Biological and Environmental Research

Funding Profile by Subprogram

(dollars in thousands)

	FY 2004 Comparable Appropriation	FY 2005 Original Appropriation	FY 2005 Adjustments	FY 2005 Comparable Appropriation	FY 2006 Request
Biological and Environmental Research					
Life Sciences	200,320	204,011	-1,175[a]	202,836	204,035
Climate Change Research	137,997	142,959	-1,965[a]	140,994	142,959
Environmental Remediation	104,758	105,272	-816[a]	104,456	94,694
Medical Applications and Measurement Science	180,973	124,348	-642[a]	123,706	14,000
Subtotal, Biological and Environmental Research	624,048	576,590	-4,598	571,992	455,688
Construction	0	10,000	-80[a]	9,920	0
Total, Biological and Environmental Research	624,048[bc]	586,590	-4,678	581,912	455,688

Public Law Authorization:
Public Law 95-91, "Department of Energy Organization Act"

Mission

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

Benefits

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

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[a] Reflects a rescission in accordance with P.L. 108-447, the Consolidated Appropriations Act, 2005.
[b] Includes an increase of $53,250,000 for supplemental appropriations, and a reduction of $3,796,000 rescinded in accordance with P.L. 108-137, the Consolidated Appropriations Act, 2004.
[c] Includes reduction of $15,541,000, which was transferred to the SBIR program and $1,865,000, which was transferred to the STTR program.

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. Both normal and abnormal health—from normal human development to cancer to brain function—can be understood and improved using radiotracers, advanced imaging instruments, and novel biomedical devices. Understanding the biological effects of low doses of radiation can lead to the development of science-based health risk policy to better protect workers and citizens.

Strategic and Program Goals

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

Science Strategic Goal
General Goal 5, World-Class Scientific Research Capacity: Provide world-class scientific research capacity needed to: ensure the success of Department missions in national and energy security; advance the frontiers of knowledge in physical sciences and areas of biological, medical, environmental, and computational sciences; or provide world-class research facilities for the Nation's science enterprise.

The BER program has one program goal which contributes to General Goal 5 in the "goal cascade":

Program Goal 05.21.00.00: Harness the Power of Our Living World – Provide the biological and environmental discoveries necessary to clean and protect our environment, offer new energy alternatives, and facilitate the entrainment of physical sciences advances in the biomedical field.

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

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

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

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

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

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

- **Life Sciences:** Characterize the multi protein complexes (or the lack thereof) involving a scientifically significant fraction of a microbe's proteins. Develop computational models to direct the use and design of microbial communities to clean up waste, sequester carbon, or produce hydrogen.
- **Climate Change Research:** Deliver improved climate data and models for policy makers to determine safe levels of greenhouse gases for the earth's system. By 2013, substantially reduce differences between observed temperature and model simulations at subcontinental scales using several decades of recent data.
- **Environmental Remediation:** Develop science-based solutions for clean-up and long-term monitoring of DOE contaminated sites. By 2013, a significant fraction of DOE's long-term stewardship sites will employ advanced biology-based clean-up solutions and science-based monitors.
- **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.

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[a] This indicator is not a PART measure.

Annual Performance Results and Targets

FY 2001 Results	FY 2002 Results	FY 2003 Results	FY 2004 Results	FY 2005 Targets	FY 2006 Targets
Program Goal 05.21.00.00 (Harness the Power of Our Living World)					
Life Sciences					
Increase the rate of DNA sequencing: Produce at least 5.8 billion base pairs of high quality DNA microbial and model organism genome sequence. [Met Goal]	Increase the rate of DNA sequencing; Produce at least 12.7 billion base pairs of high quality DNA microbial and model organism genome sequence. [Met Goal]	Increase the rate of DNA sequencing: Produce at least 14 billion base pairs of high quality DNA microbial and model organism genome sequence. [Met Goal]	Increase the rate of DNA sequencing: Produce at least 20 billion base pairs of high quality DNA microbial and model organism genome sequence. [Met Goal]	Increase the rate of DNA sequencing -- Number (in billions) of base pairs of high quality (less than one error in 10,000 bases) DNA microbial and model organism genome sequence produced annually. FY 2005 at least 28 billion base pairs will be sequenced.	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.
Climate Change Research					
Improve climate models: Documented consistency between observed temperature changes in the atmosphere and ocean and model simulated temperature changes using the Parallel Climate Model designed to run on the massively parallel computers at DOE laboratories. [Met Goal]	Improve climate models: Released a new coupled climate model with a horizontal resolution of 2.8 degrees (longitude and latitude) in the atmosphere and 0.7 degrees in the ocean and sea ice components, compared to the previous version with a resolution of 2.8 degrees in the atmosphere and 2.0 degrees in the ocean. Executed an 800-year equilibrium climate simulation with the new model. [Met Goal]	Improve climate models: Constructed a climate model for the next round of IPCC Working Group 1 Assessment simulations. This model increased the realism of the coupled atmosphere-ocean-land surface-sea ice system through improvements in the physical parameterizations, particularly the cloud sub models. The standard model increased the horizontal resolution to 1.4 degrees in the atmosphere and maintained the 0.7 degree resolution in the ocean and sea ice components. More objective and systematic methods to test (evaluate) the performance of both the model components (i.e., atmosphere, ocean, land surface, and sea ice sub models) as well as the fully coupled model, were applied. [Met Goal]	Improve climate models: Implement a model test bed system to incorporate climate data rapidly into climate models to allow testing of the performance of sub-models (e.g. cloud resolving module) and model parameters by comparing model simulations with real world data from the ARM sites and satellites. [Met Goal]	Improve climate models: Implement three separate component submodels (an interactive carbon cycle submodel, a secondary sulfur aerosol submodel, and an interactive terrestrial biosphere submodel) within a climate model and conduct 3-4 year duration climate simulation using the fully coupled model.	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

