Biological and Environmental Research

Funding Profile by Subprogram

(dollars in thousands)

	FY 2006 Current Appropriation	FY 2007 Request	FY 2008 Request
Biological and Environmental Research			
Life Sciences	197,695	264,158	282,343
Climate Change Research	136,630	134,909	138,124
Environmental Remediation	91,190	97,196	97,430
Medical Applications and Measurement Science	138,562	14,000	14,000
Total, Biological and Environmental Research	564,077[a]	510,263	531,897

Public Law Authorization:
Public Law 95-91, "Department of Energy Organization Act", 1977
Public Law 103-62, "Government Performance and Results Act of 1993"
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 biological 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 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 scientific research capacity and advancing scientific knowledge by supporting peer-reviewed scientific research in biology and environmental science that produces results published in the scientific literature. Basic biological and environmental research has broad impacts on our energy future, our environment, and our health. An ability to predict long-range and regional climate enables effective planning for future needs in energy, agriculture, and land and water use. By understanding complex biological systems and developing computational tools to model and predict their behavior, biotechnology solutions are possible for DOE energy, environmental, and national security challenges. For example, biology-based solutions for energy production can be developed by understanding and utilizing the incredible complexity and potential of plants and microbes. Understanding the global carbon cycle and the associated role and capabilities of microbes and plants can lead to solutions for reducing carbon dioxide concentrations in the atmosphere. Understanding the complex role of biology, geochemistry, and hydrology beneath the Earth's surface will lead to improved decision making and solutions for contaminated DOE weapons sites as well as other sites for which DOE has environmental stewardship responsibility. Development of advanced radiotracers, new imaging instruments, and novel biomedical devices can improve

[a] Total is reduced by $5,857,000 for a rescission in accordance with P.L. 109-148, the Emergency Supplemental Act to Address Hurricanes in the Gulf of Mexico and Pandemic Influenza, 2006; $14,066,000, which was transferred to the SBIR program; and $1,688,000, which was transferred to the STTR program.

understanding of both normal and abnormal health—from normal human development to cancer to brain function. 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 GPRA Unit Program Goals

The Department's Strategic Plan identifies five Strategic Themes (one each for nuclear, energy, science, management, and environmental aspects of the mission) plus 16 Strategic Goals that tie to the Strategic Themes. The BER program supports the following goals:

Strategic Theme 3, Scientific Discovery & Innovation
Strategic Goal 3.1, Scientific Breakthroughs: Achieve the major scientific discoveries that will drive U.S. competitiveness; inspire America; and revolutionize our approaches to the Nation's energy, national security, and environmental quality challenges.

Strategic Goal 3.2, Foundations of Science: Deliver the scientific facilities, train the next generation of scientists and engineers, and provide the laboratory infrastructure required for U.S. scientific primacy.

The BER program has one GPRA Unit Program Goal which contributes to Strategic Goal 3.1 and 3.2 in the "goal cascade."

GPRA Unit Program Goal 03.1/2.47.00: 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 Strategic Goals 3.1, Scientific Breakthroughs and 3.2, Foundations of Science

BER contributes to Strategic Goals 3.1 and 3.2 by advancing fundamental world-class, merit-reviewed research in genomics, proteomics, climate change, environmental remediation, radiation biology, and medical imaging. 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 intend to 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 the causes and consequences of global climate change and our ability to predict climate over decades to centuries may enable us to develop science-based solutions to minimize the potential adverse impacts of climate change and to better plan for our Nation's future energy needs and resource use. Understanding the biological effects of low doses of radiation could lead to the development of science-based health risk policy to better protect workers and citizens. Understanding the fate and transport of environmental contaminants may lead the way to discovering innovative approaches for cleaning up and monitoring the environment.

BER research leads to the development of advanced medical imaging technology, including radiopharmaceuticals for use in diagnosis and treatment of disease. BER research currently supports the development of an artificial retina that will enable the blind to see.

This research capitalizes on the national laboratories' resources and expertise in biological, chemical, physical, and computational sciences, and on their sophisticated instrumentation (neutron and light sources, mass spectroscopy, and high field magnets), lasers and supercomputers. This research is coordinated with and complementary to other Federal programs.

In addition, BER plans, constructs, and operates reliable, 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 William R. Wiley Environmental Molecular Sciences Laboratory (EMSL) (including the

Molecular Sciences Computing Facility) where research activities support long-term environmental remediation and other DOE missions in energy and national security; the Production Genomics Facility (PGF) for DNA sequencing; and the Atmospheric Radiation Measurement (ARM) facilities for climate change research.

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:** Provide the fundamental scientific understanding of plants and microbes necessary to develop new robust and transformational basic research strategies for producing biofuels, cleaning up waste, and sequestering carbon.
- **Climate Change Research:** Deliver improved scientific data and models about the potential response of the Earth's climate and terrestrial biosphere to increased greenhouse gas levels for policy makers to determine safe levels of greenhouse gases in the atmosphere.
- **Environmental Remediation:** Provide sufficient scientific understanding such that DOE sites would be able to incorporate coupled physical, chemical and biological processes into 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 Strategic and GPRA Unit Program Goal

(dollars in thousands)

	FY 2006	FY 2007	FY 2008
Strategic Goal 3.1, Scientific Breakthroughs and 3.2, Foundations of Science			
GPRA Unit Program Goal 03.1/2.47.00, Harness the Power of Our Living World			
Biological and Environmental Research	564,077	510,263	531,897

[a] This indicator is not a PART measure.

Annual Performance Results and Targets

FY 2003 Results	FY 2004 Results	FY 2005 Results	FY 2006 Results	FY 2007 Targets	FY 2008 Targets
GPRA Unit Program Goal 03.1/2.47.00 (Harness the Power of Our Living World)					
Life Sciences					
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 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.	Increase the rate and decrease the cost of DNA sequencing of microbial and model organism genomes. Cost reductions will increase the number of high quality base pairs determined (less than one error in 10,000 bases) by 10% from the FY 2007 actuals.
Climate Change Research					
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 of water vapor concentration and cloud properties and measurements of these quantities on the timescale of 1 to 4 days. [Met Goal]	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.	Report results of decade-long control simulation using geodesic grid coupled climate model and produce new continuous time series of retrieved cloud, aerosol, and dust properties, based on results from the ARM Mobile Facility deployment in Niger, Africa.

FY 2003 Results	FY 2004 Results	FY 2005 Results	FY 2006 Results	FY 2007 Targets	FY 2008 Targets
Environmental Remediation					
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 remobilization 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. [Met Goal]	Implement a field-oriented, integrated experimental research program to quantify coupled processes that control reactive transport of at least one key DOE contaminant.	Identify the critical redox reactions and metabolic pathways involved in the transformation/ sequestration of at least one key DOE contaminant in a field environment.
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 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. [Goal Not Met]	Advance blind patient sight: Begin testing of prototypes for 256 microelectrode array artificial retina. [Met Goal]	Advanced blind patient sight: complete design and construction of final 256 electrode array. Begin in vitro testing and non-stimulating testing in animals.	Advance blind patient sight: Complete in vitro testing of 256 electrode array and continue animal studies of final design 256 electrode array.
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 (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 95% 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.	Maintain and operate BER facilities (Life Science – PGF; Climate Change Research – ARM; 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 Genomics: GTL program which supports the development of a new research infrastructure needed to understand fundamental biological principles underlying the function and control of biological systems. 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 problems in energy production and environmental cleanup.

Our ability to predict climate on global and regional scales, to develop strategies for the removal of excess carbon dioxide (suspected to adversely impact global climate) from the atmosphere, and to provide the science to underpin the prediction of the impacts of climate change, will depend on the continued development of novel research tools and a close integration of experimental, observational, 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 William R. Wiley Environmental Molecular Sciences Laboratory (EMSL), the Production Genomics Facility (PGF), and the Atmospheric Radiation Measurement (ARM) 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 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 and monitoring.

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)

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 and has taken or will take the necessary steps to continue to improve performance.

In the FY 2003 PART review for the FY 2005 Budget, OMB gave the BER program a score of 86% overall which corresponds to a rating of "Effective". The assessment found that BER has developed a limited number of adequate performance measures which are continued for FY 2008. These measures have been incorporated into this Budget Request, BER grant solicitations, and the performance plans of senior managers. As appropriate, they will be incorporated into the performance based contracts of M&O contractors. To better explain our scientific performance measures, the Office of Science developed a website (http://www.sc.doe.gov/measures) that answers questions such as "What does this measure mean?" and "Why is it important?" Roadmaps, developed in consultation with the Biological and Environmental Research Advisory Committee (BERAC), will guide triennial reviews by BERAC of progress toward achieving the long term Performance Measures. These roadmaps are posted on the SC website. The Annual Performance Targets are tracked through the Department's Joule system and reported in the Department's Annual Performance and Accountability Report.

OMB has previously provided BER with three recommendations to further improve performance:

- Engaging the National Academies in an independent assessment of the scientific basis and business case for the program's microbial genomics research efforts. [Action completed]

  In response, BER has engaged a committee of the National Research Council (NRC) of the National Academies to review the design of the Genomics: GTL program and its infrastructure plan. The committee was directed to specifically examine whether the program was scientifically and technically well-tailored to the challenges faced by the DOE in energy technology development and environmental remediation. The NRC committee report, *Review of the Department of Energy's Genomics: GTL Program* (available at http://DOEGenomestoLife.org), released in May, 2006, provided a strong endorsement of the Office of Science GTL program, recommending that the program's focus on systems biology for bioenergy, carbon sequestration, and bioremediation be given a "high priority" by DOE and the nation. But the report also recommended that the program's plan for new research facilities be reshaped to produce earlier and more cost-effective results. The NRC committee recommended that the GTL facilities should be focused not on particular technologies, but on research underpinning particular applications – bioenergy, carbon sequestration, or environmental remediation.

  In response to the report and the NRC recommendations, the Office of Science has revised its original single-purpose user facilities plan to instead develop and support vertically-integrated GTL Research Centers to accelerate systems biology research. The vertically-integrated GTL Research

Centers will not require construction of facilities. These centers will not only possess the robust scientific capabilities needed to carry out their broad mission mandates, but also draw upon the broader GTL program for technology development and foundational research. The GTL program will integrate these capabilities and advanced technologies with the robust computational infrastructure needed to better understand the genomic potential, cellular responses, regulation, and behaviors of biological systems. The first research centers will have a focus on bioenergy research; subsequent centers will focus on other aspects of bioenergy research, environmental remediation and carbon sequestration.

- Implementing the recommendations of past external panel reviews of the program's research portfolio and management practices. [Actions are completed and/or on-going as appropriate]

  In response, BER is using external panels (Committee of Visitors – COVs) to review the quality, relevance, and performance of its research portfolio and grant management practices. COVs findings and BER responses can be viewed at http://www.sc.doe.gov/measures/FY06.html.

- Reviewing operations of user facilities, and improving discrimination in identifying open user facilities versus collaborative research facilities. [Actions are completed and/or on-going as appropriate]

  BER conducted reviews of the Joint Genome Institute Production Genomics Facility (JGI/PGF) and EMSL facilities, and a review of ARM facilities is scheduled in FY 2007.

In November 2005, a BERAC subcommittee panel conducted a comprehensive review of the science, management, and operations of the DOE JGI/PGF. The committee gave high marks to the JGI with respect to scientific vision, the implementation of the role of the JGI as a user-facility and its focus on DOE mission objectives, and to the PGF for its state of the art operations with respect to cost, quality, and quantity of sequences that it produces. The JGI/PGF, in addition to functioning as an effective national user facility, has also served effectively as a lead organization in collaborations on DOE missions. This is especially evident in its pioneering approaches to the area of metagenomics, defining a unique niche for the PGF that does not overlap with other sequencing facilities and is highly aligned with DOE missions. The review was supportive of the new Laboratory Science Program at the JGI, providing guidance on its management structure, and operational and mission drivers. The review panel identified opportunities for improvements in reporting and operational procedures, but noted no serious deficiencies.

