensembles of model simulations. The ensembles will accurately incorporate the dynamic and thermodynamic feedback processes that influence climate, including clouds, aerosols, and greenhouse gas forcing. Current predictions are limited by computational resources and uncertainties in the model representations of key small-scale physical processes, especially those involving clouds, evaporation, precipitation, and surface energy exchange. BER will continue to address both the computational and scientific shortcomings through an integrated effort. Support will continue to provide climate simulations using present models that are being improved and future models that are under development. Support will continue to provide climate modelers access to the high-end computational resources needed to complete ensembles of climate simulations for modeling experiments using present and future climate models. BER will emphasize research to develop and employ information technologies that can quickly and efficiently work with large and distributed data sets of both observations and model predictions to produce quantitative information suitable for studies and assessments of climate change at regional to global scales. BER will also continue to fund the multi-institutional research consortia established in FY 2001 to further the development of comprehensive coupled GCMs for climate prediction that are of higher resolution and contain accurate and verified representations of clouds and other important climate processes. In FY 2007, BER will continue the partnerships with the Advanced Scientific Computing Research program. This includes applying the computing resources for climate simulation and continuing the improvement and development of climate model codes so they run efficiently across a wide variety of computing platforms. In addition, BER will continue to emphasize the development and application of data assimilation methods so as to quickly make use of the high-quality observational data streams from the ARM program, satellites, and other CCSP climate change programs to evaluate model performance.

In FY 2007, BER will focus on providing important input to the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report, specifically model-based scenarios of future potential climate change to different natural and human-induced climate forcing scenarios. Support for both the CCPP-ARM parameterization testbed and CCPP university research grants that complement current SciDAC computational research for climate modeling will be reduced. The model projections generated for the Fourth IPCC Assessment Report will be further analyzed to assess how well they simulate climate dynamics and historic climate patterns and trends, including interannual climate variability and abrupt climate changes. These activities will be essential for understanding the state-of-the-science of U.S. climate modeling and uncertainties in simulating future climatic changes. BER will also continue to provide the infrastructure for evaluating the performance of major climate models and defining what changes may be needed to improve their performance. This will be done through continued support and coordination of model-data intercomparisons, the development and improvement of diagnostic tools for evaluating model performance, and the maintenance of test beds for evaluating model parameterizations.

(dollars in thousands)

FY 2005	FY 2006	FY 2007
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In FY 2007, BER's SciDAC program (\$9,720,000) will continue to focus on providing models used for climate simulation and prediction. This will include the development and implementation of coupled earth system models that can simulate the interactions between the climate system and the carbon cycle, the effect of sulfate aerosols on climate, and the effect of land cover changes on climate. Efforts will also be continued to provide software engineering support for the Community Climate System Model, a code used by hundreds of researchers on many different high-end computing platforms. Research will also continue on the development of a prototype climate model of the future using new approaches to modeling climate.

The research activities in this subprogram are carried out at National Laboratories, universities, and private institutions and are selected through competitive and merit-review processes.

Climate Change Response	25,132	24,986	23,181
▪ Ecosystem Function and Response	13,896	12,934	11,583

In FY 2007, ecological research will continue to develop more mechanistic understanding of the scales of response of complex ecological systems to environmental changes, including identifying the underlying causal mechanisms and pathways and how they are linked, ranging from the proteomes of individual species to the whole ecosystem. The focus will be on understanding the responses of ecological systems to climatic and atmospheric changes, especially the linkages of scales in model terrestrial ecosystems containing simplified but hierarchical communities (e.g., higher plants, consumers of plant production, and microbes that decompose plant material and mineralize nutrients essential for plant growth). A key environmental factor (e.g., temperature, CO₂ concentration, nutrient supply) that is known to affect ecosystem functioning is experimentally manipulated and responses of individual species and the whole ecosystem will be measured at different scales, ranging from the proteome and/or genome of individual species to the entire community and ecosystem. Advanced biologically-based computational algorithms and ecosystem models will be developed to establish whether and how genomic changes (in single species, communities or whole systems) explain the responses and behavior of the entire complex ecosystem. Tools and principles developed from this research is expected to have broad generality and eventual application to problems in ecological risk assessment, carbon sequestration, environmental restoration and cleanup, and early detection of ecological responses to climatic and atmospheric changes and other environmental factors.

In FY 2007, BER will focus on supporting experimental research at the four Free-Air Carbon Dioxide Enrichment (FACE) sites located at Duke University (North Carolina), Rhinelander, Wisconsin, Oak Ridge, Tennessee, and Mercury Nevada on the Nevada Test Site. Support for other on-going or new experimental studies will be reduced. The on-going experiments will improve understanding of the direct effects of experimentally elevated carbon dioxide and other atmospheric changes (such as elevated ozone) on the structure and functioning of various terrestrial ecosystems, including their capacity to sequester carbon at the elevated level of atmospheric carbon dioxide. Emphasis will continue to be on understanding the cause of differential responses of plant species that may impact plant competition, succession, and productivity of terrestrial ecosystems. Research will also continue to explore changes over time in the effects of elevated atmospheric carbon dioxide

(dollars in thousands)

FY 2005	FY 2006	FY 2007
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concentrations on net primary productivity and the allocation of fixed carbon to soil and living biomass in either plant roots or aboveground stems and branches or both.

The long-term experimental investigation of altered precipitation on an eastern deciduous forest at Oak Ridge, Tennessee will continue to improve understanding of the direct and indirect effects of changes in the annual average precipitation amount on the structure and functioning of this forest. Both the four FACE facilities and the altered precipitation experiment at Oak Ridge represent scientific user facilities that have attracted scientists from both academic institutions and government laboratories who use these facilities to test scientific hypotheses related to ecosystem responses to climatic and atmospheric changes.

- **Free Air Carbon Enrichment (FACE)**

Facility.....	5,697	5,796	5,400
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In FY 2007, BER will continue to provide support to maintain and operate the four up-graded FACE facilities located at Rhinelander, Wisconsin, Mercury, Nevada on the Nevada Test Site, Duke Forest and Duke University, North Carolina, and Oak Ridge, Tennessee. The funding decrease is a result of completion of the upgrade of the FACE facilities. These four experimental field facilities provide semi-controlled environments for use by investigators to test hypotheses about the direct and indirect effects of elevated carbon dioxide and/or other gases on the structure and functioning of different terrestrial ecosystems. Funds for the FACE facility will continue to be used to maintain the four experimental facilities, including the purchase of carbon dioxide, the purchase of electricity to operate the facility, the logging of data on facility operations, and, when necessary, replacement of instruments, control systems and materials that are essential for continued, safe operation of the facilities. It includes support of staff required to operate and maintain the facilities so as to ensure they meet the experimental requirements of users. The four FACE facilities and scientific user facilities attract scientists from academic institutions, government laboratories, other countries, and other agencies to test specific hypothesis and to collect data required to answer specific scientific questions.