FY 2001 Results	FY 2002 Results	FY 2003 Results	FY 2004 Results	FY 2005 Targets	FY 2006 Targets
Environmental Remediation					
Determine scalability of laboratory results in field environments: Demonstrated that uranium concentrations in groundwater can be significantly decreased using bioremediation at the Field Research Center at ORNL. [Met Goal]	Determine scalability of laboratory results in field environments: Using genomic sequencing data of key bioremediation microbes, such as Geobacter, Deinococcus, and Shewanella, determined that common soil microbes produce organic compounds that interact with radionuclides, such as plutonium, providing the molecular understanding for the detection and transformation of radionuclides in subsurface environments. [Met Goal]	Determine scalability of laboratory results in field environments: Identified naturally occurring microbial populations responsible for transformation of metals and radionuclides at DOE contaminated sites. [Met Goal]	Perform combined field/laboratory/modeling to determine how to interpret data at widely differing scales: Quantify contaminant immobilization and 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.	Develop predictive model for contaminant transport that incorporates complex biology, hydrology, and chemistry of the subsurface. Validate model through field tests.
Medical Applications and Measurement Science[1]					
Advance blind patient sight: Developed an *in vitro* testing system to test all prototype artificial retina devices for safety before inserting device into a human eye. [Met Goal]	Advance blind patient sight: Developed technology to micromachine new flexible biocompatible material to be used as a platform for multi-electrode array artificial retina. [Met Goal]	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.	Advance blind patient sight: Begin testing of prototypes for 256 microelectrode array artificial retina.
All BER Facilities					
Maintain and operate BER facilities such that achieved operation time is on average greater than 90% of the total scheduled annual operation time. [Met Goal]	*Maintain and operate BER facilities such that achieved operation time is on average greater than 90% of the total scheduled annual operation time. [Met Goal]*	*Maintain and operate BER facilities such that achieved operation time is on average greater than 90% of the total scheduled annual operation time. [Met Goal]*	*Maintain and operate BER facilities 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.*	*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.*

[1] This is not a PART measure.

Means and Strategies

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

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

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

BER also plays a key role in constructing and operating a wide array of biological and environmental user facilities for the Nation's researchers.

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

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

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

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

Validation and Verification

Progress against established plans is evaluated by periodic internal and external performance reviews. These reviews provide an opportunity to verify and validate performance. Quarterly, semiannual, and annual reviews consistent with specific program management plans are held to ensure technical progress, cost and schedule adherence, and responsiveness to program requirements.

Program Assessment Rating Tool (PART) Assessment

The Department implemented a tool to evaluate selected programs. PART was developed by OMB to provide a standardized way to assess the effectiveness of the Federal Government's portfolio of programs. The structured framework of the PART provides a means through which programs can assess their activities differently than through traditional reviews. BER has incorporated feedback from OMB into the FY 2005 and FY 2006 budget request and has taken the necessary steps to continue to improve performance.

In the FY 2005 PART review, OMB gave BER a high score of 86% overall which corresponds to a rating of "Effective." OMB found that the program is well coordinated with other federal research agencies, uses targeted grant solicitations that convey the long term goals of the program, and funds high risk research that regularly delivers important results. The assessment found that BER has developed a limited number of adequate performance measures that are continued for FY 2006. 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 these complex scientific measures, the Office of Science has 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) and also available on the website, will guide tri-annual BERAC reviews of progress toward achieving the long term Performance Measures. The annual performance targets are tracked through the department's Joule system and reported in the department's Annual Performance Report. In response to PART findings, BER established a Committee of Visitors (COV) to provide outside expert validation of the program's merit based review processes for impact on quality, relevance, and performance. The COV report is available on the web at http://www.science.doe.gov/ober/berac/ERSDCOV.pdf. BER developed an action plan to respond to the findings and recommendations of the COV within 30 days of receiving the report. This action plan is also available on the web at http://www.science.doe.gov/ober/berac/Reports.html.