BER conducted a June 2006 follow-on review of the William R. Wiley Environmental Molecular Sciences Laboratory (EMSL) to validate the corrective actions taken in response to the management and operations findings of the BERAC and Office of Science/Office of Project Assessment reviews in May, 2005. These reviews validated the status of EMSL as a National Scientific User Facility. The June 2006 review committee found that actions taken in response to the May 2005 reviews were "timely, comprehensive, and on target" and that implementation of those actions was "effective, widely accepted, and appears to be on its way to completion" by the end of FY 2006.

In FY 2007 the ARM facilities will be reviewed by BERAC.

To improve public access to PART assessments and follow up actions, OMB has created the ExpectMore.gov web site. Information concerning BER PART assessments and current follow up actions can be found by searching on "biological environmental research" at http://www.ExpectMore.gov.

Overview

BER supports basic 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 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 and led by the sequencing of the human genome, will bring revolutionary and unconventional solutions to some of our most pressing and expensive challenges in energy, the environment, national security, and health.

The Challenges

A new biology—Can we understand the workings of biological systems, both plants and microbes, 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 and sophistication of diverse plants, each with exquisitely precise and efficient functions and controls, will enable us to use and even redesign these molecular machines, microbes, or plants to address DOE and national needs.

Understanding and predicting climate—Advanced climate and Earth system models are needed to describe and predict the roles of oceans, the atmosphere, sea ice, and land masses on climate, including the interactions and feedbacks between the various components of the climate system. So too, the role of clouds and aerosols in controlling solar and terrestrial radiation onto and away from the Earth needs to be better understood since their effects are still a major source of uncertainty in climate prediction. Moreover, the impacts of excess carbon dioxide in the atmosphere from human activities, including energy use, on Earth's climate and ecosystems need to be determined and possible mitigation strategies developed.

A cleaner environment—The Department of Energy faces the country's largest set of environmental remediation challenges, many of which currently have no solutions. The Department's environmental clean up objectives require advances in our understanding of the biological, chemical and physical processes that control contaminant mobility in the environment. Sufficient understanding will allow accurate predictions of future conditions and the ability to make informed decisions regarding the need for and types of remedial actions at a given site. This understanding also will provide the foundation for novel and more effective clean up and monitoring technologies needed to implement such action. Many remediated sites have intractable residual contamination that will require long-term stewardship, including monitoring and actions to ensure protection of human health and the environment.

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. Furthermore, 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.

The Investment Plan

All BER Research and Development (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 may 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) understanding the biological effects of low doses of radiation that will lead to the development of science-based health risk policy to better protect workers and citizens, (3) an improved ability to predict climate on global and regional scales; (4) development of strategies to remove excess carbon dioxide from the atmosphere; (5) new science-based strategies for the remediation, and long-term monitoring of the environment; and (6) the development of unique devices and technologies for the medical community.

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 solicits 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 and subcommittees created by the National Science and Technology Council and the Office of Science and Technology Policy (OSTP). BER, as a collaborative partner in interagency programs, such as the U.S. Climate Change Science Program, also consults with and receives advice from some boards and panels of the National Academies of Science and its National Research Council. 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; Legacy Management, Civilian Radioactive Waste 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. 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 as previously discussed.

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 of funded scientists 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 and its National Research Council.

Planning and Priority Setting

BER supports research and develops new research initiatives across many fields of science that 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 biological and environmental sciences. This includes planning for future directions and opportunities, within the BER research portfolio; maintaining the flexibility to quickly move into promising new areas; contributing to the health of the educational pipeline in 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 involvement of the research community.

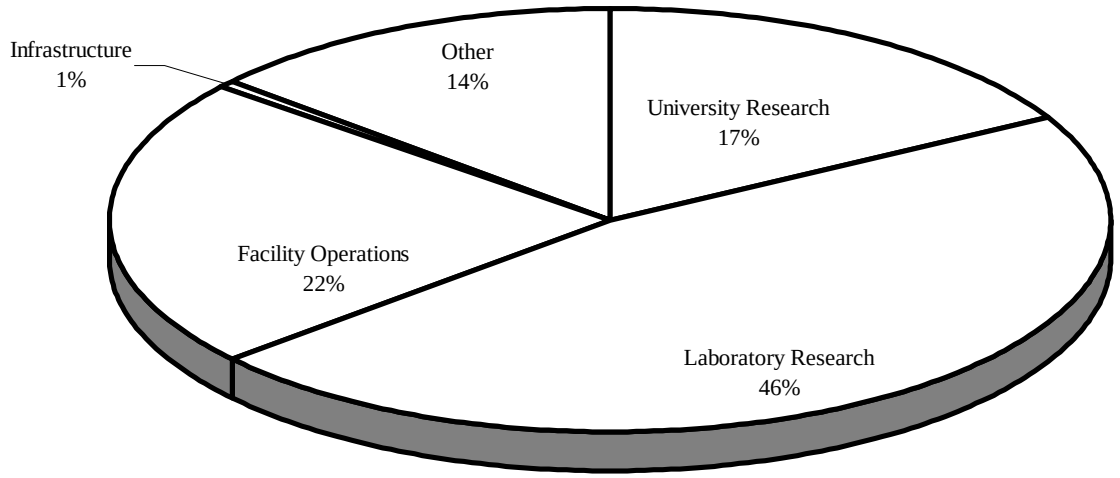
BER planning and priority setting are also key BERAC activities and part of BER's interagency coordination. Individual BER program elements, e.g., Genomics: GTL, low dose radiation research, genomic DNA sequencing, global climate change research, environmental remediation research, and medical sciences 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 (17%); basic research at national laboratories (46%); and user facility operations (22%). The remaining 15% 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 (14%)). Research at national laboratories also includes the Environmental Remediation Sciences field research sites and other elements that represent a research infrastructure for the scientific community that is available to both university and laboratory scientists. BER's user facilities (Facility Operations - 22%) include the infrastructure at synchrotron and neutron sources for structural biology and the environmental sciences, operation of the William R. Wiley Environmental Molecular Sciences Laboratory (EMSL), support for high-throughput DNA sequencing at the Joint Genome Institute, and Atmospheric Radiation Measurement Infrastructure (including the ARM Aerial Vehicles).

Biological and Environmental Research Budget Allocation
FY 2008



Research

In FY 2008, the BER program will support 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 and Private Sector 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. Private sector research institutions are playing an increasingly important role in BER biological and medical research. BER will continue its commitment to and dependence on scientists at the Nation's universities and private research institutions.

  In general, BER-supported research activities at universities and at private sector research institutions are single and multi-investigator projects. Increasingly, this research is also becoming multi-institutional, commonly including collaborations with DOE laboratories. University scientists

are the major scientific users at BER facilities that include the ARM program, DNA sequencing, structural biology, and EMSL.

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 Facilities, 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 roles for the Department and the national and international scientific communities including:

- Manage research on microbes and plants for energy and the environment 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 cutting edge technologies, facilities (including high-throughput community DNA sequencing capabilities), and resources for genomics research;
- Provide scientific user facilities for environmental molecular research;
- Provide leadership in low dose radiation research;
- Provide leadership in ground-based measurement of clouds and atmospheric properties and processes to resolve key uncertainties in climate change; and development of advanced predictive capabilities using coupled climate and Earth system models on the Nation's premier computers for decade-to-century long simulations of climate change;
- Provide leadership to understand, predict and control processes that determine the fate and transport of metal and radionuclide contaminants in the subsurface environment;
- Provide 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 DOE laboratories or in activities using DOE funds are protected while advances in biomedical, environmental, nuclear, and other research lead to discoveries that benefit humanity.

Significant Program Shifts

- BER will fund the first two GTL Bioenergy Research Centers (to be selected and partially funded in FY 2007) and will add a third center; all three will conduct fundamental research on microbes and plants needed to produce biologically-based fuel.
- The Ethical, Legal, and Societal Issues (ELSI) research will increase to further explore issues related to biotechnology and nanotechnology, including the ecological effects of nanoparticles.
- JGI/PGF sequencing will continue to address mission-relevant genomes of plants, microbes, and microbial communities, including the initiation of the Laboratory Science Program (LSP) to stimulate participation in GTL-relevant sequencing at the national laboratories. The LSP will complement the success of the existing Community Sequence Program (CSP).
- BER will continue research at the Laboratory for Comparative and Functional Genomics ("Mouse House"). However, BER will no longer fund the Mouse House as a user facility. BER's programmatic need for this facility has greatly decreased with the completion of human genome related research and the growth of the GTL program. There is still a broad need for mouse genetic resources in the scientific community, especially at the National Institutes of Health. BER's Low Dose Radiation Research activity will continue to fund research at the "Mouse House."
- Free Air Carbon Dioxide Enrichment (FACE) experiments to study the direct effect of elevated carbon dioxide and other trace gases on terrestrial ecosystems will no longer be operated as user facilities. Research on the effects of carbon enrichment on terrestrial ecosystem structure and functioning will continue under Terrestrial Carbon Processes Research and Ecosystem Function and Response Research. The activity is best characterized as field experiments in which multiple investigators jointly participate as collaborators to understand the direct effect of elevated carbon dioxide and other trace gases on terrestrial ecosystems rather than as a user facility.
- The Climate Change Research Subprogram will enhance climate modeling research to address strategic questions in abrupt climate change, including, incorporating mechanisms into coupled climate models, and testing the models vis-à-vis records of past abrupt climate change.
- The Environmental Remediation Sciences subprogram will conduct research at two additional field research sites (total of 3), one at Hanford, Washington and the other at Old Rifle, Colorado. The sites were selected by merit review in late 2006. The existing site at Oak Ridge, Tennessee will continue. This will provide new opportunities to validate laboratory findings under field conditions, to provide DOE-relevant samples to other investigators, and to support additional SciDAC research to develop improved models for the reactive flow and transport of subsurface contaminants, and provide information for geologic carbon sequestration.

Genomics: GTL Research

The FY 2008 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. It will determine the diverse biochemical capabilities of DOE relevant microbes, microbial communities, and plants, with the goal of tailoring and translating those capabilities into solutions to DOE mission needs.

Development of a global biotechnology based energy infrastructure requires a science base that will enable scientists to control or redirect genetic regulation; and redesign specific proteins, biochemical pathways, and even entire plants or microbes. Renewable biofuels could be produced using plants,

microbes, or isolated enzymes. Understanding the biological mechanisms involved in these energy producing processes may allow scientists and technologists to design novel biofuel production strategies involving both cellular and cell free systems that might include defined mixed microbial communities or consolidated biological processes. Within the Genomics: GTL program, BER will develop the understanding needed to advance biotechnology-based strategies for biofuel production, focusing on renewable, carbon-neutral energy compounds such as ethanol and hydrogen.

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 portion of U.S. gasoline demand. A workshop convened jointly by the Office of Science's Biological and Environmental Research program and the Office of Energy Efficiency and Renewable Energy's (EERE) Biomass program resulted in a research roadmap for cellulosic ethanol research through concerted application of modern biology tools ("Breaking the Biological Barriers to Cellulosic Ethanol: A Joint Research Agenda," available at www.doegenomestolife.org/biofuels/; DOE/SC-0095). This joint research agenda, pairing the research goals of the Office of Science with the commercialization pathway of the Office of Energy Efficiency and Renewable Energy, could provide the tools for industry to develop better feedstocks and improve conversion processes, resulting in biofuel production at a scale needed to make a real difference in transportation consumption of fossil fuels. 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 biomass, primarily lignocellulosic material. 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. Research will support the development of new biological and chemical tools to provide detailed understanding of plant cell walls, their roles in plant function, and factors controlling recalcitrance and optimization of processes for fermentation of sugars. Research will also support the identification of genes involved in the synthesis of cell-wall polymers and higher structures; reactions performed by the multitude of enzymes involved; design principles of cell walls; and factors controlling the amounts, composition, and structure of polymers and polymer matrices. Discovery of new biomass-degrading organisms across many different kingdoms of life—including plants, fungi, and bacteria—will also expand our capabilities relevant to biomass conversion to biofuels.