- **Integrated Assessment**

4,118	4,830	4,772
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The Integrated Assessment Program, with a strong academic involvement, will continue to support research to improve methods and models that can provide better estimates of the costs and benefits of possible actions to mitigate global climate change. The goal is to improve the integrated assessment models to include several greenhouse gases, and international trading of emission permits. Model improvements are needed to better represent the efficiency gains and losses of alternative emission reduction plans, including market adjustments to interregional differences among relative energy prices, regulations, and production possibilities in the international arena.

The Integrated Assessment Program will support research to develop internally consistent sets of scenarios that can be used for national-scale decision making. The scenarios will be evaluated in selected integrated assessment models also funded by the program.

	(dollars in thousands)		
	FY 2005	FY 2006	FY 2007
▪ Education	1,421	1,426	1,426
BER's Global Change Education Program will continue to support DOE-related research in climate change for both undergraduate and graduate studies through the DOE Summer Undergraduate Research Experience (SURE) and the DOE Graduate Research Environmental Fellowships (GREF). Both the GREF and the SURE provide students with the opportunity to propose and conduct research that is of interest to them and relevant to DOE's climate change research. Their research is conducted under a mentor of their choice at either a university or a DOE laboratory. The SURE continues to be a magnet for highly qualified undergraduates most of whom have gone on to graduate school to study in fields directly related to what they did under SURE. Similarly students in the GREF program have received graduate degrees and many have stayed in the field and initiated their own research related to climate change. Both SURE and GREF will be continued in FY 2007 to support climate change research by undergraduate and graduate students and thereby contribute to the training of students for future careers in climate change research.			
Climate Change Mitigation.....	8,550	6,947	5,014
Ocean carbon sequestration research is concluded in FY 2006. This is due to adverse effects on deep ocean biology and chemistry of injecting a relatively pure stream of carbon dioxide into the deep ocean as a possible strategy for sequestering carbon dioxide separated from fossil fuel power plants and industrial stack gases.			
In FY 2007, BER's carbon sequestration research will focus only on terrestrial carbon sequestration. Research will continue on studies to identify and understand the biological and environmental processes (e.g., carbon assimilation, retention and storage) that limit or constrain carbon sequestration in terrestrial ecosystems and to develop approaches (e.g., genetic selection, microbial manipulation, and soil carbon management) for overcoming such limitations to enhance sequestration long-term storage pools in terrestrial vegetation and soils. It will also continue to support research needed to understand and assess the potential environmental implications of purposeful enhancement of carbon sequestration in terrestrial ecosystems.			
SBIR/STTR.....	—	3,936	3,708
In FY 2005 \$3,476,000 and \$418,000 were transferred to the SBIR and STTR programs, respectively. FY 2006 and FY 2007 amounts are the estimated requirements for continuation of the programs.			
Total, Climate Change Research	135,535	141,529	134,909

Explanation of Funding Changes

FY 2007 vs.
FY 2006
(\$000)

Climate Forcing

▪ The ARM research increases to support research using ARM data to develop and test cloud resolving models and other parameterization schemes and incorporate them in cloud modeling approaches such as the Multi-scale Modeling Framework. The cloud modeling approaches will then be incorporated in Atmospheric General Circulation Models to test and intercompare their performance in improving climate simulations.....	+1,034
▪ The ARM infrastructure remains at near FY 2006 levels.....	-40
▪ Atmospheric Sciences is held at FY 2006 levels.....	-1
▪ Terrestrial Carbon Processes research increases to support additional process studies that are needed to interpret the observed variation in carbon fluxes at some of the AmeriFlux sites.	+852
▪ Ocean Sciences research is concluded. DOE has met its commitment to the scientific community to support the analysis of ocean carbon data. Analysis of ocean carbon data and modeling of ocean carbon cycling is being done by other agencies (e.g., NSF, NOAA, and NASA) which negate the need for continuing DOE investments in those efforts.....	-2,994
Total, Climate Forcing	-1,149

Climate Change Modeling

▪ Climate Modeling - Support for the Climate Change Prediction Program-ARM Parameterization Testbed will be scaled back because the increased funding for ARM science will allow it to cover most of the costs of testing the performance of parameterization schemes (e.g., cloud models) in climate models. In addition, the Climate Change Prediction Program investments will be scaled back and reduced to projects that complement SciDAC projects, thus focusing on analysis of long-term observational data and climate model simulation data sets to yield new insights into climate variability and change. Support for university grants that complement the current SciDAC computational research for climate modeling will be reduced because the SciDAC projects at DOE labs are considered adequate to meet existing programmatic needs.	-1,505
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Climate Change Response

▪ Ecosystem Function and Response decreases. Support for major experimental studies to quantify the response of terrestrial ecosystems to climatic and atmospheric changes will be reduced to support higher priority programs within BER. This will delay the initiation of new experimental studies and the production of data needed to produce and test models for simulating the response of some major ecological systems to climatic changes.....	-1,351
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FY 2007 vs.
FY 2006
(\$000)

▪ FACE user facility funding decreases as the upgrade of the facility has been completed.	-396
▪ Integrated Assessment is held at FY 2006 levels.	<u>-58</u>
Total, Climate Change Response	-1,805

Climate Change Mitigation

▪ Carbon Sequestration research - Ocean Carbon Sequestration research is concluded. Because of the adverse effects of deep ocean disposal of CO ₂ on ocean biology and ecology, and the ineffectiveness and potential risks to the ecology of the ocean of large-scale iron fertilization, neither ocean sequestration option is currently considered environmentally acceptable or viable. Hence, there is no need for continuing research on ocean sequestration as a potential option for helping to mitigate the increase in atmospheric CO ₂ concentrations.	-1,933
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SBIR/STTR

▪ SBIR/STTR reduced due to research program reductions.	<u>-228</u>
Total Funding Change, Climate Change Research	-6,620

Environmental Remediation

Funding Schedule by Activity

	(dollars in thousands)		
	FY 2005	FY 2006	FY 2007
Environmental Remediation			
Environmental Remediation Sciences Research.....	61,435	52,270	50,479
Facility Operations	39,140	39,190	44,453
SBIR/STTR	—	2,284	2,264
Total, Environmental Remediation	100,575	93,744	97,196

Description

The mission of the Environmental Remediation subprogram is to deliver the scientific knowledge, technology, and enabling discoveries in biological and environmental research needed to underpin the Department of Energy's mission for environmental quality.

Benefits

The fundamental research supported in this subprogram will reduce the costs, risks, and schedules associated with the cleanup of the DOE nuclear weapons complex; extend the frontiers of methods for remediation; discover the fundamental mechanisms of contaminant transport in the environment; and develop cutting edge molecular tools for investigating environmental processes. This research also will provide fundamental knowledge that applies to a broad range of remediation problems, including avoidance of environmental hazards for future nuclear energy options.