Funding by General and Program Goal

	(dollars in thousands)		
	FY 2004	FY 2005	FY 2006
General Goal 5, World-Class Scientific Research Capacity			
Program Goal 05.21.00.00 Harness the Power of Our Living World			
Life Sciences	200,320	202,836	204,035
Climate Change Research	137,997	140,994	142,959
Environmental Remediation	104,758	104,456	94,694
Medical Applications and Measurement Science	180,973	123,706	14,000
Construction	0	9,920	0
Total, General Goal 5, World-Class Scientific Research Capacity	624,048	581,912	455,688

Overview

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

The Opportunity

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

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

The Challenges

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

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

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

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

The Investment Plan

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

How We Work

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

Advisory and Consultative Activities

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

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

Program Reviews

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

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

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

Planning and Priority Setting

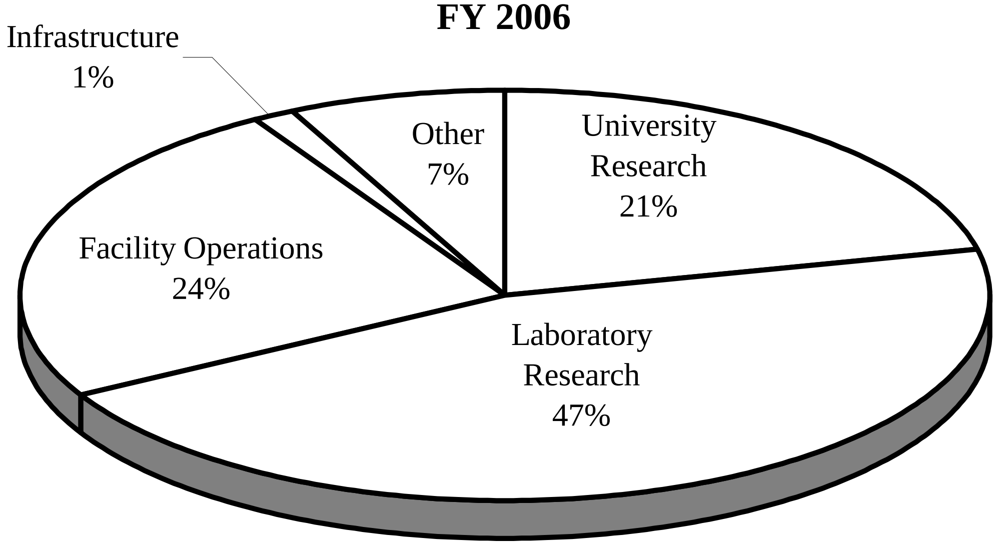
BER prides itself on supporting research and developing new research initiatives that lead the way across many fields of science and that effectively bring together many different disciplines, including biology, chemistry, engineering, computing, and the physical sciences. Merit reviews and user feedback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

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

How We Spend Our Budget

The BER budget has three major components: basic research at universities (21%); basic research at national laboratories (47%); and user facility support (24%). The remaining 8% 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 (7%)). Research at national laboratories also includes Unmanned Aerial Vehicles and other elements that represent a research infrastructure for the scientific community that includes both university and laboratory scientists. BER's user facilities include the infrastructure at synchrotron and neutron sources for structural biology and the environmental sciences, operation and equipment for the Environmental Molecular Sciences Laboratory (EMSL), support for high-throughput DNA sequencing at the Joint Genome Institute, Atmospheric Radiation Measurement Infrastructure, Free-Air CO_2 Enrichment (FACE) experimental facilities, and for the Laboratory for Cooperative and Functional Genomics ("Mouse House").

Biological and Environmental Research Budget Allocation FY 2006



Research

In FY 2006, the BER program will support fundamental research in climate change, environmental remediation, genomics, proteomics, radiation biology, and medical sciences at over 200 public and private research institutions in over 40 states and at 14 DOE laboratories in 10 states. This research will be conducted in over 1,000 different research projects by over 2,500 researchers and students. In addition to the principal investigator for each research project funded by BER, individual projects typically have between 1 and 20 additional Ph.D.-level scientists who are funded collaborators. Information on scientific collaborators is not routinely tracked.

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

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

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

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

BER Leadership and Unique Roles

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

- Manage research on microbes for energy and the environment, and work with the Advanced Scientific Computing Research program to develop the computational methods and capabilities needed to advance understanding of complex biological systems, predict their behavior, and use that information to address DOE needs.
- Provide the facilities, instrumentation, and technology needed to (1) characterize the multi-protein complexes that result in microbial products and processes of use to DOE, and (2) determine the functional repertoire of complex microbial communities that can be used to address DOE needs.
- Provide world-class structural biology user facilities.
- Provide cutting edge technologies, facilities (including high-throughput community DNA sequencing capabilities), and resources, including animal models, for genomics research.
- Provide world-class scientific user facilities for environmental and climate change research.
- Provide world leadership in low dose radiation research.
- Provide world leadership in the understanding of how metal and radionuclide contaminants interact with the environment and how environments respond to their presence.
- Provide world leadership in ground-based measurement of clouds and atmospheric properties to resolve key uncertainties in climate change, through the ARM program.
- Develop advanced predictive capabilities using coupled climate models on the Nation's premier computers for decade-to-century long simulations of climate change.

- Support fundamental research on carbon sequestration to develop technologies that enhance the uptake of carbon in terrestrial and ocean ecosystems.
- Provide the scientific knowledge and enabling discoveries to reduce the risks and costs associated with the cleanup of the DOE weapons complex and provide a basis for similar mission needs related to energy, water, and the disposal and storage of waste.
- Provide leadership in the development of reagents and imaging technologies for wide use in the medical and research communities.
- Enable interdisciplinary teams of scientists to use the unique resources in physics, chemistry, material sciences, and biology at the National Laboratories to develop novel medical applications.
- Provide world leadership in the development of intelligent micro machines that interface with the brain and spinal cord to overcome disabilities.
- Ensure that the rights and welfare of human research subjects at the Department are protected while advances in biomedical, environmental, nuclear, and other research lead to discoveries that benefit humanity.