DOE and other relevant agencies utilize guidance from the Biomass Technical Advisory Committee and the Biomass R&D Board established under the Biomass Research and Development Act of 2000 to integrate R&D across agencies. In 2006, the Board began preparation of an interagency National Biofuels Action Plan. This plan will be followed by a comprehensive interagency coordination and planning document that will be reviewed by the National Academies beginning in late 2007. In addition to assessing the goals and plans for interagency biomass research, the Academy will be tasked with considering economic and other impacts of increased biomass utilization under various energy price and policy scenarios.

BER and USDA have conducted two joint solicitations for genomics-based research that will lead to improved feedstocks for cellulosic ethanol. BER and the Basic Energy Sciences (BES) program complement each other's research programs; distinguished primarily by BER's emphasis on biological solutions that are aimed at understanding and manipulating the metabolic pathways, and BES's emphasis on understanding the photosynthetic process and aimed at the intersection with chemical sciences and physics, such as self-assembly of biomaterials.

This research is expected to lead to a fundamentally new process and biorefinery paradigm that could enable an efficient and economic industry for converting plant biomass to liquid fuels.

The FY 2008 request includes $15,000,000 for bioethanol research.

Biological Production of Hydrogen–Some microorganisms produce hydrogen naturally, and biotechnologies based on these microbial systems could lead to the development of clean, renewable sources of hydrogen. Through a process known as biophotolysis, green algae and cyanobacteria can use energy from the sun to split water and generate hydrogen. Other anaerobic microbes can generate hydrogen from conversion of biomass or sugars, a process known as dark fermentation. Fundamental research will be supported to understand biophotolysis and dark fermentation processes, well enough that predictive models of hydrogenase (the enzyme that cleaves water to produce hydrogen) structure and function, metabolite and reductant flux through metabolic pathways, 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, applying directed evolution or synthetic biology approaches to create improved hydrogenases with greater catalytic efficiency and oxygen resistance, metabolic engineering to redirect the flux of reductants or substrates through fermentation pathways, and systems biology to optimize genetic regulatory and biochemical processes that influence hydrogen production. This new knowledge will be used to engineer the ideal microbe or to construct stable microbial consortia to use in hydrogen bioreactors and fuel cells.

As with ethanol research, above, BER and BES also complement each other's hydrogen research programs in similar ways: BER is more focused on genomics and BES is more focused on understanding at the molecular and atomic level.

The FY 2008 request includes $15,000,000 for biohydrogen research.

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 2008 is $129,585,000.) 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 abrupt climate change, 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 environmental costs and benefits of climate change and the different potential options for mitigation and adaptation to such change. The deliverables from this BER research are expected to be useful to policy makers.

In FY 2008, 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 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, including abrupt climate change; and (4) developing and evaluating assessment tools needed to study costs and benefits of potential strategies for reducing net carbon dioxide emissions.

Scientific Discovery through Advanced Computing

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 simulations that are impossible using theoretical or laboratory studies alone. 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.

In FY 2008, BER will continue to advance the science of climate and Earth system modeling by coupling models of different components of the earth system related to climate and by significantly increasing the spatial resolution of such models. These SciDAC-enabled activities will allow climate scientists to gain unprecedented insights into interactions and feedbacks between, for example climate change and global biogeochemical cycling of carbon and the potential effects of carbon dioxide and aerosol emissions from energy production and use on the global climate system.

BER will add SciDAC components 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 from metabolomic or proteomic profiling. Environmental Remediation SciDAC will provide opportunities for subsurface and computational scientists to develop and improve methods of simulating subsurface reactive transport processes. 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. Such advances have application to environmental remediation, long-term environmental stewardship and carbon sequestration.

Scientific Facilities Utilization

The BER request includes funds to maintain support of the Department's major scientific user facilities. BER's facilities include the 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 Joint Genome Institute Production Genomics Facility; and the Atmospheric Radiation Measurement 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[a]

	(estimated)		
	FY 2006	FY 2007	FY 2008
William R. Wiley Environmental Molecular Sciences Laboratory (EMSL)			
Optimal hours	4,365	4,365	4,365
Scheduled hours	4,365	4,365	4,365
Operation Time	95%	>98%	>98%
Users	1600	1700	700[b]
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	80	120	120[c]
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	800	850	900[d]

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, capital equipment is held at approximately the FY 2007 level.

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

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[a] Note, as explained in the Significant Program Shifts, FACE and the Laboratory for Comparative and Functional Genomics ("Mouse House") are now characterized as research activities rather than as user facilities.

[b] EMSL users are both onsite and remote. Beginning in FY 2008, BER will revise the definition of "User" for the EMSL. This change in definition is reflected in a revised target for FY 2008. Under the revised definition, individual users are counted once per year.

[c] 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.

[d] ARM users are both onsite and remote. A user is an individual who accesses ARM databases or uses equipment 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.

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 important 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 can be important for the development of the next generation of scientists, engineers, and science educators.

Specific fellowship programs for undergraduate and graduate students are also sponsored by BER through its Global Change Education Program to help develop the next generation of scientists needed for climate change research and to target emerging areas of need in such research.

About 1,500 graduate students and post-doctoral investigators will be supported collectively by all BER programs at universities and at national laboratories in FY 2008, 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 2008.

Office of Science user facilities also play a 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 2008. 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, working with BES, provides funding to each of the synchrotron light sources to support BER sponsored scientists as well as for 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, university, and private sector 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, low dose radiation research, climate change research, and environmental remediation research. Furthermore, university scientists work in close partnership with scientists at national laboratories in BER programs including genomics, and carbon sequestration research.

		(estimated)	
	FY 2006	FY 2007	FY 2008
# University Grants	700	700	705
Average Size per year	$250,000	$250,000	$250,000
# Laboratory Projects	375	350	355
# Permanent Ph.D's[a]	1,321	1,291	1,320
# Postdoctoral Associates[b]	299	297	304
# Graduate Students[b]	436	423	429
# Ph.D.s awarded[c]	100	105	105

External Independent Reviews

The costs of conducting External Independent Reviews (EIRs) for Capital Asset Projects greater than $100,000,000 within SC are 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 2006	FY 2007	FY 2008
Life Sciences			
Structural Biology	15,449	15,300	15,300
Molecular and Cellular Biology	112,571	159,942	179,462
Human Genome	60,823	74,575	72,733
Health Effects	8,852	7,321	7,321
SBIR/STTR	—	7,020	7,527
Total, Life Sciences	197,695	264,158	282,343

Description

The mission of the Life Sciences subprogram is to foster fundamental research, to develop novel technological capabilities for biological research, and to provide biological solutions to the DOE's energy and environmental mission needs. Life Sciences research is expected to deliver a new knowledge base for cost effective cleanup of environmental contamination, design of new strategies for enhanced capture of atmospheric carbon dioxide, rational design and improvement of new energy crops and increased bio-based sources of fuel or electricity. The program may 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 systems biology, 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 metabolic capabilities of mixed microbial communities that could be used to produce clean energy, clean up or stabilize wastes *in situ*, or sequester excess atmospheric carbon dioxide. Community user facility resources are made widely available for determining high-resolution protein structures at DOE synchrotrons, and high-throughput genomic DNA sequencing of microbes, microbial communities, and complex organisms such as plants. New capabilities are developed in the Genomics: GTL program for understanding the structure, function, and biochemical capabilities of complex, DOE-relevant microbial communities—information needed to develop biotechnological solutions for DOE needs.

Supporting Information

BER Life Sciences supports research and research infrastructure in the following areas:

- Bioenergy Research Centers conducting comprehensive, multidisciplinary, and integrated research programs in energy-related systems and synthetic biology.
- 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 – scaling from single microbes to communities of multiple microbial species to plants. This information can be used to develop innovative biotechnology

solutions for energy production, environmental mitigation, and carbon management, including biotechnological solutions for bioethanol and biohydrogen.

- A high-throughput DNA sequencing user facility to meet DNA sequencing needs of the scientific community in DOE mission 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 an informed scientific basis for effective radiation protection standards to protect DOE radiation and cleanup workers, and the public.

Periodic retrospective analysis will be employed to evaluate the accumulation of knowledge and validate specific outcomes. This subprogram was reviewed by a BERAC Committee of Visitors (COV) in FY 2005. The next scheduled review of the Life Sciences subprogram by a BERAC COV will be in FY 2008.

FY 2006 Accomplishments

- **Sequencing the Poplar Genome:** DOE national laboratories led an international collaboration to sequence the first tree genome, with the actual sequencing work on Populus trichocarpa, more commonly known as poplar, performed at the DOE Joint Genome Institute Production Genomics Facility. With a genome size of just over 500 million letters of genetic code, it is the most complex genome to be sequenced and assembled by a single public sequencing facility. The analysis of the genetic possibilities of the completed poplar sequence was published in the summer of 2006, revealing a substantial expansion of genes involved in carbon allocation to cellulose, lignin and flavonoid biosynthesis, disease resistance, meristem development and metabolite transport. The information encoded in the poplar genome will provide researchers with a critical resource to develop faster growing trees, trees that produce more biomass for conversion to biofuels such as ethanol, and trees that can sequester more carbon from the atmosphere or be used to clean up waste sites.
- **The 100th Microbial Genome:** U.S. Department of Energy Joint Genome Institute (DOE JGI) has finished the sequence of 100 microbial genomes and released this information for the benefit of the global research community. The microbes sequenced by DOE JGI, both single-celled and those multi-celled organisms invisible to the naked eye, cross all main branches of the tree of life: Eubacteria, Archaea, and even the Eukaryota, which include microscopic fungi, plants, and animals. The 100th microbial genome is *Methanosarcina barkeri fusaro*, a methane-producing organism that exploits a unique metabolic pathway to do the job. This metabolic flexibility helps this microbe to survive in diverse environments, from freshwater mud to the rumen of cattle where cellulose and other polysaccharides are digested. Microbes, thriving in even the world's most extreme environments, are capable of performing myriad biological functions, learned over the billions of years they have inhabited the planet. Those lessons, and how they can be captured to render clean renewable sources of energy and to repair damaged environments, are among the many secrets encoded in their DNA sequence.
- **Microbial Stress Management:** The microbe *Desulfovibrio vulgaris* Hildenborough adapts its physiology so it can survive in habitats containing toxic and radioactive metal wastes and fluctuating high levels of salt. Using a variety of approaches such as transcriptomics, proteomics, metabolite assays, and electron microscopy, GTL investigators applied a systems approach to explore the effects of excess salt on *D. vulgaris*. They discovered that this microbe's coping mechanisms include importation of protective small molecules, the up-regulation of pump systems and the ATP synthesis

(metabolic energy) pathway, changes in the stability of nucleic acids, changes in cell wall fluidity, and an increase in the activity of chemotaxis genes. The systems-level integration of data from multiple methods has led to a conceptual model for salt stress response in *D. vulgaris* that can now be compared to other microorganisms, leading to general, predictive models of microbial stress response and adaptation.

- **Microbial Electricians—Wired for Energy:** *Geobacter* and *Shewanella* are versatile microbial performers for cleaning up toxic waste, due in part to their useful metabolic ability to extract radioactive and toxic metals from the surrounding soil and water, shuttling electrons in the process. Linked to this ability to "breathe" on metals, rather than oxygen, these microbes build long, thin extracellular filaments that are associated with electron-shuttling, membrane-bound cytochromes. Since these filaments, 20,000 times finer than a human hair, have been found to conduct electricity, they are often called "nanowires." It's not known what these nanowires are made of, how they are assembled, or what their biological function is. However, these nanowires may be common to other microbes and microbial consortia dependent on electron transfer. Furthermore, nanowires could be responsible for cell-to-cell electron transfer processes in biofilms and complex microbial mat communities. On a more practical note, nanowires in the photosynthetic microbe *Synechocystis* have been used to construct solar-powered microbial fuel cells, perhaps leading to additional strategies for energy transduction systems.
- **Marine Plankton Mix it Up:** *Crenarchaeota* comprise an estimated 20% of all planktonic microbes; their sheer abundance thus renders them a significant influence on biogeochemical cycling in marine ecosystems. GTL science has predicted important components in the reconstruction of carbon and energy metabolism from the partial genome sequence of an uncultivated planktonic sample. The sequence reconstruction predicts the organism's ability to use carbon dioxide as a sole carbon source to produce building blocks in amino acid and cofactor biosynthesis, as well as reduced nitrogen compounds such as ammonia or urea to fuel energy metabolism. Thus genomics confirms what prior isotopic labeling studies suggested: under nutrient-poor conditions, these microbes have the capacity for light-independent autotrophic growth on simple compounds such as ammonia and carbon dioxide, whereas when organic material is readily available, these plankton can switch to mixotrophic growth. The conservation and ubiquity of planktonic pathways for carbon assimilation and ammonia oxidation substantiate the importance of these tiny plankton in marine ecosystems.