Supporting Information

Research priorities for the Environmental Remediation Sciences subprogram include 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. The subprogram also is responsible for operation of the William R. Wiley Environmental Molecular Sciences Laboratory (EMSL). This national user facility provides advanced molecular tools to the scientific community to address critical environmental issues including: environmental remediation, contaminant fate and transport in the environment, biology and genomics applications in the environment, atmospheric science and physical chemistry.

Within the subprogram, the EMSL budget is to be increased to maintain operations at full capacity. Reductions in Environmental Remediation Sciences research funding will result in the termination of research on high-level waste, including waste storage tanks. Currently funded projects in this area of research will be terminated. This will eliminate SC efforts to develop science-based alternatives for the closure and long-term stewardship of high-level waste and waste storage tanks. As a result of ongoing prioritization by BER, research emphasis within the Environmental Remediation Sciences subprogram is being focused on issues of subsurface cleanup. The nature of the scientific questions and the timelines associated with those questions are better suited to the basic science mission of Environmental Remediation Sciences than are those of high level waste.

The Environmental Remediation Sciences subprogram research activities were integrated in FY 2006 based on recommendations of a BERAC Committee of Visitors (COV) review. The COV report was supportive of the subprogram and the approach to selecting and funding research projects. The COV found that Environmental Remediation Sciences activities were well-focused on the key science needs for DOE clean-up. The COV supported previous recommendations to expand opportunities for field-based research within the subprogram.

The Environmental Remediation subprogram will develop a fundamental understanding of biological, chemical and physical phenomena across a range of scales up to and including the field scale. The resulting knowledge and technology will assist DOE's environmental clean-up and stewardship missions by developing: a more comprehensive understanding of contaminant fate and transport, *in situ* remediation technologies, subsurface characterization techniques, and performance monitoring of remedial technologies. This will be accomplished by soliciting and funding a range of projects from lab-based, single investigator research to complex, multidisciplinary, large-scale research projects that evaluate processes relevant to the environment at the field scale. This broad-based, tiered approach responds to the recommendations of the BERAC Environmental Remediation Sciences subcommittee and the COV review. The recently integrated research program is designed to respond to the BER long-term environmental remediation measure "...to provide sufficient scientific understanding to allow a significant fraction of DOE sites to incorporate coupled biological, chemical and physical processes into decision making for environmental remediation."

Periodic retrospective analysis will be employed to evaluate the accumulation of knowledge and validate specific outcomes.

FY 2005 Accomplishments

- Field Research Leads to Advances in Understanding the Role of Microbes in Contaminant Fate & Transport: Following recommendations of its BERAC subcommittee and a Committee of Visitors, the Environmental Remediation Sciences subprogram is expanding field-based research. Current field research helped to establish the potential for subsurface microorganisms to immobilize contaminant metals and radionuclides *in situ*. Researchers at the Old Rifle Uranium Mill Tailings Remedial Action (UMTRA) site are using advanced DNA and mRNA techniques to link gene expression of subsurface metal-reducing bacteria to the bioremediation of uranium. The results show that increases in gene expression levels can be used to quantitatively model microbial metabolism *in situ*. Thus, gene expression techniques may be used to better design natural and enhanced bioremediation technologies. Researchers at the Hanford site have successfully tested a commercially available product that enhances the activity of metal-reducing microorganisms to immobilize chromium in the subsurface. Work at the Field Research Center (FRC) at the Oak Ridge site is demonstrating an *in situ* remediation process that manipulates subsurface conditions to make uranium available for consequent reduction and immobilization by microorganisms. Sequencing efforts at the JGI will provide the first example of a complete set of sequenced genomes of a complex subsurface microbial community (Oak Ridge FRC). These results should allow a comprehensive description of the genetic potential of a subsurface microbial community. The incorporation of seismic and electrical surveys during *in situ* stimulation of microbial communities indicated that stimulated changes in the subsurface could be monitored over time by surface measurements, markedly reducing the need for recovery of expensive cored material from the subsurface.

- Grand Challenges in Environmental Molecular Sciences: The Environmental Remediation Sciences subprogram, in collaboration with Pacific Northwest National Laboratory (PNNL), has implemented a Grand Challenges concept at the Environmental Molecular Sciences Laboratory (EMSL). EMSL has launched two scientific Grand Challenges that will bring together some of the world's leading environmental molecular scientists to study fundamental questions in membrane biology and biogeochemistry that underlie issues critical to DOE and the Nation. Grand Challenges engage multi-institutional and multidisciplinary teams to address complex, large-scale scientific and engineering problems with broad scientific and environmental or economic impacts by using multiple experimental and computational capabilities within the EMSL. Scientists from more than twenty universities and research institutions worldwide are focused on the first EMSL Grand Challenges in biogeochemistry and membrane biology. The EMSL Grand Challenge in Biogeochemistry is led by PNNL scientists and is examining a key feature of the interface between the biosphere and the geosphere: how microorganisms regulate energy, electron and proton fluxes between cells and mineral solids present in soils and subsurface sediments. The research is expected to have broad implications for contaminant transport in the environment and remediation, corrosion, mineral formation and for understanding global biogeochemical cycles. The EMSL Grand Challenge in Membrane Biology is led by university scientists and is directed toward the fundamental changes that occur in membrane processes in Cyanobacteria due to changes in the surrounding environment. This investigation of one of the most abundant groups of microorganisms on earth is expected to make significant contributions to the harvesting of solar energy, global carbon sequestration, nutrient metal acquisition, and hydrogen production in marine and freshwater ecosystems.
- High-level Waste: The high-level radioactive waste program continued with 75 projects in FY 2005, addressing key scientific issues in characterization of tank wastes, separation and processing of components of the wastes that have been removed from the storage tanks, and assessing the stability of waste storage forms. This research already demonstrated direct value to the Environmental Management (EM) cleanup program through, for example, reduction of foaming problems that disrupted waste processing, and through development of novel extraction agents for removal of strontium from waste mixtures. Each of these accomplishments resulted in large savings of both cost and time by solving otherwise intractable problems. Current research is directed at overcoming a number of major obstacles in the cleanup process, including finding means of reducing the volumes of alkaline tank waste and development of green separation technologies that minimize residue from processing of high level radioactive wastes.
- New Efforts in the Environmental Molecular Sciences: Researchers at the DOE/National Science Foundation (NSF) co-funded Environmental Molecular Science Institutes (EMSI) are providing fundamental insights into reactions occurring at the water-mineral interface and within microbial biofilms at mineral surfaces, issues critical to prediction of contaminant fate and transport as well as to development of new remediation concepts. Researchers at the Stanford University EMSI are continuing to probe the fundamental structure of liquid water. Previous research by this group was recently featured as one of the top ten science stories of 2004 by *Science* magazine. Investigations at the Penn State University EMSI are documenting the rates of environmentally important reactions occurring across a variety of scales within the subsurface. An American Chemical Society symposium led by Penn State EMSI researchers highlighted the issues involved in scaling geochemical reactions occurring at the sub-nanometer scale to processes occurring at the field scale (meters to kilometers). These researchers also have developed a computer model that begins to describe changes in subsurface pore structure due to mineral precipitation in groundwater—a key issue for contaminant immobilization technologies. Researchers at the Stony Brook University EMSI

continue to probe geochemical reactions that lead to the sequestering of contaminants, such as arsenic and radionuclides, at mineral surfaces and immobilization of contaminants in subsurface environments.