Significant Program Shifts

Based on the PART findings, the confirmation of the BER long term Performance Measures, and program evaluation using the R&D investment criteria, BER significant program shifts for FY 2006 will focus on:

- As part of the BER program evaluation process, BERAC has confirmed that Genomics: GTL facilities are of the highest relevance to BER. Research to underpin the development and design of the technologies to be incorporated into these facilities is funded as part of the Genomics: GTL program.
- The Ethical, Legal, and Societal Issues program will include activities applicable to biotechnology and nanotechnology in cooperation with other programs in the Office of Science.
- Moving the management of the National Institute for Global Environmental Change (NIGEC) from the University of California at Davis to BER will increase performance by reducing overhead costs and freeing up funds to support additional relevant and high quality research. This action has been confirmed by the BERAC COV for the Climate Change Research program. The number of NIGEC regional centers will also be reduced from six to four by holding an open competition for the four centers. NIGEC will be managed through a cooperative agreement with each of the four centers selected through the competition. Universities wishing to serve as a host institution of one of the four NIGEC regional centers can compete for a center in FY 2005 for FY 2006 funding. The existing cooperative agreement with the University of California at Oakland that currently operates NIGEC for DOE will be discontinued to further reduce overhead costs. NIGEC will continue to solicit proposals for research relevant to BER's climate change research priorities and needs from investigators in universities and other non-Federal research institutions within each of the newly defined regions covered by the four NIGEC centers to be selected.
- Based on scientific and program relevance, ocean carbon sequestration field research on the environmental effects of ocean carbon sequestration is completed and the results of previous studies are modeled and new research on microbial processes that affect carbon transformation and sequestration in terrestrial soils using technologies, capabilities, and methods developed by the GTL program will be initiated.

- Based on fiscal restraints, BER will focus research activities on higher priorities including GTL and Climate Change Research in support of Departmental goals and objectives. Funding reductions are initiated in the Environmental Remediation Research subprogram and the Medical Applications and Measurement Science Research subprogram, accordingly. The current research activities will be phased out in FY 2005.
- Based on the BERAC COV findings for the Environmental Remediation Research subprogram, the research activities are integrated into a single program to increase the efficiency of the activities and better address the BER long term goals in environmental remediation research. This includes having the Savannah River Ecology Laboratory (SREL) compete for research funding within our overall research program rather than being a separately funded activity.
- Our enhanced climate change research will deliver earth system models that will provide regional climate predictions.

Genomics: GTL Research

The FY 2006 budget includes funds for the continued expansion of the Genomics: GTL program—a program at the forefront of the biological revolution. This program employs a systems approach to biology at the interface of the biological, physical, and computational sciences to address DOE's energy, environment, and national security mission needs. This research will continue to more fully characterize the inventory of multi-protein molecular machines found in selected DOE-relevant microbes and higher organisms. It will determine the diverse biochemical capabilities of microbes and microbial communities, especially as they relate to potential biological solutions to DOE needs, found in populations of microbes isolated from DOE-relevant sites. Support for Microbial Genomics research as a separate research activity is terminated to consolidate all microbial research within Genomics: GTL. Support of structural biology, human genome, and health effects research is reduced to support GTL research. GTL research will provide the scientific community with knowledge, resources, and tools that benefit large numbers of research projects with positive impacts on more scientists and students than are negatively impacted by the initial reduction.

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 2006 is $132,109,000.) DOE, in conjunction with its interagency partners, including NSF, NASA, NOAA, USDA, Interior, and EPA, will continue to focus its Climate Change Research in CCSP priority areas. These areas include advanced climate modeling, critical climate processes (including effects of clouds and water vapor on the atmospheric radiation balance), carbon cycling, atmospheric composition (with a focus on both greenhouse gas concentrations and effects of various aerosols on climate), effects of climate change on important terrestrial ecosystems, and the development and evaluation of tools for assessing the costs and benefits of climate change mitigation options. The deliverables from this BER research will be highlighted by information useful to policy makers.

In FY 2006, BER will contribute to the CCRI from four programs: Terrestrial Carbon Processes, Climate Change Prediction, ARM, and Integrated Assessment. Activities will be focused on (1) helping to resolve the North American carbon sink question (i.e., the magnitude and location of the North

American carbon sink); (2) deployment and operation of a mobile ARM Cloud and Radiation Testbed facility to provide data on the effects of clouds and aerosols on the atmospheric radiation budget in regions and locations of opportunity where data is lacking or sparse; (3) using advanced climate models to simulate potential effects of natural and human-induced climate forcing on global and regional climate and the potential effects on climate of alternative options for mitigating increases in human forcing of climate; and (4) developing and evaluating assessment tools needed to study costs and benefits of potential strategies for reducing net carbon dioxide emissions.

Scientific Discovery through Advanced Computing (SciDAC)

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

In FY 2006, BER will continue to advance the science of climate modeling by coupling models of different components of the earth system related to climate and by significantly increasing the spatial resolution of global climate models. These SciDAC-enabled activities will allow climate scientists to gain unprecedented insights into potential effects of energy production and use on the global climate system.

Scientific Facilities Utilization

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

BER will maintain and operate its user facilities so that the achieved operation time will be greater than 95%, on average, of total scheduled annual operation.