Detailed Justification

(dollars in thousands)

	FY 2006	FY 2007	FY 2008
Structural Biology	**15,449**	**15,300**	**15,300**

The Structural Biology program 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 and maintenance of 22 experimental stations at several 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.

(dollars in thousands)

	FY 2006	FY 2007	FY 2008
Molecular and Cellular Biology	**112,571**	**159,942**	**179,462**
▪ **Carbon Sequestration Research**	**7,663**	**7,127**	**7,127**

Microbes and plants play substantial roles in the cycling of carbon through the environment. Carbon sequestration research seeks to understand the fundamental mechanisms of carbon fixation, conversion, and cycling in microbes, microbial communities and plants. The program has initiated a new focus on carbon sequestration and utilization for biofuels, with genomics-based research that will lead to the improved use of biomass and plant feedstocks for the production of carbon-neutral fuels such as ethanol or renewable chemical feedstocks. This is part of the BER contribution to the Climate Change Technology Program (see the Climate Change Science subelement for additional information). Systems biology approaches are supported to yield fundamental knowledge of the structure, function and organization of plant genomes leading to increased carbon fixation and biomass yield, improved feedstock characterization and sustainability. Fundamental research focuses on understanding carbon uptake, fixation and storage in plants and soil microbes, strongly leveraging the increasing availability of information from whole organism genomes and community metagenomes. Research will also focus on understanding the role that microbial communities or plant-microbe associations play in the transfer of carbon between the roots and the soil, to identify strategies that would lead to increased carbon storage in the rhizosphere and surrounding soil. This research leverages BER's fundamental microbial systems biology research in Genomics: GTL and BER's terrestrial carbon cycle research to evaluate options for molecular-based terrestrial carbon sequestration and contributes to the President's Advanced Energy Initiative (AEI).

▪ **Genomics: GTL**	**87,902**	**135,319**	**154,754**
• **Genomics: GTL Foundational Research**	**64,502**	**65,319**	**39,754**

Genomics: GTL has the mission goal of developing the science, technology, and knowledge base to harness microbial and plant systems for cost-effective renewable energy production, carbon sequestration, and environmental remediation. The research program supports fundamental research and technology development that underpins all microbial and plant research conducted in the Genomics: GTL program overall and in the GTL Bioenergy Research Centers. GTL foundational research also develops the robust computational infrastructure needed to understand, predict and ultimately use the genomic potential, cellular responses, biological regulation, and behaviors of biological systems of interest to the DOE mission.

In FY 2008, the program continues to support a mix of approximately eight large multidisciplinary research teams and 30 smaller individual investigator projects to:

- develop innovative high-throughput genomic and analytic strategies and research tools for improving plant biomass and for the subsequent microbial conversion of plant biomass to biofuels, fundamental research that will contribute to GTL Bioenergy Research Centers and to GTL Bioethanol research;
- develop novel technologies to characterize the internal environment, subcellular architecture and metabolism of microbes, fundamental research that will contribute to GTL Bioenergy Research Centers and to GTL Bioethanol and Biohydrogen research; and

- develop genomic, metabolic and imaging technologies to study the structure and function of microbial communities with respect to fate and transport of environmental contaminants, bioenergy production and the fate and flow of carbon through terrestrial and marine environments.

This activity includes capital equipment support for the Genomics: GTL program that will provide state-of-the-art equipment and high performance instrumentation to meet the program's advanced imaging, high-throughput, and analytic requirements.

This activity will develop a computational infrastructure for Genomics: GTL research. The necessary algorithmic and computational tools will be developed to allow modeling of critical metabolic pathways in plants, microbes and microbial communities. Further, computational databases will be developed that have the capacity to integrate large and diverse data sets into a unified model that predicts the behavior of relevant biological systems. The research is closely coordinated with SC's Office of Advanced Scientific Computing Research and includes the GTL SciDAC research.

In FY 2008, increased GTL SciDAC research will initiate new research to develop mathematical and computational tools needed to model *in silico* genomic changes to plants and microbes. This new computational capability is expected to enable the more economical design, development and improvement of desirable properties of organisms to enable more efficient conversion of sunlight to biomass and biomass to biofuels as well as to better predict the earth's biological carbon cycle.

Over the long-term, the GTL Foundational Research should provide the scientific knowledge base and technology that can accelerate progress in all aspects of the Genomics: GTL program, as well as bridge to other DOE offices such as Energy Efficiency and Renewable Energy, Fossil Energy, and Environmental Management to develop 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.

The research is coordinated across DOE programs, both within and outside SC (BER, Basic Energy Sciences, and Energy Efficiency and Renewable Energy), across Federal Agencies, including the Department of Agriculture, the National Institutes of Health, the National Science Foundation, and across DOE laboratories, academia, industry, and non-governmental organizations.

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

- **Genomics: GTL Sequencing** **10,900** **10,000** **10,000**

DNA sequence data underpins and is the starting point for all aspects of the Genomics: GTL program. The vast majority of high-throughput DNA sequencing of plants, microbes, and microbial communities conducted at the JGI/PGF user facility is directly relevant to the Genomics: GTL program. However, the Genomics: GTL program has some unique DNA sequencing needs and challenges. In FY 2008, research will continue within Genomics: GTL to

generate DNA sequence data of cDNA expression, whole genomes and metagenomes in order to provide essential information needed to formulate genetic engineering strategies for microbes and plants, to understand plant and microbe molecular machines, to determine the composition of complex microbial communities, and to dissect plant-microbe associations. The DNA sequencing done in this sub-program complements the broader DNA sequencing activities conducted at the JGI/PGF and will specifically provide genetic data to projects within the Genomics: GTL program, including the Bioenergy Centers, and to sequencing projects that have a direct scientific impact on the Genomics: GTL program.

The research is 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 non-governmental organizations.

- **Genomics: GTL Biohydrogen Research** **12,500** **20,000** **15,000**

  Genomics: GTL research will contribute to the President's Advanced Energy Initiative with biotechnology solutions for production of two biofuels: hydrogen and ethanol. 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 exist that can use solar energy to convert water to hydrogen and oxygen, or to break down biomass and convert the component sugars into hydrogen.

  This activity supports innovative systems biology research with a specific emphasis on biological hydrogen production, such as the discovery and development of improved or oxygen-tolerant hydrogenases, characterization of specific cellular architecture to facilitate electron transfer for optimum hydrogen production, and the redirection of metabolic pathways and metabolite flow into hydrogen production. While this activity draws upon the foundational research and technology development within the broader GTL portfolio, it is specifically directed towards scientific issues and challenges unique to biological hydrogen production.

  FY 2008 funding is decreased in support of Genomics: GTL Bioenergy Research Centers.

  The research is coordinated across DOE programs (both within and outside SC), across federal agencies (including the Department of Agriculture and National Science Foundation), and across DOE laboratories, academia, industry, and nongovernmental organizations.

- **Genomics: GTL Bioethanol Research** **—** **20,000** **15,000**

  GTL research will contribute to the President's Advanced Energy Initiative with biotechnology solutions for two biofuels: ethanol and 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 residues such as corn plants left after a corn harvest or energy crops such as poplar trees that are specifically grown as biomass for energy production.

(dollars in thousands)

FY 2006	FY 2007	FY 2008

While this activity draws upon the foundational research and technology development within the broader GTL portfolio it is specifically directed towards scientific issues and challenges unique to understanding the metabolic conversion of 5- and 6-carbon sugars to ethanol. In FY 2008, research will support understanding of mechanisms that control glycolytic flux, analysis and rational design of more robust ethanolgenic biocatalysts, and discovery of biochemical approaches to improve produce tolerance to inhibition during ethanol production in hydrolysates.

FY 2008 funding is decreased in support of Genomic: GTL Bioenergy Research Centers.

The research is coordinated across DOE programs (both within and outside SC), across federal agencies (including the Department of Agriculture and National Science Foundation), and across DOE laboratories, academia, industry, and nongovernmental organizations.

- **Genomics: GTL Bioenergy Research Centers** — **20,000** **75,000**

GTL Bioenergy Research Centers will contribute to the President's Advanced Energy Initiative. The Research Centers will conduct fundamental biological research and involve no construction of facilities. The three Bioenergy Research Centers, potentially involving academic, industrial, and national lab scientists, are designed to accomplish the GTL program objectives more rapidly, more effectively, and at a reduced cost by concentrating appropriate technologies and scientific expertise to go from the genome sequence to an integrated systems understanding of the pathways and internal structures of plants and microbes most relevant to the steps required to develop bioenergy compounds. The first two GTL Bioenergy Research Centers are expected to be selected and initiated in late FY 2007 following the issuance of a competitive funding opportunity announcement on August 1, 2006 and site selection according to merit-based peer review criteria. In FY 2008, these two Bioenergy Centers are fully supported at roughly $25,000,000 each. A third GTL Bioenergy Research Center will be initiated in FY 2008 following site selection based upon merit-based peer review criteria.

Research at the Centers will focus on developing the science underpinning biofuel production that will ultimately lead to technology deployable in the Nation's energy economy. A major emphasis will be on development of cost-effective strategies to convert biomass to ethanol, and potentially, production of biodiesel, hydrogen, methane and biofuels for aviation. The Centers will draw heavily on technology and basic science generated in the foundational research, biohydrogen, and bioethanol Genomics: GTL activities. The research programs in the Centers will be distinguished from those sub-programs by being broader in scope. The research at the Centers will, potentially:

- encompass the entire spectrum from research on enhancing biomass generation and improving/modifying biomass feedstocks to biofuel production,
- pursue more high-risk, high-return approaches to bioenergy production,
- be more flexible in being able to incorporate new knowledge and change scientific direction, and
- be more problem oriented with respect to cost-effective biofuel production.

(dollars in thousands)

FY 2006	FY 2007	FY 2008

The Centers will be held to both intermediate and long term scientific deliverables to ensure that they are to help meet the longer-term goals of the Advanced Energy Initiative.

- **Low Dose Radiation Research** **17,006** **17,496** **17,581**

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.

It remains a substantial challenge to resolve the scientific uncertainty surrounding the current use of the linear no-threshold (LNT) model for developing radiation protection standards at low doses of radiation.

In FY 2008, 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. Comparative genomics will afford new opportunities for identification of specific genetic markers within affected cell populations.

University scientists, competing for funds in response to requests for applications, conduct a substantial fraction of the research in this activity.

Human Genome **60,823** **74,575** **72,733**

- **Joint Genome Institute** **51,500** **62,055** **60,000**

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 10% to approximately 60 billion base pairs in FY 2008 to support the increasing demand and need of the DOE research programs and the scientific community. The JGI's Community Sequencing Program (CSP) devotes all of its sequencing capacity to the merit-reviewed sequencing needs of the broader scientific community, while addressing the DOE mission-relevant criteria of energy production, carbon sequestration research and bioremediation research, and low dose radiation research.

In FY 2008, the CSP will sequence DNA from individual microbes, microbial communities, and small and large plants that will be selected by the CSP's merit review panel in FY 2007. The Laboratory Science Program is expected to be initiated in FY 2007 to expand participation in genomic-based research at the DOE national laboratories. Funds are provided to 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, as well as to the increasing difficulty of assembly of highly repetitive complex plant genomes.

(dollars in thousands)

FY 2006	FY 2007	FY 2008

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 production sequencing factory is located in Walnut Creek, California.

- **Tools for DNA Sequencing and Sequence Analysis** **7,723** **10,520** **7,733**

  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, from energy-relevant microbes to low dose radiation effects. Use of sequence information to understand human biology and health effects 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.