Detailed Justification

	(dollars in thousands)		
	FY 2005	FY 2006	FY 2007
Environmental Remediation Sciences			
Research.....	61,435	52,270	50,479
▪ Environmental Remediation Sciences			
Research.....	56,892	45,727	43,936

The Environmental Remediation Sciences Research activity will address critical questions of fundamental environmental remediation science at the interfaces of biology, chemistry, geology and physics. Research results will provide the scientific foundation for the solution of key environmental challenges within DOE's cleanup mission at scales ranging from molecular to the field, including issues of fate and transport of contaminants in the environment; novel strategies for *in situ* remediation; and long-term monitoring of remediation strategies.

The research activity will support a tiered set of projects that range from relatively small, specialized, single investigator, laboratory-based research projects to complex, multidisciplinary, large-scale research projects that evaluate processes relevant to the environment at the field scale. The overall focus and integration strategy will center on field research since the ultimate goal of the Environmental Remediation Sciences subprogram is the development of science-based remediation strategies and a conceptual understanding of environmental processes that can be implemented to solve existing environmental problems. In addition to research on the environmental processes that control contaminant transport, this activity will develop new tools for measuring and characterizing the broad range of biological, environmental, and geophysical parameters associated with the behavior of contaminants in the environment. This broad-based, tiered approach responds to recommendations of the BERAC Environmental Remediation Sciences subcommittee and a Committee of Visitors review.

This integrated research effort will lead to the development of improved models to predict the transport of contaminants in the environment and then to validate those predictions using field data. Knowledge of the factors controlling contaminant mobility in the environment is essential to understand the fate of contaminants, before, during, and after remediation, and is a necessary step toward the BER long-term measure for environmental remediation. Funding reductions in FY 2006 have delayed plans to initiate new field-based research aimed at achieving that goal. These new efforts are now planned for initiation in FY 2007 and will complement ongoing work at the Oak Ridge Field Research Center (FRC), the Old Rifle UMTRA site and the Hanford site. This expanded field-based research will allow scientists to evaluate concepts and hypotheses under a variety of geochemical conditions. The expanded field efforts will have broad applicability to current research programs on heavy metal and radionuclide contamination as well as to the DOE clean-up mission. These new activities also will emphasize the need for coordination between experimentation and computer simulation as critical components of both experimental design and model development.

(dollars in thousands)

FY 2005	FY 2006	FY 2007
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The expanded field research activities will be used to evaluate and validate the results of laboratory-based science and predictive modeling efforts.

This newly integrated research activity will continue to foster interdisciplinary research and be more responsive to new knowledge and to advanced computational and analytical tools that emerge from research at the EMSL, the synchrotron light sources, and from within the GTL program in support of DOE's clean-up mission.

BER participation in 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. The intent is to explore potential advantages that high-end computing can bring to the understanding of optimal model complexity, the scalability of biogeochemical reactions, model abstraction methods, sources of uncertainty, parameter estimation and characterization measurements as input in subsurface reactive transport modeling.

In FY 2007 reductions in Environmental Remediation Sciences subprogram research funding will result in termination of research in high-level waste, including waste in storage tanks. Currently funded projects in this area of research will be terminated. This will eliminate SC efforts to develop science-based alternatives for the closure and long-term stewardship of high-level waste and waste storage tanks. As a result of ongoing prioritization by BER, research emphasis within the Environmental Remediation Sciences subprogram is being focused on issues of subsurface cleanup. The nature of the scientific questions and the timeliness associated with those questions are better suited to the basic science mission of Environmental Remediation Sciences than are those of high level waste. The Environmental Remediation Sciences research subprogram will narrow its research efforts to focus on subsurface science in support of its long-term measure for environmental cleanup.

▪ **General Purpose Equipment (GPE).....** **1,659** **403** **403**

GPE funding will continue to provide general purpose equipment for Pacific Northwest National Laboratory (PNNL) and Oak Ridge Institute for Science and Education (ORISE) such as information system computers and networks, and instrumentation that supports multi-purpose research.

▪ **General Plant Projects (GPP)** **2,884** **6,140** **6,140**

GPP funding is continued for minor new construction, other capital alterations and additions, and for buildings and utility systems, such as replacing piping in 30- to 40-year old buildings, modifying and replacing roofs, and HVAC upgrades and replacements. Funding of this type is essential for maintaining the productivity and usefulness of Department-owned facilities and meeting the requirements for safe and reliable facilities operation. This activity includes stewardship GPP funding for PNNL and for ORISE. The total estimated cost of each GPP project will not exceed \$5,000,000.

	(dollars in thousands)		
	FY 2005	FY 2006	FY 2007
Facility Operations.....	39,140	39,190	44,453
▪ EMSL Operating Expenses	31,958	33,702	35,649
The EMSL is a scientific user facility located at the Pacific Northwest National Laboratory focused on conducting interdisciplinary, collaborative research in molecular-level environmental science. Operating funds are used for: staff support for users; maintenance of instruments and buildings; utilities; environment, safety and health compliance activities; and communications. With over 55 leading-edge instruments and a supercomputer system, the EMSL annually supports approximately 1,600 users. The core EMSL science team networks with the broader academic community as well as with DOE National Laboratories and other agencies. EMSL users have access to unique expertise and instrumentation for environmental research, including a Linux-based supercomputer; a 900 MHz nuclear magnetic resonance (NMR) spectrometer that highlights a suite of NMRs in EMSL; a collection of mass spectrometers, including an 11.5 Tesla high performance mass spectrometer; laser desorption and ablation instrumentation; ultra-high vacuum scanning, tunneling and atomic force microscopes; and controlled atmosphere environmental chambers.			
In FY 2007 EMSL operations funding is increased to enhance user facility operations and increase services to users.			
▪ General Plant Projects (GPP)	3,200	—	—
The GPP (TEC \$4,450,000) for EMSL's Molecular Science Computing Facility (MSCF) adds approximately 4,000 sq. ft of additional space. The additional MSCF space is needed to meet the demand for new data storage systems due to the volume of data being generated by EMSL's high-throughput mass spectrometer, NMR, and other systems. Design of this project is in progress and is planned for completion in FY 2006.			
▪ Capital Equipment.....	3,982	5,488	8,804
Capital equipment support for the EMSL enables instrument modifications needed by collaborators and external users of the facility as well as the ability to make upgrades to existing instrumentation and to provide additional capabilities in order to maintain EMSL capabilities for environmental molecular scientific research. In FY 2007 increased capital equipment funds will be used to upgrade and refresh critical analytical capabilities in the areas of surface analytics (e.g., x-ray spectroscopy, Auger electron spectroscopy, secondary ion spectroscopy); increase capacity and throughput in proteomics (additional mass spectrometers) and high-field nuclear magnetic resonance spectroscopy (additional conventional and customized cryoprobes and consoles); increase electronic data storage capacity for data archiving of spectroscopic and proteomic output, and refurbish and replace aging support equipment (e.g., turbopumps and laser systems, cryostats).			
SBIR/STTR.....	—	2,284	2,264
In FY 2005 \$2,316,000 and \$278,000 were transferred to the SBIR and STTR programs, respectively. FY 2006 and FY 2007 amounts are the estimated requirements for continuation of the programs.			
Total, Environmental Remediation	100,575	93,744	97,196