User Statistics

	FY 2004	FY 2005	FY 2006
	Actual	Estimate	
EMSL			
Optimal hours	4,365	4,365	4,365[a]
Scheduled hours	4,365	4,365	4,365[a]
Operation Time	95%	95%	>95%[a]
Users	1400	1400	1600
Production Genomics Facility			
Optimal hours	8,400	8,400	8,400[b]
Scheduled hours	8,400	8,400	8,400[b]
Operation Time	>98%	>98%	>98%[b]
Users	50	50	80
Laboratory for Comparative and Functional Genomics ("Mouse House")			
Optimal hours	3,536	3,536	3,536[c]
Scheduled hours	3,536	3,536	3,536[c]
Operation Time	>99%	>99%	>99%[c]
Users	20	20	20
Atmospheric Radiation Measurement (ARM)			
Optimal hours	7,862	7,862	7,862[d]
Scheduled hours	7,862	7,862	7,862[d]
Operation Time	>98%	>98%	>98%[d]
Users	765	800	800
Free Air Carbon Dioxide Enrichment (FACE)			
Optimal hours	3,966	3,966	3,966[e]
Scheduled hours	3,966	3,966	3,966[e]
Operation Time	>95%	>95%	>96%[e]
Users	200	195	200

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.

[a] Approved by BERAC May 2004. Overall average scheduled operating hours estimated at approximately 12 hours per day, 365 days per year.
[b] Approved by BERAC May 2004. The PGF DNA sequencing facility now operates almost continuously.
[c] Approved by BERAC May 2004. Definition of an operating hour was changed by BERAC from 24 hours per day, 7 days per week, 52 weeks per year to i.e., when staff are present at the facility 12 hours a day Monday-Friday and 4 hours a day on the weekend.
[d] Approved by BERAC May 2004. Allows for weather related downtime based on climatology, e.g., lightning strikes, hail, extreme winds, and cold events.
[e] Approved by BERAC May 2004. Definition of an operating hour was changed by BERAC from a sum of 4 sites to the average over the 4 sites.

Construction and Infrastructure

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

For BER activities the capital equipment is held approximately at the FY 2005 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 plant equipment (GPE). In addition to the general-purpose line item projects funded out of the Science Laboratories Infrastructure program, GPP and GPE represent the capital investment funding provided by the Department for the general laboratory infrastructure. This ensures that the PNNL and ORISE infrastructures will continue to enable the Department's mission activities at these sites.

Workforce Development

Workforce development is an integral and essential element of the BER mission to help ensure a science-trained workforce, including researchers, engineers, science educators, and technicians. The research programs and projects at the National Laboratories, universities, and research institutes actively integrate undergraduate and graduate students and post-doctoral investigators into their work. This "hands-on" approach is essential for the development of the next generation of scientists, engineers, and science educators. Specific fellowship programs are also sponsored by BER to target emerging areas of need in global change research. About 1,400 graduate students and post-doctoral investigators will be supported at universities and at National Laboratories in FY 2006, 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 2006.

Office of Science user facilities are playing an increasingly important role in workforce development. Graduate and postdoctoral students from many different disciplines use Office of Science user facilities. For example, researchers in the environmental, biological, and physical sciences use the instruments at EMSL and the synchrotron light sources. The unique capabilities at these facilities provide graduate and postdoctoral students the opportunity to participate in leading-edge research. Approximately half of all DOE facility users are graduate or postdoctoral students, for example some 600 to 700 students will conduct research at EMSL in FY 2006. Students who use EMSL receive their funding from a number of sources including the EMSL user (operating) budget, other BER projects, other DOE programs, other federal agencies, international sponsors, and private industry.

The fastest growing user community at the synchrotron light sources is environmental researchers. BER is working with BES (that manages these facilities) to prepare a plan for BER support to develop and operate environmental user stations at DOE synchrotron light sources and for user support for these stations. In addition, BER is working with scientists in the environmental research community who receive funding from DOE and from other agencies to develop more environmental science user stations at the synchrotron light sources that provide both technical support to users and that are user friendly. This will further increase the impact of SC facilities on workforce development in important research fields, such as the environmental sciences.

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

University-based scientists are the principal users of BER user facilities. University scientists also form the core of the science teams in the Climate Change Research Programs that network with the broader academic community as well as with scientists at DOE laboratories and other agencies, such as the National Aeronautics and Space Administration and the National Oceanic and Atmospheric Administration. In addition, university-based scientists are funded through Requests for Applications across the entire BER program including genomics, structural biology, low dose radiation research, climate change research, bioremediation research, medical imaging, and radiopharmaceutical development. Furthermore, university scientists work in close partnership with scientists at National Laboratories in many other BER programs including genomics, and carbon sequestration research.

	FY 2004	FY 2005 est.	FY 2006 est.
# University Grants	883	855	650
Average Size / Duration	$219,000/yr-3 yrs	$300,000/yr-3yrs	$250,000/yr-3yrs
# Laboratory Projects	400	400	375
# Permanent Ph.D.s[a] (FTEs)	1,517	1,540	1,260
# Postdoctoral Associates[b] (FTEs)	372	400	280
# Graduate Students[b] (FTEs)	488	500	410
# Ph.D.s awarded[c]	NA	NA	100

[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. Such data will be collected for FY 2006.