  In FY 2008, the continued funding will support additional efforts to develop high-throughput annotation methods that keep pace with the rapidly increasing rate of DNA sequencing.

- **Ethical, Legal, and Societal Issues (ELSI)** **1,600** **2,000** **5,000**

  BER ELSI research will continue the transition to activities applicable to Office of Science issues in bioenergy, synthetic biology, and nanotechnology, including exploration of, and communication of, the societal implications arising from these programs. The ecological and environmental impacts of nanoparticles (including nanotracers) resulting from nanotechnology applied to energy technologies will be studied. The research will be coordinated across the Office of Science and with other relevant Federal agencies and offices (e.g., EPA and OSTP).

  In FY 2008, activities will include support for peer-reviewed research on intellectual property and commercialization issues, economic impacts of sustainable agriculture-based biofuels, including land-use patterns, biorefineries, public perceptions of synthetic biology and nanotechnology applications, and added support for activities exploring the societal implications of research to be carried out by and at the BES Nanoscience Centers. The increased funding will support research on the ecological and environmental impacts of nanoparticles (including nanotracers) resulting from nanotechnology applied to energy technologies.

Health Effects **8,852** **7,321** **7,321**

Health effects research in functional genomics provides a link between human genomic sequencing and the development of information that is useful in understanding normal human development and disease processes including susceptibility to low doses of ionizing radiation. The mouse continues to be a useful experimental tool for this understanding. The Center for Comparative and Functional Genomics ("Mouse House") at Oak Ridge National Laboratory serves as a national focal point for high-throughput genetic studies using mice. The Mouse House creates and genetically characterizes new mutant strains of mice that serve as important models of human genetic diseases and for understanding gene function. It also develops high-throughput tools and strategies to characterize these mice.

(dollars in thousands)

FY 2006	FY 2007	FY 2008

In FY 2008, research will continue at the Laboratory for Comparative and Functional Genomics related to low dose radiation. However, BER will no longer fund the Mouse House as a user facility. BER's programmatic need for this facility as a resource for understanding the human genome has ended with the completion of human genome related research and the growth of the GTL program. However, there is still a broad need for mouse genetic resources in the scientific community, especially at the National Institutes of Health.

The research activities are principally carried out at national laboratories, selected through merit-reviewed processes.

SBIR/STTR	**—**	**7,020**	**7,527**

In FY 2006 $4,884,000 and $588,000 were transferred to the SBIR and STTR programs, respectively. FY 2007 and FY 2008 amounts are the estimated requirements for continuation of the programs.

Total, Life Sciences	**197,695**	**264,158**	**282,343**

Explanation of Funding Changes

	FY 2008 vs. FY 2007 ($000)
Molecular and Cellular Biology	
▪ Genomics: GTL Foundational Research will decrease to initiate funding for a third GTL Bioenergy Research Center and fully fund operation of the two bioenergy research centers expected to be initiated in FY 2007.	-25,565
▪ GTL Biohydrogen research decreases to support the Bioenergy Research Centers.	-5,000
▪ GTL Bioethanol research decreases to support the Bioenergy Research Centers.	-5,000
▪ Genomics: GTL Bioenergy Research Centers will increase to initiate funding for a third GTL Bioenergy Research Center and fully fund operation of the two bioenergy research centers expected to be initiated in FY 2007.	+55,000
▪ Low Dose Radiation Research is held near FY 2007 levels.	+85
Total, Molecular and Cellular Biology	**+19,520**
Human Genome	
▪ The Joint Genome Institute's (JGI) high-throughput DNA sequencing factory is decreased. However, because of advances in sequencing technology, the JGI DNA sequencing will increase at least 10 percent over FY 2007 levels.	-2,055
▪ Tools for DNA sequencing is decreased as the Human Genome Program has ended. The level of support will provide innovative tools and strategies for the scientific community to utilize and exploit rapidly expanding genomic data base.	-2,787

	FY 2008 vs. FY 2007 ($000)
▪ BER ELSI will initiate studies on the ecological and environmental impacts of nanoparticles (including nanotracers) resulting from nanotechnology applied to energy technologies.	+3,000
Total, Human Genome	**-1,842**
SBIR/STTR	
▪ Increases in SBIR/STTR due to increases in Life Sciences research funding.	+507
Total Funding Change, Life Sciences	**+18,185**

Climate Change Research

Funding Schedule by Activity

(dollars in thousands)

	FY 2006	FY 2007	FY 2008
Climate Change Research			
Climate Forcing	76,310	77,831	77,778
Climate Change Modeling	26,955	25,175	32,427
Climate Change Response	26,891	23,181	19,380
Climate Change Mitigation	6,474	5,014	4,747
SBIR/STTR	—	3,708	3,792
Total, Climate Change Research	136,630	134,909	138,124

Description

The mission of the Climate Change Research subprogram is to deliver relevant scientific knowledge that will enable both scientifically based predictions and assessments of the potential effects of greenhouse gas and aerosol emissions on climate and the environment, and the development of approaches for enhancing carbon sequestration in terrestrial ecosystems.

Benefits

This subprogram's research is expected to reduce and resolve key uncertainties and provide the scientific foundation needed to predict, assess, and help mitigate greenhouse gas forcing of climate resulting from energy production and use. Climate forcing research leads to understanding and quantification of natural and human-induced forcing of the climate system and the processes that affect such forcing, including the role of clouds, aerosols and carbon cycling. Climate change modeling research leads to the development, testing and application of fully coupled climate and Earth system models needed to project the likely response of the climate system to natural and human-induced climate forcing. Climate change response research leads to the understanding and ability to predict the response of ecological and human systems to ongoing and projected future changes in climate and atmospheric composition associated with energy production. Climate change mitigation research leads to the development of strategies or technologies for modifying or managing terrestrial systems to enhance their sequestration capacity.

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 and aerosols from fossil fuel combustion. It is also focused on how the climate system would likely respond to human-induced and natural changes in radiative forcing. The subprogram also includes research to understand and quantify the potential response of ecological systems to climatic changes. Lastly, it includes research to understand how natural processes in terrestrial ecosystems 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 CO_2. 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 element in Climate Change Research plus the carbon sequestration activity in the Life Sciences subprogram are BER's contribution to the CCTP.

The CCRI is a set of cross-agency activities in areas of high priority climate change research where substantial progress is anticipated over the next two to four years. The specific focus areas include climate forcing (atmospheric concentrations of greenhouse gases and aerosols); climate observations, climate feedbacks and sensitivity; climate modeling, including enabling research; regional impacts of climate change, including environment-society interactions; and climate observations. In FY 2008, BER will continue to participate in specific research areas of the CCRI. These areas include climate forcing, which includes modeling carbon sources and sinks, especially those in North America and quantifying the magnitude and location of the North American carbon sink, a high priority need identified in the interagency Carbon Cycle Science Plan. In climate modeling, DOE's contribution to the CCRI will continue to involve the production of future potential climate scenarios for use in assessing the environmental implications of different future possible climate states. In the climate observations area of the CCRI, the ARM mobile facility will be deployed to a location where data are needed to fill gaps in understanding key atmospheric properties and processes, and their effect on the Earth's radiation balance and climate. The Integrated Assessment Research contribution to the CCRI will continue to be the development of tools for use in assessing the costs and benefits of human-induced climate change, including those associated with different policy options for mitigating such change. (BER's FY 2008 CCRI request is $23,672,000).

Periodic retrospective analysis is employed to evaluate program management processes, priorities, and outcomes. A BERAC Committee of Visitors (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 full report and the BER response are at http://www.science.doe.gov/ober/berac.html. The next COV for the Climate Change Research Program will be in FY 2007. The BERAC is also tasked to conduct reviews of specific programs. The most recent was a review of the Terrestrial Carbon Processes Program in FY 2006 by a subcommittee of BERAC. BERAC was also tasked to undertake a review of the Integrated Assessment Program in early FY 2007.

FY 2006 Accomplishments

Climate Forcing:

- **Multi-Scale Simulations of Clouds:** The Multi-scale Modeling Framework (MMF) is a recently developed approach to climate modeling, in which a two-dimensional cloud-resolving model (CRM)

is embedded into each grid column of an Atmospheric General Climate Model (AGCM), replacing traditional cloud and radiation parameterizations. Two studies demonstrated improvements in climate simulations using the MMF. The first showed that a model using the MMF produces a simulation of upper tropospheric cloudiness that is much more realistic than a control run from a model without the MMF. The second study compared model simulations with observations from two of the ARM sites. The simulations included a run using the MMF as well as a run with traditional or standard cloud and radiation treatments. Time series of cloud fraction, precipitation intensity, and downwelling solar radiation flux at the surface were analyzed. The distributions of these variables from the MMF run were found to be more consistent with observations from the Tropical Western Pacific ARM site than those from the run using the standard cloud and radiation treatments. This change is attributed to the improved representation of convective clouds in the MMF compared to the conventional climate model which contained a standard representation of clouds. For the Southern Great Plains site, use of the MMF approach showed little or no improvement in predicting the same quantities, suggesting that standard cloud and radiation parameterization schemes may be sufficiently reliable for modeling the cloud properties and processes and their interactions with radiation for some but not all climatic regions of the globe.

- **Modeling Study Shows Important Role of Isoprene as Precursor of Secondary Organic Aerosol:** A major puzzle in recent field measurements has been a much greater abundance of organic aerosols than had been expected based on chemical modeling of previously known sources of these aerosols. A recent study which included isoprene as a source of secondary organic aerosol (SOA) in a global aerosol model found that the global burden of SOA from all sources was increased by more than a factor of two. The isoprene source substantially increases SOA concentrations in the free troposphere, because isoprene, and, more importantly, its oxidation products, exhibit much greater concentrations at higher altitudes than other biogenic SOA precursors, highlighting the role of semi-volatile organics for SOA formation. This additional source of SOA enhances production of SOA from other parent hydrocarbons by 17%, and leads to an overall distribution of SOA that differs enough from previous predictions to warrant reevaluation of the radiative effects of organic carbon aerosol.

- **Net Ecosystem Exchange of Carbon Dioxide for Different Vegetation Types:** The effect of different vegetation types on net ecosystem exchange (NEE) of carbon dioxide between the atmosphere and terrestrial biosphere was determined from AmeriFlux Network sites in close proximity. Five years of NEE measurement showed that average annual NEE values of three vegetation types were 4.4, 4.5, and 0.09 tonnes of carbon per hectare for mature and mostly deciduous forest, young pine, and old-field (mostly grass) stands, respectively. These measures represent annual net carbon gain by vegetation types that are typical of those across the uplands of the Southeastern United States. Contrary to some notions, these observations indicate that mean annual NEE of the mature forest is not significantly different from that of a 35 year old plantation (i.e., 4.4 vs 4.5 tonnes). Year-to-year response to variation in precipitation was much greater in the pine plantation than in the other vegetation types; NEE of the plantation stand increased 33% in a wet year and decreased by 21% in a dry year compared to the 5-year average, while the hardwood stand showed little year-to-year variability in the NEE measure. These multi-year AmeriFlux observations for climate variations over the 5-year period provide robust data for isolating vegetation influences on terrestrial carbon budgets of terrestrial ecosystems.

Climate Change Modeling:

- **Estimated Climate Sensitivity Constrained by Temperature Reconstructions Over the Past Seven Centuries:** The magnitude and impact of future global climate change depends on the sensitivity of the climate system to changes in greenhouse gas concentrations. The commonly accepted range for the equilibrium global mean temperature change in response to a doubling of the atmospheric carbon dioxide concentration, termed climate sensitivity, is 1.5 to 4.5^{o} C. A number of observational studies, however, find a substantial probability of significantly higher sensitivities, yielding upper limits on climate sensitivity of 7.7^{o} C to above 9^{o} C. DOE-sponsored researchers demonstrated that observational estimates of climate sensitivity can be tightened if reconstructions of Northern Hemisphere temperature over the past several centuries are considered. Using large-ensemble energy balance modeling to simulate the temperature response to past solar, volcanic and greenhouse gas forcing, the climate sensitivities which yield simulations that are in agreement with proxy reconstructions were determined. After accounting for the uncertainty in reconstructions and estimates of past external forcing, an independent estimate of climate sensitivity was determined that is very similar to those from instrumental data. When the latter are combined with the result from all proxy reconstructions, the 5% to 95% range of climate sensitivity shrinks to 1.5^{o} to 6.2^{o} C, thus substantially reducing the probability of very high climate sensitivity to a doubling of the concentration of atmospheric dioxide.