Explanation of Funding Changes

FY 2007 vs. FY 2006 (\$000)

Environmental Remediation Sciences Research

- Reductions in Environmental Remediation Sciences research funding will terminate research on high-level waste, including waste storage tanks. Currently funded projects in this area will be terminated. This will eliminate SC efforts to develop science-based alternatives and understanding for the closure and long-term stewardship of high-level waste and waste storage tanks. As a result of ongoing prioritization by BER, research emphasis within the Environmental Remediation Sciences subprogram is being focused on issues of subsurface cleanup. The nature of the scientific questions and the timelines associated with those questions are better suited to the basic science mission of Environmental Remediation Sciences than are those of high level waste..... -1,791

Facility Operations

- In FY 2007, EMSL operations funding is increased to maintain existing levels of user service..... +1,947
- In FY 2007, funding for EMSL capital equipment increases. Increased capital equipment funds will be used to upgrade and refresh critical analytical capabilities in the areas of surface analysis techniques; functional genomics analysis and high-field nuclear magnetic resonance spectroscopy. These funds will also increase electronic storage capacity within EMSL for archiving spectroscopic and functional genomics data by allowing refurbishment or replacement of aging archival support equipment.... +3,316

Total, Facility Operations..... +5,263

SBIR/STTR

- SBIR/STTR decreases with reduction in research..... -20

Total Funding Change, Environmental Remediation..... +3,452

Medical Applications and Measurement Science

Funding Schedule by Activity

	(dollars in thousands)		
	FY 2005	FY 2006	FY 2007
Medical Applications and Measurement Science			
Medical Applications.....	117,858	138,576	13,608
Measurement Science.....	4,066	—	—
SBIR/STTR	—	3,987	392
Total, Medical Applications and Measurement Science	121,924	142,563	14,000

Description

The mission of the Medical Applications and Measurement Science subprogram is to deliver the scientific knowledge and discoveries that will lead to new radio-isotopically based diagnostic and therapeutic tools, non-invasive medical imaging technology, and bioengineering solutions to critical medical problems.

Benefits

The basic research supported by the subprogram leads to new diagnostic and therapeutic technologies and reagents for the medical community that impact medical imaging and cancer treatment. The research also leads to the development of new medical devices such as neural prostheses, e.g., an artificial retina, that improve quality of life for affected patients.

Supporting Information

The modern era of nuclear medicine is an outgrowth of the original charge of the Atomic Energy Commission (AEC), “to exploit nuclear energy to promote human health.” From the production of a few medically important radioisotopes in 1947, to the development of production methods for radiopharmaceuticals used in standard diagnostic tests for millions of patients throughout the world, to the development of ultra-sensitive diagnostic instruments, e.g. the PET (positron emission tomography) scanner, the Medical Applications program has led and continues to lead the field of nuclear medicine.

Today the subprogram seeks to develop new imaging technologies and new applications of radiotracers in diagnosis and treatment driven by the latest concepts and developments in genomic sciences, structural and molecular biology, computational biology, and instrumentation. Research capitalizes on the National Laboratories’ unique resources and expertise in biological, chemical, physical, and computational sciences for technological advances related to human health. The expertise of the National Laboratories in micro-fabrication, micro-electronics, material sciences, and computer modeling provides the capability to develop intelligent micro-machines (e.g., the artificial retina) that interface with the brain to overcome disabilities and novel biomedical sensors with a broad range of biomedical applications including neural prostheses, such as the artificial retina.

Coordination with the National Institutes of Health (NIH) is provided through joint participation of NIH research staff and management on BERAC Subcommittees, and NIH technical staff participation on BER merit review panels to reduce the possibility of undesirable duplications in research funding. DOE and NIH also organize and sponsor workshops in common areas of interest, for example: a joint

workshop on Optical and X-ray Imaging, and Nanomedicine. Members of the Medical Sciences subprogram staff are formal members of the National Cancer Advisory Board, the BioEngineering Consortium (BECON) of NIH Institutes, and are on critical committees of the recently established National Institute of Bioimaging and Bioengineering (NIBIB). Program staff also participate in interagency activities such as the Multi Agency Tissue Engineering Science (MATES) working group that includes representatives of seven agencies and the Office of Science Technology Policy.

The Medical Applications and Measurement Science subprogram continues a substantial involvement of academic scientists along with the scientists at the National Laboratories.

Periodic retrospective analysis will be employed to evaluate the accumulation of knowledge and validate specific outcomes. This program was examined as part of a BERAC review of the entire BER program in FY 2001. The next scheduled comprehensive review of the Medical Applications and Measurement Science subprogram by a BERAC COV will be in FY 2006.

FY 2005 Accomplishments

- Progress in Helping the Blind to See: The DOE Artificial Retina Program (ORNL; SNL; LANL; ANL; LLNL; University of Southern California; UC, Santa Cruz; North Carolina State; and Second Sight Corp.) has made significant progress in the roadmap to developing a device to restore vision to people suffering from retinal blindness. Six blind patients have been implanted with a 16-electrode device. They are now able to recognize moving light, discriminated light from dark, and discern large objects. A sixty electrode device is completing animal testing and will be implanted in 2006. Design for a 256 electrode device has been completed and construction is underway.
- Smaller, More Versatile PET Scanners: BNL has completed a prototype mobile PET scanner (“the rat cap”) which will record images in the awake animal. The mobile PET will be able to acquire positron-generated images in the absence of anesthesia-induced coma and correct for motion of the animal. The long-term goal is to develop PET instrumentation able to diagnose neuro-psychiatric disorders in children.
- Ultra-high performance Hybrid Imaging Instrumentation Developed: Scientists at the Thomas Jefferson National Accelerator Facility have built a small-animal imaging device that is an ultra-high performance gamma camera detector combined with an optical detector. The instrument is a high resolution hybrid tomographic system for small animals and is capable of producing 3 dimensional images of the distribution of both radiotracers and fluorescent/bioluminescent molecules. It will achieve a remarkable spatial resolution of under 0.5mm.
- Highest Resolution PET scanner Developed: Scientists at the LBNL have developed the world’s most sensitive PET scanner. The instrument is 10-times more sensitive than a conventional PET scanner. The instrument became operational in 2005.
- Imaging Gene Expression in Cancer Cells: Images of tumors in whole animals which detect the expression of three cancer genes were accomplished for the first time by investigators at Thomas Jefferson University and the University of Massachusetts Medical Center. The three cancer genes probed were CCND1, MYC, and KRAS. This advanced imaging technology will lead to the detection of cancer in human using cancer cell genetic profiling.
- Modeling Radiation Damage to the Lung: Treatment of thyroid disease and lymphomas using radioisotopes can cause disabling lung disease. Investigators at Johns Hopkins University have developed a Monte Carlo model that can be used to determine the probability of lung toxicity and be