Life Sciences

Funding Schedule by Activity

	(dollars in thousands)				
	FY 2004	FY 2005	FY 2006	$ Change	% Change
Life Sciences					
Structural Biology	23,863	21,892	15,300	-6,592	-30.1%
Molecular and Cellular Biology	102,955	100,768	111,809	+11,041	+10.9%
Human Genome	63,578	64,572	64,226	-346	-0.5%
Health Effects	9,924	10,237	7,321	-2,916	-28.5%
SBIR/STTR	0	5,367	5,379	+12	+0.2%
Total, Life Sciences	200,320	202,836	204,035	+1,199	+0.6%

Description

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

Benefits

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

Supporting Information

BER Life Sciences supports research in the following areas:

- biological effects of low doses of ionizing radiation. The program works closely with scientists, regulators, and the public to ensure that the research results are available to develop a better scientific basis for adequately protecting people from the adverse effects of ionizing radiation.

- Genomics: GTL research, developing, together with the Advanced Scientific Computing Research program, experimental and computational resources, tools, and technologies to understand the complex behavior of biological systems – from single microbes to communities of multiple microbial species. This information can be used to develop innovative biotechnology solutions for energy production, waste cleanup, and carbon management.
- a high-throughput DNA sequencing user resource to meet DNA sequencing needs of the scientific community.
- resources, tools, and technologies to understand the function of human genes identified as part of the International Human Genome Project using model organisms such as the mouse.

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

FY 2004 Accomplishments

The Institute for Genomic Research Partners Complete Sequence of Corrosive Bacterium Desulfovibrio Vulgaris. A team of scientists led by the Institute for Genomic Research (TIGR) has sequenced the genome of Desulfovibrio vulgaris, a sulfate-reducing bacterium that can damage oil and natural gas pipelines and corrode oilfield equipment. The microbe takes part in a process called microbially influenced corrosion (MIC), in which bacteria act together to create a biofilm that covers metal pipelines or equipment by reducing sulfate to hydrogen sulfide which reacts with metals to produce metal sulfide corrosion products. MIC has caused "staggering" economic losses at industrial sites around the world, according to TIGR. It is expected that analysis of the microbe's genes will help minimize such damage. In their analysis of the D. vulgaris genome, scientists found a network of c-type cytochromes—proteins that facilitate electron transfer and metal reduction during energy metabolism and are thought to give the organism a significant capacity for reducing metals. The organism could be used to help remediate metallic pollutants such as uranium and chromium. In addition to TIGR, the sequencing team included scientists from the University of Calgary, the University of Missouri-Columbia, Johns Hopkins University, and George Washington University Medical Center. The study, funded by the U.S. Department of Energy Microbial Genome Program, was published in the May 2004 issue of Nature Biotechnology.

New Resource for Understanding Human Gene Function. The completion of the human genome sequence gave us a commonly accepted parts list of all human genes, the instructions for making proteins, the principle structural and functional molecules of life. With the completion of the human DNA sequence, a massive international effort (partially funded by the DOE Human Genome Program) was begun in August 2002 to annotate (characterize or describe) these putative genes. Over 41,000 full length DNA copies, so-called cDNAs, of the messenger RNA molecules that are the intermediate information molecules between a DNA sequence and the production of a protein were analyzed. This Full Length cDNA Annotation Jamboree involved over 100 biologists and computer scientists was initially hosted by the Japan Bioinformatics Research Center in Tokyo and has continued for the past two years. The results will be made publicly available online at http://www.publiclibraryofscience.org/. This effort was coordinated by the Integrated Molecular Analysis of Genome Expression (IMAGE) consortium, http://image.llnl.gov/, a project initiated by the DOE Human Genome Program and now funded by the National Institutes of Health. This remarkable new resource will speed discovery of gene function.

Premature Aging Caused by Low Telomerase Levels - Telomerase is an enzyme catalyzing critical steps in the replication of the exceptional chromosome tip structures, the telomeres. Telomeres require a replication mechanism distinct from that of the rest the chromosome, being comprised of multiple linear copies of a short DNA sequence. Telomeres progressively shorten over a life span, eventually limiting chromosome and cell replication. This is thought to be one of the several defenses against tumors and cancer. In the June issue of Molecular and Cellular Biology, an ORNL team describes a new protein component of the telomerase complex. The ORNL team with collaborators at the University of Toronto explored effects of exceptionally low levels of telomerase, which was genetically engineered into the mouse. In the April issue of Proceedings of the National Academy of Sciences, they report that low telomerase mice suffer premature aging effects, and so mimic a known human inherited disorder that causes premature aging. Thus a physiological balancing becomes evident, i.e., too much telomerase activity in the adult may increase the risk of cancer, while too little promotes too rapid aging. This insight is one of many achieved by the ORNL researchers over the years, using the mouse as a model for inherited genetic diseases.