Climate Change Response:

- **Counteracting Effects of Rising Atmospheric CO_2 and Ozone Concentrations on Tree Growth:** Research at a Free-Air Carbon dioxide (CO_2) Enrichment (FACE) facility near Rhinelander, Wisconsin, is determining possible effects of rising concentrations of CO_2 and ozone (O_3) in the lower atmosphere on the growth (accumulated living biomass) of northern hardwood tree stands. After six years of treatments using concentrations of O_3 projected for the year 2050 (i.e., 50% greater than today), total biomass of aspen stands, aspen-birch mixtures, and aspen-maple mixtures, was reduced 23%, 13%, and 14%, respectively relative to that in control stands exposed to current ambient concentrations of O_3. When exposed to both elevated O_3 and CO_2 concentrations, the latter also projected for the year 2050 (i.e., 560 ppm), the aspen biomass was only 8% lower compared to that in stands of aspen growing in the present ambient atmosphere. Moreover, the accumulated biomass of the aspen-birch and aspen-maple mixtures was stimulated (8% and 24%, respectively) by the combination of elevated CO_2 and elevated O_3 relative to the present ambient atmosphere. The results amplify the importance of studying the combined effect of multiple changes in the environment rather than the effect of only single (isolated) factors, and indicate the importance of species-specific effects of environmental change.

Climate Change Mitigation:

- **Elevated Atmospheric CO_2 Increases Soil Carbon:** Carbon accrual in soil was determined from FACE and other CO_2 experiments of 2-9 year duration. In these field studies, the carbon dioxide enrichment is roughly double pre-industrial atmospheric levels (or 50% greater than today's ambient concentration), and both plant growth and productivity are stimulated, resulting in large increases of root mass and litter. For these conditions the overall soil carbon content increased by 5.6%, and at a rate of 0.19 megagrams of carbon per hectare per year. Over half of the accrued carbon was incorporated into microaggregates, which can protect carbon from rapid decomposition and increase its potential residence time in the soil. These findings indicate that the carbon storage capacities of many soils—including some with large organic matter stocks—may not be saturated at present and

might be capable of serving as carbon sinks if detrital inputs increase as a result of passive CO_2 fertilization or active management efforts to sequester carbon.

Detailed Justification

	(dollars in thousands)		
	FY 2006	FY 2007	FY 2008
Climate Forcing	**76,310**	**77,831**	**77,778**
▪ **Atmospheric Radiation Measurement (ARM) Research**	**14,714**	**14,765**	**14,765**

A major emphasis in the Climate Forcing area of the Climate Change Research subprogram is on understanding the radiation balance from the surface of the Earth to the top of the atmosphere and how this balance is affected by clouds, aerosols, and changes in increases in the concentration of greenhouse gases in the atmosphere. This area also includes research to understand the processes in the terrestrial biosphere that affect the exchange of carbon dioxide between the terrestrial biosphere and atmosphere and to quantify their net effect on atmospheric concentrations of carbon dioxide so as to better understand how they might affect atmospheric concentrations and climate forcing in the future.

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. An important element of this research is on developing component process models (e.g., cloud resolving and aerosol process models) and parameterization schemes of processes that affect climate forcing so they can be included and tested in climate models. In FY 2008, 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 funding will 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 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 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 European Center for Medium-Range Weather Forecasting. In addition, the model parameterization test bed implemented at Lawrence Livermore National Laboratory 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** **33,795** **35,174** **35,150**

  In FY 2008, the ARM infrastructure will continue to support and maintain the operation of three stationary ARM facilities and associated ground-based instrumentation ($24,903,000). It will also support the maintenance, upgrading and deployment of the ARM mobile facility ($5,000,000). It will continue to support application of ARM Aerial Vehicles for use in field campaigns around the ARM facilities and at sites of opportunity where measurement campaigns are conducted to obtain data on clouds and atmospheric properties and processes at different altitudes ($2,733,000). The ARM Infrastructure program will continue to provide data to the scientific community through the ARM Archive ($2,514,000).

  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). Selection of proposed IOPs for implementation is based on a solicitation for proposals and a competitive merit review. 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 are 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, use the ARM facilities to “ground truth” measurements made with some of their satellite-based instruments. The ARM program, including the ARM Aerial Vehicles program (AAVP), 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. The deployment location for the ARM mobile facility and the scientific focus and location of ARM IOPs in FY 2008 have not yet been determined, but a decision is expected following the review of proposals that are solicited from the research community.

  The research activities are carried out at national laboratories, universities, and private institutions, and are selected through competitive, merit review processes.

	(dollars in thousands)		
	FY 2006	FY 2007	FY 2008
▪ **Atmospheric Science**	**12,794**	**12,551**	**12,551**

The entire Atmospheric Science Program is focused on research dealing with aerosol properties and processes and their effect on radiation and climate. The focus of this program is 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 effect on climate.

In FY 2008, the Atmospheric Science Program (ASP) will continue to characterize the physical, chemical, and optical properties of energy-related aerosols and their direct and indirect effects on radiation and 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 continue supporting 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 by conducting joint field campaigns with the ARM program and providing aerosol process models for testing in climate models. The ASP will 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 2008 ($2,000,000) aimed at measuring interactions of aerosols with clouds in a region that is not well simulated by current climate models, and monitoring changes in these interactions for regional aerosols of differing physical and chemical properties. The location of this campaign is not yet finalized. Data from this and other field campaigns sponsored by the ASP will be analyzed and results will be aimed at measuring interactions of aerosols with clouds in a region that is not well simulated by current climate models, and monitoring changes in these interactions for regional aerosols of differing physical and chemical properties.

Research activities are carried out by scientists at national laboratories, universities and private institutions and are selected through competitive and merit-review processes.

▪ **Terrestrial Carbon Processes**	**10,444**	**13,332**	**13,439**

In FY 2008, BER will continue support of AmeriFlux, a network of research sites where the net exchange of carbon dioxide, energy, and water between the atmosphere and major terrestrial ecosystems in North America is continuously measured. Approximately 25 of the sites are funded by BER at an average of $200,000 each, along with the quality assurance of the measurements and data, and the data archiving to make it available to the broader scientific community. There are approximately 75 additional sites in the AmeriFlux network that are funded by other agencies

(NASA, NOAA, United States Geological Service (USGS), Forest Service, and Agriculture Research Service). The AmeriFlux 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.

In FY 2008, three of the four free-air carbon dioxide enrichment (FACE) experiments, previously funded as FACE user facilities, will be funded as part of the Terrestrial Carbon Processes research activity for approximately $4,500,000. These are the three sites located in Nevada, North Carolina, and Tennessee. Support for the fourth (Rhinelander, Wisconsin) will be provided by the Ecosystem Function and Response research activity. The focus of the FACE experiments funded by the Terrestrial Carbon Processes Program is on the capacity of the ecosystems to capture and store carbon when exposed to an elevated concentration of carbon dioxide.

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. In FY 2008, 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 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 regions of North America.

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. A major emphasis in FY 2008 will be on the development of a framework for simulating the cycling of carbon at subcontinental and continental scales that span a wide diversity of bioclimatic conditions, ecosystem types and land use.

Research activities are carried out at national laboratories, universities, and private institutions and are selected through competitive and merit-review processes.

- **Ocean Sciences** **2,696** **136** **—**

Ocean sciences research is concluded. DOE has met its commitment to the scientific community to support the analysis of ocean carbon data.

- **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 and industrial emissions of greenhouse gases, greenhouse gas fluxes from terrestrial systems, ocean pCO_2 data, and air quality data. Archiving, management, and dissemination of ocean carbon data will continue. Disseminating data on greenhouse gases 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

(dollars in thousands)

	FY 2006	FY 2007	FY 2008

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.

Climate Change Modeling	**26,955**	**25,175**	**32,427**

BER will continue to develop, improve, evaluate, and apply state-of-the-science coupled atmosphere-ocean-land-sea ice models (GCMs) that simulate climate variability and change over decade to centennial time scales. The goal is to achieve understanding of regional climate variability and change on scales as small as river basins, based on ensemble simulations. The ensemble simulations will accurately incorporate dynamic and thermodynamic feedback processes that influence climate, including clouds, aerosols, and greenhouse gas forcing. Current predictions and projections 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 models that are being improved and develop new innovative models for use in the future. 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 current and the future climate models. BER will emphasize research to develop and employ enabling technologies that can efficiently work with large and distributed data sets of both observations and model output to produce quantitative information suitable for studies and assessments of climate change at regional to global scales.

In FY 2008, BER researchers will examine specific model-based scenarios of future potential climate change to different natural and human-induced climate forcing scenarios. New research will be initiated to address strategic questions in abrupt climate change (approximately $3,800,000). The Climate Variability and Change Interagency Working Group of the U.S. Climate Change Science Program has identified Abrupt Climate Change as a priority focus area for FY 2008. The research will undertake the following: understanding the thresholds and nonlinearities in the climate system with a focus on mechanisms of abrupt climate change, incorporating mechanisms into coupled climate models, and testing the models vis-à-vis records of past abrupt climate change. DOE's focus on Abrupt Climate Change Modeling will be attribution of past abrupt climate change, and potential future abrupt climate change based on climate projections using a model that includes different mechanisms that have been hypothesized as causes of abrupt climatic change.

The model projections generated for the IPCC fourth 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

(dollars in thousands)

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. A Climate Change Science Program Synthesis and Assessment report on the evaluation of climate models for the historic period 1880-2000 will be completed, under the auspices of a DOE Federal Advisory Committee, as part of DOE's commitment to the U.S. Climate Change Science Program.

In FY 2008, BER's SciDAC for Climate Change Research ($7,776,000) will continue partnerships with the Advanced Scientific Computing Research program that were initiated under the 2006 SciDAC-2 competition. This will include work towards the creation of a first-generation Earth System model based on the Community Climate System Model that treats the coupling between the physical, chemical, and biogeochemical processes in the climate system. The model will include comprehensive treatments of the processes governing well-mixed greenhouse gases, natural and anthropogenic aerosols, the aerosol indirect effect and troposhpheric ozone for climate change studies. It also includes research to develop and test a global cloud resolving model using a geodesic grid, with grid-cell spacing of approximately 3 km, capable of simulating the circulation associated with large convective clouds. The SciDAC university grants program will be recompeted in FY 2007, and meritorious projects that address issues related to climate model development, e.g., the development of new innovative dynamical cores such as stretched grid or adaptive grid will be sponsored.

The research activities are carried out at national laboratories, universities, and private institutions and are selected through competitive and merit-review processes.

Climate Change Response	**26,891**	**23,181**	**19,380**
▪ **Ecosystem Function and Response**	**14,884**	**11,583**	**13,182**

The goal of the Ecosystem Function and Response research subprogram will continue to be the reduction of important scientific uncertainties about potential effects of climatic change on the structure and functioning of important terrestrial ecosystems in North America. The FY 2008 focus will be on understanding the biological mechanisms responsible for potential changes in the structure and functioning of ecosystems caused by climatic changes. Critical topics that will be studied include: (a) effects of warming on northern forests; (b) effects of altered precipitation timing and amount on western ecosystems, including woodlands, forests, grasslands, and shrublands; (c) effects of changes in atmospheric composition (i.e., increases in both carbon dioxide and ozone concentrations) on interactions between primary producers and consumers in forest ecosystems; (d) interacting effects of rising carbon dioxide concentration and warming on the structure and functioning of model grassland ecosystems; and (e) effects of sea level rise and increased intensity of coastal storms on coastal ecosystems. New research projects will be initiated in FY 2008 based on results of a planned competition in 2007. Both manipulative experiments and process modeling will be used in the subprogram's research.