incorporated into a therapeutic regimen. This model will optimize the dose of radioactivity delivered to cancer cells and avoid untoward effects on the lung.

- New radiopharmaceuticals with Important Clinical Applications: The DOE radiopharmaceutical science program has developed a number of innovative radiotracers for the early diagnosis of neuro-psychiatric illnesses. Three agents were developed at the University of California at Irvine. One agent localizes to beta amyloid in the brain plaques found in Alzheimer's Disease. A new nicotine receptor imaging agent, 18F-nifrolidine has a high affinity for targets in the diagnosis and understanding of Alzheimer's Disease and schizophrenia. A new serotonin receptor imaging agent, 18F-mefway, will be useful in the diagnosis of depression and anxiety disorders.
- Rapid Preparation of Radiopharmaceuticals for Clinical Use: The preparation of radiohalogenated pharmaceuticals for use in Nuclear Medicine is a formidable task. The DOE sponsored program at the University of Tennessee has developed a totally new method for preparing radiopharmaceuticals by placing a boron-based salt at the position that will be occupied by the radiohalogen. The salt is simply mixed with a radiohalogen and the desired product decanted or filtered from the salt-like starting materials. The method has been used to prepare a variety of cancer-imaging agents.
- Brain Pathway in Obesity Uncovered: Using highly-specific radiotracers as molecular probes, BNL researchers discovered a deficiency in the reward circuits in the brains of obese individuals that are similar to abnormalities observed in drug abusers. This suggests that obese individuals are overeating to compensate for a deficiency in the dopamine system in the brain which regulates the reward system. These results may be useful in developing strategies for the treatment of obesity.
- Understanding Nicotine Addiction: BNL researchers have developed a new radiopharmaceutical agent to image the brain nicotine system and have used this tracer to show striking images of nicotine binding sites in the human brain. The new radiotracer is being used to understand the molecular basis of nicotine addiction and to devise smoke-ending strategies.

Detailed Justification

	(dollars in thousands)		
	FY 2005	FY 2006	FY 2007
Medical Applications	117,858	138,576	13,608
▪ Medical Applications	38,735	13,480	13,608

In FY 2007, BER supports basic research that builds on unique DOE capabilities in physics, chemistry, engineering, biology, and computational science. It supports fundamental imaging research, maintains core infrastructure for imaging research and development, and develops new technologies to improve the diagnosis and treatment of psycho-neurological diseases and cancer and the function of patients with neurological disabilities, such as blindness and paralysis. BER research develops new metabolic labels and imaging detectors for medical diagnosis; tailor-made radiopharmaceutical agents for treatment of inoperable cancers; and the capabilities to more accurately determine the structure and behavior of cells and tissues, information needed to engineer more effective or specific drugs. BER utilizes the resources of the National Laboratories in material sciences, engineering, microfabrication and microengineering to fund development of unique neuroprostheses and continue to develop construction of an artificial retina to restore sight to the blind. DOE's clinical goal for the artificial retina project is to develop the technology and construct a

(dollars in thousands)

	FY 2005	FY 2006	FY 2007
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1,000+ electrode intraocular device that will allow a blind person to read large print, recognize faces, and move around without difficulty.

The research activities in this subprogram are principally carried out at National Laboratories and are selected through competitive and merit-reviewed processes.

▪ Congressionally Directed Activities	79,123	125,096	—
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Congressional direction was provided in FY 2005 for a science building at Waubonsee Community College in Illinois; digital playback hardware and software for Recording for the blind and dyslexic; All Children's Hospital in Florida; Eckerd College in Florida; Applied Research and Technology Park electrical and communication infrastructure improvements in Springfield, Ohio; a Multiple Sclerosis, Alzheimer's, Parkinson's, Lou Gehrig's Imaging System at the Cleveland Clinic in Ohio; Duchenne Muscular Dystrophy research-related equipment at Children's National Medical Center in the District of Columbia; Duchenne Muscular Dystrophy research-related equipment at the University of Washington-Seattle; the Northeast Regional Cancer Center in Scranton, Pennsylvania; Ohio State University for environmental research in cooperation with Earth University; the University of Akron, Ohio, Polymer Center; the Ohio Northern University, Ada, Ohio, Science and Pharmacy Building; the Alabama A&M University; University of Texas at Arlington optical medical imaging equipment; the Missouri Alternative and Renewable Energy Technology Center, Crowder College; the San Antonio, Texas, Cancer Research and Therapy Center; the University of South Alabama Cancer Center; the Virginia Commonwealth University Massey Cancer Center; the Saint Francis Hospital, Delaware, Cardiac Catheterization Lab; the Jacksonville University Environmental Science Center; the Houston, Texas, Alliance for Nanohealth; the Virginia Science Museum; the Polly Ryon Memorial Hospital, Texas; the St. Thomas University Minority Science Center, Miami, Florida; Project Intellicare, Roseville, California; the Virginia Polytechnic Institute Center for High-Performance Learning Environment; Georgia State University; the Michigan Research Institute for life science research; the University of Arizona Environment and Natural Resources Phase II Facility; the Children's Hospital of Illinois ambulatory care project; the Loma Linda University, California, Medical Center synchrotron expansion; the University of Dubuque, Iowa, Environmental Science Center; the Ball State University, Indiana, Bioenergetics Research Initiative; the Clearfield Area School District, Pennsylvania, Energy Initiative; Digital Cardiology equipment at Children's Hospital and Research Center, Oakland, California; the National Childhood Cancer Foundation; the Roswell Park Cancer Institute, New York, Center for Genetics and Pharmacology; Bucknell University, Pennsylvania, Materials Science Laboratory; the Science Center at Mystic Seaport, Connecticut; the Saratoga Hospital, New York, radiation therapy center; the San Joaquin Community Hospital, Bakersfield, California; the Syracuse University, New York, Environmental Systems Center; the University of Tennessee Sim Center; the St. Mary's Hospital, Kankakee, Illinois; the Derby Center for Science and Mathematics at Lyon College in Arkansas; the Rush Presbyterian St. Lukes Medical Center in Illinois; Medical Research and Robotics at the University of Southern California; the Advanced Building Efficiency Testbed at Carnegie Mellon University; DePaul University Biological Sciences; the Philadelphia Educational Advancement Alliance; Northwestern University Institute of Bioengineering and Nanoscience in Medicine; the Rensselaer Polytechnical Institute Center for Bioscience; St. Peter's Biotechnical Research in New Jersey; the Berkshire Environmental Center in Massachusetts; the Center for the Environment at the University of