Science Publishes the Genome Sequence of Geobacter, a Microbe that Precipitates Radionuclides and Metals. The genome sequence of the bacterium Geobacter sulfurreducens was published in the December 12 issue of the journal Science. The genetic code of this tiny microorganism may hold the answers to some of DOE's most difficult cleanup problems and for generating power through bio-based energy sources. The collaborative research by scientists at the University of Massachusetts and The Institute for Genomic Research (TIGR) was supported by the BER program. Geobacter microbes are commonly found in contaminated subsurface environments. These bacteria can precipitate a wide range of radionuclides and metals (including uranium, technetium, chromium, and even gold) from groundwater, thus removing contaminants from the aqueous phase and reducing risk to humans and the environment. The genome codes for all the biochemical "parts" from which Geobacter cells are built, and this knowledge should allow researchers to harness the catalytic power of this microbe in a process known as bioremediation. Geobacter is also of strong interest to the DOE because of its ability to create an electrical current in a "bio-battery". The genome sequence revealed over 100 genes that encode for c-type cytochrome proteins that facilitate electron transfer and metal reduction. Genome data also showed that Geobacter can sense and move toward metallic substances. The genome sequence and the additional research that it makes possible will lead to new strategies and biotechnologies for cleaning up metal and radionuclide-contaminated groundwater at DOE sites and for generating energy.

Protein Crystallography with Neutrons Analyzes Industrial Enzyme. The three-dimensional structures of large biological molecules such as proteins often are determined by crystallography with x-rays. Now research has demonstrated that crystallography with neutrons can reveal important structural information that cannot be found using x-rays. A newly-opened experimental station for crystallography at the Los Alamos Neutron Science Center (LANSCE) was used to determine the precise arrangement of hydrogen atoms at the active site of the enzyme D-xylose isomerase. This enzyme is used commercially to convert glucose into fructose for the manufacture of high-fructose corn syrup, a widely used sweetener in foods and beverages. The LANSCE data enabled pin-pointing the location of the hydrogen atoms of the enzyme that interact with glucose during the process. The results of the demonstration study have been published in Acta Crystallographica and a feature article about the new station has appeared in Physics Today.

X-Ray Microscopy Becomes a National Research Resource. X-rays are more energetic than visible light and thus have a shorter wavelength. This offers the possibility of using x-rays to image features in cells that are too small to be seen using optical microscopy and cannot be visualized by other types of imaging. This potential has now been realized with the initiation in April 2004 of the Resource for X-ray Tomography of Whole Cells at the Advanced Light Source (ALS) at the Berkeley Lab with joint funding by NIH and DOE. The resource will enable biologists from around the country to study sub-cellular structures in bacteria as well as human cells. The x-rays will provide pictures of the organization of essential components of the cells, pictures that will lead to better understanding of functions relevant to environmental, energy, and medical research.

Structural Biology Beamline Upgrades Work Flawlessly at New Synchrotron Ring. The storage ring at the Stanford Synchrotron Radiation Laboratory was completely replaced and recommissioned from April 2003 to March 2004 (the SPEAR3 project). The new ring emits x-ray beams that are many times more intense than those of the previous ring. This places great demands on the performance and reliability of all the experimental instrumentation using the beams. In anticipation of SPEAR3, the beamlines for structural biology were upgraded in the period 2000–2004 to meet the new requirements. They were among the first to go into service as the new ring began operation early in 2004, and have given consistently excellent results.

New DNA Sequencing User Resource for the Scientific Community. The remarkable DNA sequencing capabilities that have become available in recent years because of the success of the Human Genome Project have revolutionized the way that biologists think about and carry out their research. However, the power and value of DNA sequence information has also resulted in a demand for genomic sequencing far exceeding the remarkable capacity that is available. Now scientists have a resource that they can use on a competitive, merit-reviewed basis, to determine the DNA sequence of organisms of scientific interest and value, at no cost to the scientists. The Department’s high-throughput DNA sequencing facility, the JGI, has established a Community Sequencing Program which is providing, as a user resource, high-throughput DNA sequencing to the scientific community.

Synthetic Genome. DOE-funded researchers at the Institute for Biological Energy Alternatives (IBEA) have achieved a significant scientific advance in their efforts to piece together DNA strands, thereby helping develop new, biological methods to capture carbon dioxide from the atmosphere, produce hydrogen and clean the environment. IBEA scientists have assembled more than 5,000 bases or building blocks of DNA to create a small artificial virus, a so-called bacteriophage that infects bacteria but not humans. The researchers accomplished this in 14 days, from start to finish, reducing the time required to synthesize such a microbe from many months, even years to days. This advance brings us closer to being able to create entire microbes that are 100 to 1,000-times larger than the artificial virus created so far speeding our ability to design microbes living within the emission-control system of a coal-fired plant, consuming its pollution and its carbon dioxide, or employing microbes to radically reduce water pollution or to reduce the toxic effects of radioactive waste.

Sargasso Sea Sequencing & Discovery. Department of Energy-funded researchers at the Institute for Biological Energy Alternatives (IBEA) have sequenced DNA from Sargasso Sea samples and have discovered at least 1,800 new microbial species and more than 1.2 million new genes. IBEA researchers’ discoveries include 782 new rhodopsin-like photoreceptor genes (only a few dozen have been characterized in microorganisms to date). These new discoveries in environmental genomics lead the way to the development of new biotechnology approaches to use microbial capabilities to address DOE energy and environmental needs.

Detailed Justification

	(dollars in thousands)		
	FY 2004	FY 2005	FY 2006
Structural Biology	**23,863**	**21,892**	**15,300**
▪ **Basic Research**	**8,563**	**6,592**	**0**

Basic Structural Biology research is terminated to support Genomics: GTL research. Support for characterization, including imaging, of multiprotein complexes and of gene regulatory networks are transferred to Genomics: GTL.