Research in FY 2008 will also continue to highlight quantitatively important linkages between different levels of biological organization in ecosystems. In particular, experiments will continue with the aim of unraveling linkages between proteomes of individual species and key processes occurring at the level of whole ecosystems. The focus will be on understanding the responses of

ecological systems to climatic and atmospheric changes as they are mediated by changes in the genomes or proteomes of plants and microorganisms in those ecosystems. Genetic limitations placed on the ability of organisms, communities, and ecosystems to migrate in response to climatic changes will also be studied. The latter topic will be critical to understanding how ecological processes might be affected by climatic change at the scale of landscapes and regions.

In FY 2008, the subprogram will continue to support the operation and maintenance of the free-air carbon dioxide enrichment (FACE) experimental infrastructure near Rhinelander, Wisconsin (approximately $1,700,000). This unique field experiment, previously funded as a FACE user facility, is enriching the atmosphere within constructed forest communities with carbon dioxide and ozone. It is being used to answer important questions about how changes in atmospheric composition associated with energy production, i.e., increasing atmospheric concentrations of carbon dioxide and ozone in the troposphere might directly affect the biological and ecological structure and functioning of a northern hardwood forests in the United States and elsewhere. The focus of this FACE experiment is on ecosystem response to the individual and combined effect of elevated ozone and carbon dioxide concentrations, whereas the focus of the FACE experiments funded by the Terrestrial Carbon Processes Program is on the capacity of the ecosystems to capture and store carbon when exposed to an elevated concentration of carbon dioxide.

New data and understanding obtained through the research funded by this subprogram will foster informed decision making about the uses of and the means of producing energy needed by society. It will do this by defining relationships between environmental changes caused by energy production and the potential effects of those environmental changes on the delivery of important goods and services provided by terrestrial ecosystems. Tools and principles developed from this research are expected to have broad generality and eventual application to problems in ecological risk assessment, carbon sequestration, and early detection of effects of climatic and atmospheric changes on ecological systems.

The research activities are carried out at national laboratories, universities, and private research institutions and are selected through a competitive, merit-review process.

- **Free Air Carbon Dioxide Enrichment (FACE) Facility** **5,638** **5,400** **—**

In FY 2008, support for the conduct of FACE experiments will not be funded as user facility operations but instead as distinct experiments at the existing FACE sites in Wisconsin, Nevada, North Carolina, and Tennessee. Support for one of the FACE experiments will be provided by the Ecosystem Function and Response subprogram and three will be supported by the Terrestrial Carbon Processes subprogram. The activity is best characterized as field experiments in which multiple investigators jointly participate as collaborators to understand the direct effect of elevated carbon dioxide and other trace gases on terrestrial ecosystems rather than as a user facility.

	(dollars in thousands)		
	FY 2006	FY 2007	FY 2008
▪ **Integrated Assessment**	**4,948**	**4,772**	**4,772**

In FY 2008, 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 global climate change and of possible actions to mitigate such change. The goal is to improve the integrated assessment models to include several greenhouse gases, including non-carbon based gases, such as nitrous oxide and ozone. An increased emphasis in FY 2008 will be on developing an ability to analyze various policy options for mitigating greenhouse gas emissions especially relevant to a post-Kyoto timeframe (after 2012), such as inducements to participate by lesser developed countries through financial and technology transfer incentives. Development of a capability to analyze the costs and benefits of alternative technology options will remain a priority. Particular emphasis will be on the representation of biologically-derived transportation fuels, such as cellulosic ethanol, and the ancillary effects on agriculture, land and water use, and international trade. Emphasis will continue on the development and analysis of the implications of long-term emission scenarios, such as the greenhouse gas stabilization scenarios presented in the CCSP Synthesis and Assessment report on emission scenarios that is being prepared by DOE as a Synthesis and Assessment Report for the U.S. Climate Change Science Program.

The research activities are carried out at national laboratories and universities and are selected through a competitive, merit-review process.

▪ **Education**	**1,421**	**1,426**	**1,426**

BER's Global Change Education Program will continue to support both undergraduate and graduate studies in FY 2008 through the DOE Summer Undergraduate Research Experience (SURE) and the DOE Graduate Research Environmental Fellowships (GREF). The GREF and the SURE provide a total of 45 students with support to 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. Funding for GREF and SURE only supports the students, not the mentor under which they each choose to work. The SURE continues to be a magnet for highly qualified undergraduates, most of who go 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.

Climate Change Mitigation	**6,474**	**5,014**	**4,747**

Ocean carbon sequestration research concluded in FY 2006, due to adverse effects (e.g., mortality of invertebrates in the deep ocean) 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 2008, BER's carbon sequestration research, part of BER's support to the Climate Change Technology Program, will focus only on terrestrial carbon sequestration. Research will continue on studies to enhance long-term sequestration processes and the stability of stored carbon in terrestrial vegetation and soils. The research focuses on understanding mechanisms controlling rates and capacities of soil carbon accretion of plant-soil systems, and how biological processes can be

(dollars in thousands)

	FY 2006	FY 2007	FY 2008

manipulated in terms of allocating more carbon to the plant rhizosphere, and how to understand the properties of micro-biological systems that transform plant lignocellulose compounds into long-lived humic components of soil organic matter. The research addresses the effects of chemical manipulations to understand the role of calcium and nitrogen amendments on formation and stability of humic compounds in soil, including complexation of organic matter by iron oxide and other soil minerals that can potentially be purposefully altered to enhance carbon sequestration of terrestrial ecosystems. 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	**—**	**3,708**	**3,792**

In FY 2006, $3,508,000 and $419,000 were transferred to the SBIR and STTR programs, respectively. FY 2007 and FY 2008 amounts are the estimated requirements for continuation of the programs.

Total, Climate Change Research	**136,630**	**134,909**	**138,124**

Explanation of Funding Changes

	FY 2008 vs. FY 2007 ($000)
Climate Forcing	
▪ The ARM infrastructure remains at near FY 2007 levels.	-24
▪ Terrestrial Carbon Processes remains at near FY 2007 levels.	+107
▪ Ocean Sciences research is concluded and phased out in FY 2007.	-136
Total, Climate Forcing	**-53**
Climate Change Modeling	
▪ Climate Modeling increases to accelerate research to create a first-generation Earth System model that is based on the Community Climate System Model. The Earth System model will treat the coupling between the physical, chemical, and biogeochemical processes in the climate system and allow modeling experiments to be conducted to investigate the interactions and feedbacks between the processes. The model will include comprehensive treatments of the processes governing well-mixed greenhouse gases, natural and anthropogenic aerosols, the aerosol indirect effect and tropospheric ozone for climate change studies. Furthermore, increased funding of approximately $3,800,000 will include the following: understanding the thresholds and nonlinearities in the climate system with a focus on mechanisms of abrupt climate change, incorporating mechanisms into coupled climate models, and testing the models vis-à-vis records of past abrupt climate change.	+7,252

	FY 2008 vs. FY 2007 ($000)
Climate Change Response	
▪ Ecosystem Function and Response increases to support the operational costs of an ongoing FACE experiment at Rhinelander, Wisconsin. The costs for this experiment were previously funded as part of a national user facility. In FY 2008, these costs will be funded as a research activity rather than as a national user facility.	+1,599
▪ FACE user experiments to study the direct effect of elevated carbon dioxide and other trace gases on terrestrial ecosystems will no longer be funded as user facilities. Research costs are included in Terrestrial Carbon Processes Research and Ecosystem Function and Response Research.	-5,400
Total, Climate Change Response	**-3,801**
Climate Change Mitigation	
▪ Carbon Sequestration research decreases—Ocean Carbon Sequestration research is concluded.	-267
SBIR/STTR	
▪ SBIR/STTR increases due to research program increases.	+84
Total Funding Change, Climate Change Research	**+3,215**

Environmental Remediation

Funding Schedule by Activity

(dollars in thousands)

	FY 2006	FY 2007	FY 2008
Environmental Remediation			
Environmental Remediation Sciences Research	52,171	50,479	52,339
Facility Operations	39,019	44,453	42,691
SBIR/STTR	—	2,264	2,400
Total, Environmental Remediation	91,190	97,196	97,430

Description

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

Benefits

The fundamental research supported in this subprogram are expected to reduce the costs, risks, and schedules associated with the cleanup and monitoring of the DOE nuclear weapons complex; discover the fundamental mechanisms of contaminant transport in the environment; extend the frontiers of methods for remediation; and develop cutting edge molecular tools for investigating and monitoring 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. The research is already bridging the gap from basic research to application for other DOE offices. New, research-based, environmental remediation strategies and characterization tools are being deployed by the offices of Environmental Management and Legacy Management.

Supporting Information

Research goals for the Environmental Remediation Sciences subprogram include defining and understanding the processes that control contaminant fate and transport in the environment; providing opportunities for the use, or manipulation of natural processes to alter contaminant mobility and developing tools to accomplish those goals. Research results should help to 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 subprogram is closely integrated with the DOE offices of Environmental Management and Legacy Management. The goal of this integration is to provide basic research that supports the environmental remediation missions of these two offices and to optimize opportunities for the transfer of scientific advances to these offices' programmatic applications. 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 Environmental Remediation Sciences research activity is increased to provide support for two additional field research sites (for a total of 3) and to support SciDAC research projects; the EMSL budget is increased to maintain operations at full capacity.

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 its 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. This program will again host a COV in FY 2008.

The Environmental Remediation Sciences 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 cleanup 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 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 and long-term stewardship."

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

FY 2006 Accomplishments

- **Uranium can be Sequestered in Common and Unusual Subsurface Minerals:** Scientists from PNNL as well as the DOE/NSF collaborative Environmental Molecular Sciences Institutes report laboratory-based research on subsurface materials indicating that radionuclides such as uranium can be adsorbed and sequestered by a variety of common subsurface minerals including calcite, gibbsite, ferrihydrite and quartz in addition to forming unusual minerals such as sodium boltwoodite within the pores of subsurface materials. The results are important for developing more accurate models of the long-term sources and transport behavior of subsurface radionuclide contaminants at DOE sites such as Hanford, Oak Ridge and Uranium Mill Tailings Remedial Action (UMTRA) sites.
- **Whole Genome Analysis of Microorganisms at the Oak Ridge Field Research Center:** Researchers from multiple collaborating national laboratories and universities working at the Oak Ridge Field Research Center employed GTL-derived whole genome analysis of subsurface microbial communities involved in stimulated bioreduction of metals and radionuclides. The results will serve as a library of the genetic potential of organisms found in the subsurface and a basis for linking gene expression with the variable geochemical conditions found in the subsurface at this site. Assessing and linking the activity of microorganisms with the key biogeochemical processes controlling contaminant transport in the subsurface at DOE sites remains a priority.
- **Environmental Molecular Sciences Laboratory Assists in Hanford Cleanup:** A permeable reactive barrier installed in the late 1990s at the Hanford Site has been used to prevent chromate—used to prevent fuel element corrosion in nuclear reactors—from reaching the nearby Columbia

River. However, the toxic material has been detected in several groundwater monitoring wells at the site, indicating premature loss of reductive capacity of the barrier. To inhibit chromate migration, a researcher from the Pacific Northwest National Laboratory has successfully used the subsurface flow and transport capabilities at the Environmental Molecular Sciences Laboratory to conduct column and flow cell experiments to assess the viability of adding zero-valent iron enhanced with polymer solutions to portions of the barrier that have lost reductive capacity. The experiments effectively yielded the necessary polymer, polymer concentration, and injection parameters to considerably improve the effectiveness and longevity of the barrier. Fluor-Hanford is using these results for the design of a pilot test for the insertion of the zero-valent iron and polymer solution to the barrier in FY 2007.