(dollars in thousands)

FY 2005	FY 2006	FY 2007
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Massachusetts; technical upgrades at St. Joseph Hospital in Arizona; the Center for Science at the University of San Francisco in California; Augsburg College in Minnesota; the Bronx Community Center for Sustainable Energy; Marquette General Hospital in Marquette, Michigan; the Illinois-Indiana Super-Grid Program connecting Argonne National Laboratory and Purdue and Notre Dame Universities; the Purdue Calumet Water Environmental Institute; the Multi-Discipline Engineering Institute at Notre Dame in Indiana; the Energy Efficiency Project at Valparaiso University in Indiana; the Mental Illness and Neuroscience Discovery Institute in New Mexico; Military Spirit in New Mexico; the Academic Center Sustainable Design Project at St. Francis College, New York; the University of Louisville Pediatric Clinical Proteomic Center; the University of Louisville Institute for Advanced Materials; the Advanced Bioreactor located in Butte, Montana; to expand the Center for Integrated and Applied Environmental Toxicology at the University of Southern Maine; the University of Tennessee Cancer Institute; St. Jude Children's Research Hospital in Tennessee; the Huntsman Cancer Institute; the Mega-Voltage Cargo Imaging Development Applications for the Nevada Test Site; the California Hospital Medical Center PET /CT Fusion Imaging System; the Luci Curci Cancer Center Linear Accelerator; Project Intellicare in California; the University Medical Center in Las Vegas, Nevada; the Southern California Water Education Center; Live Cell Molecular Imaging System at the University of Connecticut; the St. Francis Hospital Wilmington, Delaware, MRI and Cardiac Catherization Laboratory; the University of Delaware for the Delaware Biology Institute; the University of Nevada-Las Vegas School of Public Health; the Latino Development and Technology Center; the Swedish American Health Systems; DePaul University Chemistry Lab Renovation Project; the Edward Hospital Cancer Center; the Mary Bird Perkins Cancer Center; the Morgan State University Center for Environmental Toxicology; the Suburban Hospital in Montgomery County, Maryland; the University of Massachusetts at Boston Multidisciplinary Research Facility and Library; the Martha's Vineyard Hospital; the Nevada Cancer Institute; the Mercy Hospital Grayling, Michigan Rural Healthcare Advancement Initiative; the Health Sciences Complex at Creighton University; the Hackensack University Medical Center Women and Children's Pavilion; the Kennedy Health System Linear Accelerator; the University of Buffalo Center of Excellence in Bioinformatics; the Hospital for Special Surgery National Center for Musculoskeletal Research; the New University in New York City; the Radiochemistry research facility at the University of Nevada-Las Vegas; the Hauptman-Woodward Medical Research Institute; the Vermont Institute of Natural Science; and the Tahoe Center for Environmental Services; Southwest Regional Cooling, Heating and Power and Bio-Fuel Application Center; Upgrade Chemistry Laboratories at Drew University, New Jersey; University of Texas Southwestern Medical Center, University of Texas at Dallas Metroplex Comprehensive Imaging Center; Fire Sciences Academy in Elko, Nevada for purposes of capital debt service; and the Desalination plant technology program at UMR.

Congressional direction was provided in FY 2006 for Univ. of Alabama Dept. of Neurobiology to purchase a FMRI; Baylor University Lake Whitney Assessment; SUNY IT Nano-Bio-Molecular Technical Incubator; San Antonio Cancer Center; University of South Alabama Cancer Research Institute; Indiana Wesleyan University Marion for a registered nursing program; Virginia Commonwealth University Massey Cancer Center; Construction of new science facility at Bethel College; University of Wyoming Coalbed Methane research center; Hampton University Cancer Treatment Center; George Mason University research against Biological Agents; Lehigh University

(dollars in thousands)

FY 2005	FY 2006	FY 2007
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Critical Infrastructure Lab.; St. Thomas University Minority Science center; Seton Hall Science/Tech Center; Alvernia College for a Science and Health Building; Institute for Advanced Learning Research Dansville; Galileo Magnet High School Danville; Washington & Jefferson science initiative; Science building at Waubonsee Community College; AVETeC data mamt.electronics and comm. NextEdge Tech.Park; Duchenne Muscular Dystrophy research Univ. of Washington School of Med.; Duchenne Muscular Dystrophy research Children's National Medical Ctr.; Ohio State University for Earth University; Northeast Regional Cancer Institute; Centenary College laboratory; Construction of Science Center at Midwestern Univ.; Univ. of Oklahoma Center Applications Single-Walled Nanotubes; University of Connecticut live cell molecular imaging; University of Central Florida for optics tech in X-Ray; North Shore-Long Island Jewish Health System Breast Cancer Research; Michigan Research Institute Life Science Research Center; Univ. of Arizona Environmental and Natural Resources Phase II; Children's Hospital of Illinois; Research Equipment Coe College; Loma Linda University Medical Center; Trilogy Linear Accelerator at Owensboro Medical Health System; Burpee Museum of Natural History; Rockford Health Council; Henry Mayo Hospital to purchase new equipment; Washington State University Radio Chemistry; Lapeer Regional Medical Center linear accelerator; University of Nebraska at Kearney; Science Media program at Ball State University; Franklin and Marshall life science building; Boulder City Hospital; Grady Health system disaster preparedness center project; Great Lakes Science Center; Cleveland Clinic Brain Mapping; Roswell Park Cancer Center; St. Marys Cancer Center Long Beach; National Polymer Center at the University of Akron; Biological and Environmental Center at Mystic Aquarium; Riverview Medical Center oncology program; Saratoga Hospital Radiation Therapy Center; State University of New York- Delhi; Kern Medical Center to purchase and install MRI machine; Western Michigan University Geosciences Initiative; Environmental System Center at Syracuse University; SUNY-ESF Woody Biomass Project; ORNL Supercomputer Connectivity NextEdge Technology Park; Olivet Nazarene University Science Lab; Northern Virginia Comm. College training biotechnology workers; Recording for the Blind and Dyslexic; Eckerd College Science Center; Notre Dame Ecological Genomics Research Institute; Inland Water Environmental Institute; St. Francis Science Center; Medical Research and Robotics, University of Southern California; Hampshire College National Center for Science Education; Pioneer Valley Life Science Initiative Univ. of Massachusetts; MidAmerica Nazarene Univ. nursing biological science program; Westminster College Science Center; City College of San Francisco-Health Related Equipment; Science South Development; St. Joseph Science Center; University North Carolina Biomedical Imaging; Augsburg College; Morehouse School of Medicine; Jersey City Medical Center; University of Rochester James P. Wilmot Cancer Center; Bronx Community College Center for Sustainable Energy; Texas A&M Lake Granbury and Bosque River Assessment; Methodist College Environmental Simulation Research; Brooklyn College Microscope and Imaging Center; Warner Robins Air Logistics Center; University of Chicago Comer Children's Hospital; Martha's Vineyard Hospital; Joint environmental stewardship at SUNY New Paltz and Ulster CC; Central Arkansas Radiation Therapy Institute/Mountain Home; Children's Hospital of Los Angles; Wake Forest University Institute for Regenerative Medicine; Indianapolis Energy Conversion Institute; Philadelphia Educational Advancement Alliance; Barry University-Miami Shores; Montgomery College Biotechnology Project; Purdue Calumet Water Institute; University of Chicago Integrated Bioengineering Institute; Mind Institute in New Mexico; Mississippi State University Bio-fuel Application; University of Louisville Institute for Advanced Materials; Center for River Dynamics