- **Immobilization of Uranium at Oak Ridge Field Research Center:** Results from field-scale studies conducted by investigators from Stanford University and Oak Ridge National Laboratory at the Field Research Center in Oak Ridge, Tennessee, have shown that it is possible to reduce the concentration of mobile uranium from more than 1,000 times the U.S. drinking-water limit to levels at or below the limit. Over the course of a year, the Stanford and ORNL team demonstrated that by injecting ethanol and recirculating the groundwater in a specific part of the contaminant plume they could stimulate the existing microbial community to convert the uranium in the groundwater into an immobile form that precipitated on the soil. These field studies are continuing to examine the range of physical, chemical and biological factors that influence uranium immobilization and determine its long-term stability.
- **Biogeochemistry Grand Challenge Research Determines that a Microbial Outer Membrane Protein Complex Facilitates Electron Transfer to a Mineral Surface:** A team of over twenty university and Pacific Northwest National Laboratory scientists working together as part of PNNL's Biogeochemistry Grand Challenge have shown in laboratory studies that an outer membrane protein complex facilitates the transfer of electrons in the bacteria, *Shewanella oneidensis*, to iron- and manganese-containing mineral phases. Using the experimental and computational capabilities of the EMSL and other team member resources to conduct molecular modeling and experimental research, the investigators have shown that the electron transfer reaction is intrinsically rapid, but is slowed by many orders of magnitude at the mineral-water interface. This process is fundamental to many important environmental reactions, including the immobilization and remediation of some of DOE's most problematic contaminants, including uranium, technetium and chromium.

Detailed Justification

(dollars in thousands)

	FY 2006	FY 2007	FY 2008
Environmental Remediation Sciences Research	**52,171**	**50,479**	**52,339**
▪ **Environmental Remediation Sciences Research**	**45,628**	**43,936**	**47,796**

Within this subprogram, the Environmental Remediation Sciences Research activity will address questions of fundamental environmental remediation science at the interfaces of biology, chemistry, geology and physics. The research will help to 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.

(dollars in thousands)

FY 2006	FY 2007	FY 2008

In FY 2008, the research activity will support a tiered set of approximately 100 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 (approximately $10,000,000). The overall focus and integration strategy will center on field research since the ultimate goal of the Environmental Remediation Sciences subprogram is a conceptual understanding of environmental processes that control contaminant mobility in the subsurface and the development of science-based remediation strategies to influence or control these processes. 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, chemical, and geophysical parameters associated with the behavior of contaminants in the environment.

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. FY 2008 funding supports research at multiple field research sites, including the existing Oak Ridge, Tennessee site and two additional sites, one at Hanford, Washington and the other at Old Rifle, Colorado (an UMTRA site). All three sites were selected by merit review in late 2006. Additional funding for field research in FY 2008 will expand this activity and enable scientists to evaluate concepts and hypotheses under a greater variety of geohydrologic 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 missions of environmental remediation. These enhanced field activities also will emphasize the need for coordination between experimentation and computer simulation as critical components of both experimental design and model development. The expanded field research activities will be used to evaluate and validate the results of laboratory-based science and predictive modeling efforts.

The Environmental Remediation Sciences Research activity within this subprogram will continue to foster interdisciplinary research and be responsive to new knowledge and to advanced computational and analytical tools that emerge from research at the EMSL, the SciDAC program, the synchrotron light sources, and from within the GTL program in support of DOE's clean-up mission.

In FY 2008, BER participation in SciDAC will provide an opportunity for subsurface and computational scientists to develop and improve methods of simulating subsurface reactive transport processes ($972,000). 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.

The research activities are carried out at national laboratories, universities, and private institutions and selected through competitive and merit-reviewed processes.

	(dollars in thousands)		
	FY 2006	FY 2007	FY 2008
▪ **General Purpose Equipment (GPE)**	**446**	**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 support multi-purpose research.

▪ **General Plant Projects (GPP)**	**6,097**	**6,140**	**4,140**

GPP funding is continued for minor new construction, other capital alterations and additions, and for buildings and utility systems, such as replacing infrastructure in 30- to 40-year old buildings. 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. In FY 2008, funding is reduced as building consolidation efforts over the last two years have reduced the need for funding at both PNNL and ORISE.

Facility Operations	**39,019**	**44,453**	**42,691**
▪ **EMSL Operating Expenses**	**33,537**	**35,649**	**36,228**

The William R. Wiley Environmental Molecular Sciences Laboratory (EMSL), a national scientific user facility located at the Pacific Northwest National Laboratory, provides integrated experimental and computational resources for discovery and technological innovation in the environmental molecular sciences to support the needs of DOE and the nation. Operating funds are used for: staff support for users; maintenance of instruments and buildings; utilities; environmental 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 2008, EMSL operations funding is increased to enhance user facility operations and increase services to users.

▪ **Capital Equipment**	**5,482**	**8,804**	**6,463**

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 2008, capital equipment funds will be used to enhance capabilities in high-field nuclear magnetic resonance spectroscopy (e.g., cryoprobes), microbial dynamics and visualization capabilities (e.g., coupled systems) and/or data storage, as well as maintain existing user capabilities.

	(dollars in thousands)		
	FY 2006	FY 2007	FY 2008
In FY 2008, a Field Emission Transmission Electron Microscope (TEM) with a Total Estimated Cost of $4,500,000 will be acquired. This Major Item of Equipment will enable EMSL users to image conversion reactions, including catalytic reactions, under actual reaction conditions at the atomic scale, and to thereby identify the specific reaction sites.			
SBIR/STTR	**—**	**2,264**	**2,400**
In FY 2006, $2,114,000 and $254,000 were transferred to the SBIR and STTR programs, respectively. FY 2007 and FY 2008 amounts are the estimated requirements for continuation of the programs.			
Total, Environmental Remediation	**91,190**	**97,196**	**97,430**

Explanation of Funding Changes

	FY 2008 vs. FY 2007 ($000)
Environmental Remediation Sciences Research	
▪ Within the subprogram, the Environmental Remediation Sciences Research activity is increased to provide enhanced research (e.g., a greater variety of geohydrologic conditions) at the 3 field research sites and to support SciDAC research projects to improve methods of simulating subsurface reactive transport processes on "discovery class" computers.	+3,860
▪ General Plant Projects (GPP) funding is reduced as building consolidation efforts over the last two years have reduced the need for funding.	-2,000
Total, Environmental Remediation Sciences Research	**+1,860**
Facility Operations	
▪ In FY 2008, EMSL operations funding is increased to maintain operations at full capacity.	+579
▪ EMSL capital equipment funding is sufficient to maintain and replace existing user capabilities, and increase capabilities in high-field nuclear magnetic resonance spectroscopy, microbial dynamics and visualization and data storage.	-2,341
Total, Facility Operations	**-1,762**
SBIR/STTR	
▪ SBIR/STTR increases with increases in research funding.	+136
Total Funding Change, Environmental Remediation	**+234**

Medical Applications and Measurement Science

Funding Schedule by Activity

(dollars in thousands)

	FY 2006	FY 2007	FY 2008
Medical Applications and Measurement Science			
Medical Applications	138,562	13,608	13,608
SBIR/STTR	—	392	392
Total, Medical Applications and Measurement Science	138,562	14,000	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 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.

Supporting Information

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' 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 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. Members of the Medical Applications and Measurement Science 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). BER 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. A COV review of this subprogram, originally planned for FY 2006, will be delayed

until the completion of the ongoing National Academy of Science (NAS) review of U.S. nuclear medicine research and will be combined with the scheduled review of the Life Sciences subprogram in FY 2009.

FY 2006 Accomplishments

Many advances were made in imaging technology in FY 2006. These advances are described below along with applications using those advances that were supported by work-for-others, principally for the National Institutes of Health.

- **RatCAP: A New Instrument for Imaging the Awake Rat:** Conventional animal imaging devices such as the microPET require anesthesia which serves to prevent movement but which also alters brain biochemistry. This limits the translation of results from animals to humans. The RatCAP tomograph for awake rat brain imaging with Positron Emmission Tomography (PET) has been developed. The key electronic components including an Application Specific Integrated Circuit (ASIC), which can be used in a wide variety of applications and full system reconstruction matrix have been completed and successfully tested in living animals.
- **Simultaneous PET/Magnetic Resonance Imaging (MRI) Images:** The combination of PET and MRI into a simultaneous imaging instrument allows the correlation of two complementary functional data sets acquired under identical conditions. The increased anatomic resolution of the MRI greatly enhances the functional PET image. The RatCAP PET scanner has been re-designed from totally non-magnetic materials for retrofitting inside conventional MRI instruments. The PET scanner uses a new, highly integrated Application Specific Integrated Circuit (ASIC) developed at Brookhaven National Laboratory (BNL). Recent studies at BNL demonstrate that this new highly compact, low mass PET scanner works inside an MRI magnet and simultaneous dual images have been obtained.
- **Radiolabeling of Nanoparticles:** A key need for understanding the therapeutic applications and toxicology of nanoparticles and is to develop the radiopharmaceuticals needed to image their biodistribution and movement within living animals. Investigators at BNL have recently labeled cadmium selenium nanoparticles (quantum dots) with carbon-11 and tracked their distribution and metabolism in the living rat using the microPET. This is the first total body imaging of injected nanoparticle distribution and clearance in an experimental animal and provides a methodology for testing the efficacy and safety of nanoparticles.
- **Imaging Studies to Protect the Fetus:** Fetal exposure to the toxic effects of drugs of abuse and therapeutic drugs is a major health issue. However, little is known about the passage of drugs from mother to fetus, or what fetal organs are affected by drugs from the maternal circulation. Investigators at BNL have developed the fetal macaque model combined with PET and MRI as a new scientific tool to assess potential toxic effects of therapeutic drugs used during pregnancy. This is the first imaging technique that can be used to monitor adverse effects of drugs on the fetus.
- **Progress Helping the Blind to See:** The DOE Artificial Retina Program (ORNL; SNL; LANL; ANL; LLNL; BNL; University of Southern California; UC, Santa Cruz; North Carolina State, Cal Tech; and Second Sight Corporation) has completed all pre-clinical testing for the 60 electrode device; it has been approved by the Food & Drug Administration (FDA) for trials in blind patients. The trials will be conducted by NIH. The program has completed design and fabrication of the 256 electrode device and has initiated pre-clinical testing. This multi-electrode device has the potential of restoring a high level of functional vision to patients with retinal blindness.

(dollars in thousands)

	FY 2006	FY 2007	FY 2008
Medical Applications	**138,562**	**13,608**	**13,608**
▪ **Radiopharmaceuticals and Imaging**	**5,161**	**5,382**	**5,382**

In FY 2008, BER continues to support 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, including imaging of awake animals, 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.

Essentially all the research activities are carried out at Brookhaven National Laboratory and are selected through competitive and merit-reviewed processes.

▪ **Artificial Retina**	**8,300**	**8,226**	**8,226**

In FY 2008, BER continues to utilize the resources of the national laboratories in material sciences, engineering, microfabrication and microengineering to develop unique neuroprostheses and continue development of an artificial retina to restore sight to the blind. DOE's goal for the artificial retina project is to develop the technology and fabricate a 1,000+ electrode intraocular device that will allow a blind person to read large print, recognize faces, and move around without difficulty. The DOE-sponsored phase of this effort will be completed in FY 2010.

The research activities are principally carried out at national laboratories and are selected through competitive and merit-reviewed processes.

▪ **Congressionally Directed Activities**	**125,101**	**—**	**—**

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 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; Triology 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; Oliveit 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 Calument 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 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

	(dollars in thousands)		
	FY 2006	FY 2007	FY 2008

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 Microbiologies 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.

SBIR/STTR	**—**	**392**	**392**

In FY 2006, $3,560,000 and $427,000 were transferred to the SBIR and STTR programs, respectively. FY 2007 and FY 2008 amounts are the estimated requirements for continuation of the programs.

Total, Medical Applications and Measurement Science	**138,562**	**14,000**	**14,000**

Capital Operating Expenses and Construction Summary

Capital Operating Expenses

(dollars in thousands)

	FY 2006	FY 2007	FY 2008
General Plant Projects	6,097	6,140	4,140
Capital Equipment	16,878	26,121	23,780
Total, Capital Operating Expenses	22,975	32,261	27,920

Major Items of Equipment *(TEC $2 million or greater)*

(dollars in thousands)

	Total Project Cost (TPC)	Total Estimated Cost (TEC)	Prior Year Appro-priations	FY 2006	FY 2007	FY 2008	Completion Date
EMSL Field Emission Transmission Electron Microscope, PNNL	4,500	4,500	—	—	—	4,500	FY 2008