(dollars in thousands)

FY 2005	FY 2006	FY 2007
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and Restoration at Utah State University; Texas Metroplex Comprehensive Imaging Center; Ultra Dense Memory Storage for Supercomputing in Colorado; Health Sciences Research and Education Facility; National Center for Regenerative Medicine; U. of Alabama at Birmingham-Radiation Oncology Functional Imaging Program; University City Science Park, Philadelphia; Jackson State University Bioengineering Complex; Regis University Science Building Renovation Project; St. Jude's Children's Research Hospital; California Hospital Medical Center PET/CT Fusion Imaging System; Mount Sinai Medical Center Imaging and Surgical Equipment; Benedictine University Science Lab & Research Equipment; Swedish American Health Systems; La Rabida Children's Hospital, Chicago; Edward Hospital, Plainfield, IL; Rush Medical Center; Morgan State University Center for Environmental Toxicology; Mt. Sinai Hospital Cardiac Catherization Lab; U. of Mass. at Boston Multi-Disciplinary Research Facility & Library; CIBS Solar Cell Development; University Medical Center of S. Nevada Radiology/Oncology Equip.; Pyramid Lake Paiute Tribe Energy Project; University of Delaware Medical Research Facility; St. Francis Hospital, Delaware Linear Accelerator; Wastewater Pollution and Incinerator Plant in Auburn, NY; South Nassau Hospital Green Building; ViaHealth/Rochester General Hospital Emergency Department; University of Vermont Functional MRI Research; Vermont Institute of Natural Sciences; Castleton State College Math and Science Center; Nevada Cancer Institute; Queen's Medical Center Telemedicine Project; Michigan Technological University Fuel Cell Research; St. Francis Hospital Escanaba, Michigan; Sarcoma Alliance for Research through Collaboration; Hackensack University Medical Center Green Building; Hackensack U. Medical Center Ambulatory Adult Cancer Center; College of New Jersey Genomic Analysis Facility; W. Michigan U. Expanded Energy & Natural Resources Learning Ctr; Arnold Palmer Prostate Center; LA Immersive Tech. Enterprise program at the U. of LA-Lafayette; Brown University MRI Scanner; University of Dubuque Environmental Science Center; New School University in New York City; Oregon Nanoscience and Microbiology Institute; GeoHeat Center at the Oregon Renewable Energy Center; Portland Center Stage Armory Theater Energy Conservation Project; U. of Massachusetts Medical School NMR Spectrophotometer; Mojave Bird Study; Minnesota Center for Renewable Energy; Science Center at Malby Nature Preserve in Minnesota; Existing Business Enhancement Program Building, U. of N. Iowa; Medical University of South Carolina; Community College of Southern Nevada Transportation Academy; South Dakota State University; Univ. of Arkansas Cancer Research Center; Altair Nanotech; UCLA Institute for Molecular Medicine; New York Structural Biology Center; University of North Dakota Center for Biomass Utilization; St. Joseph College, West Hartford alternative sources of energy dem.project; Portland State University's Solar Photovoltaic Test Facility System; Brockton Photovoltaic Initiative.

Measurement Science

4,066

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Measurement Science Research is integrated with Medical Applications in FY 2006. There is not a separate request for Measurement Science Research in FY 2007.

	(dollars in thousands)		
	FY 2005	FY 2006	FY 2007
SBIR/STTR	—	3,987	392

In FY 2005 \$3,066,000 and \$368,000 were transferred to the SBIR and STTR programs, respectively. FY 2006 and FY 2007 amounts are the estimated requirements for continuation of the programs.

Total, Medical Applications and Measurement Science	121,924	142,563	14,000
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Explanation of Funding Changes

FY 2007 vs. FY 2006 (\$000)

Medical Applications

- Medical Applications Research is held near FY 2006 levels. +128
- One-time Congressionally directed projects are completed. -125,096

Total, Medical Applications **-124,968**

- **SBIR/STTR**

SBIR/STTR is decreased with the decreased research funding. -3,595

Total Funding Change, Medical Applications and Measurement Science **-128,563**

Construction

Funding Schedule by Activity

	(dollars in thousands)		
	FY 2005	FY 2006	FY 2007
Construction			
Project Engineering and Design.....	9,920	—	—

Description

Facilities to support Genomics: GTL research under the Biological and Environmental Research (BER) program.

Benefits

The proposed Genomics: GTL Facility for the Production and Characterization of Proteins and Molecular Tags, would surmount a principal roadblock to whole-system analysis by implementing high-throughput production and characterization of microbial proteins. It also would generate protein-tagging reagents for identifying, tracking, quantifying, controlling, capturing, and imaging individual proteins and molecular machines in living systems.

Detailed Justification

	(dollars in thousands)		
	FY 2005	FY 2006	FY 2007
■ Project Engineering and Design	9,920	—	—

Project Engineering and Design (PED) funding supports the proposed Genomics: GTL Facility for the Production and Characterization of Proteins and Molecular Tags was appropriated in FY 2005.

Capital Operating Expenses and Construction Summary

Capital Operating Expenses

	(dollars in thousands)		
	FY 2005	FY 2006	FY 2007
General Plant Projects	6,084	6,140	6,140
Capital Equipment.....	18,821	11,016	26,121
Total Capital Operating Expenses	24,905	17,156	32,261

Construction Projects

	(dollars in thousands)				
	Total Estimated Cost (TEC)	Prior Year Appropriations	FY 2005	FY 2006	FY 2007
PED, 05-SC-004 Production and Characterization of Proteins and Molecular Tags	9,920	—	9,920	—	—
Total, Construction.....	9,920	—	—	—	—