▪ **Infrastructure Development**	**15,300**	**15,300**	**15,300**

BER develops and supports access to beam lines and instrumentation at DOE's national user facilities for the Nation's structural biologists. BER coordinates, with the NIH and the NSF, the management of experimental stations at DOE synchrotrons (Advanced Photon Source, Advanced Light Source (ALS), Stanford Synchrotron Radiation Laboratory (SSRL) and National Synchrotron Light Source) and neutron beam sources (the Los Alamos Neutron Science Center (LANSCE) and High Flux Isotope Reactor (HFIR) at ORNL). User statistics for all BER structural biology user facilities are included in the BES facility user reports. A new high performance station for small angle neutron scattering is expected to become operational at HFIR in FY 2006, as is a beamline for x-ray microscopy at the ALS. DOE investment in structural biology facilities has a large impact on basic research investments made by other agencies. DOE investments in structural biology user facilities at synchrotron light sources and at the EMSL enabled the National Institute of General Medical Sciences at the NIH to make a large investment for NIH's Protein Structure Initiative to develop and apply high-throughput methods for determining protein structure. BER also continually assesses the quality of the instrumentation at its experimental stations and supports upgrades to install the most effective instrumentation for taking full advantage of the facility capabilities as they are improved by DOE.

Molecular and Cellular Biology	**102,955**	**100,768**	**111,809**
▪ **Microbial Genomics**	**9,404**	**9,747**	**0**

Microbial genomics as a separate research activity is terminated to consolidate all microbial research within Genomics: GTL. Microbial genomics research that is terminated included research on functional characterization of multi-protein complexes, improved methods for microbial genome annotation, and methods to characterize microbial consortia, all research areas now being funded as part of Genomics: GTL.

▪ **Carbon Sequestration Research**	**7,004**	**5,961**	**7,127**

Microbes and plants play substantial roles in the global cycling of carbon through the environment. Carbon sequestration research seeks to understand how plants, and the microbes that enable them to grow, work together to sequester atmospheric carbon dioxide. In FY 2006 the program continues to leverage the genomic DNA sequence of the poplar tree, completed in FY 2004, by developing high-throughput experimental and computational methods for understanding the poplar genome and proteome, especially related to carbon utilization.

	(dollars in thousands)		
	FY 2004	FY 2005	FY 2006

Research will also focus on microbes that live in the poplar rhizosphere (root zone) with the intent of understanding the role that these microbes play in the transfer of carbon between the roots and the soil. The program will emphasize organisms and pathways that serve to increase long-term carbon storage over organisms and pathways that decrease carbon storage. A goal is to identify strategies that would lead to increased carbon storage in the poplar rhizosphere and surrounding soil, such as manipulation of the soil chemical environment to promote certain microorganisms or particular metabolic pathways. This research leverages BER's more fundamental microbial systems biology research in Genomics: GTL and BER's terrestrial carbon cycle research to evaluate options for molecular-based terrestrial carbon sequestration. Research also focuses on microbial based strategies for hydrogen production, part of a broad strategy to reduce carbon emissions.

	FY 2004	FY 2005	FY 2006
▪ **Genomics: GTL**	**68,727**	**67,564**	**87,186**

Genomics: GTL is a microbe-based program at the forefront of the biological revolution - a systems approach to biology at the interfaces of the biological, physical, and computational sciences. It will take advantage of solutions that nature has already devised to solve many of DOE's most pressing and expensive problems. Genomics: GTL offers the possibility of biotechnology solutions that can give us abundant sources of clean energy yet control greenhouse gases such as carbon dioxide, a key factor in global climate change, and that can help us clean up contamination of the environment.

Genomics: GTL is a comprehensive, systems-level, interdisciplinary research program that will require development of novel capabilities for new high-throughput biological research, e.g., for protein production, molecular imaging, small molecule production, and proteomics. It will involve a well integrated mix of experimental and computational science that will enable us to predict responses of biological systems to their environments and to use that capability to address DOE and national challenges.

Over the long-term, Genomics: GTL will support a combination of:

- fundamental research and technology development;
- development and use of scientific user facilities that will implement much of this new research and technology in high-throughput biological research user facilities much like DNA sequencing was moved from the research laboratory to sequencing facilities in the human genome project; and
- demonstration projects developed in partnership with other DOE offices such as Energy Efficiency and Renewable Energy, Fossil Energy, and Environmental Management to "field test" potential biotechnology solutions for clean energy production, reducing carbon dioxide in the atmosphere, and cleanup of the environment.

BER is developing a procurement strategy for the selection of Genomics: GTL facilities that will allow universities and other entities to compete with DOE national laboratories.

Nature has created a remarkable array of multi-protein molecular machines and complex microbial community structures with exquisitely diverse, precise, and efficient functions and controls. The goal of Genomics: GTL is to understand the nature and control of these molecular machines and of complex microbial communities so well that we can use and even redesign them to address DOE and national needs. Success in Genomics: GTL will be measured by scientific breakthroughs that lead to predictive computational models for:

- molecular machines and other molecules that work together in microbes,
- complex networks that control the assembly and operation of these machines, and
- the structure and biochemical capabilities of complex microbial communities.

The overriding goal of this long-term research program is to understand biology well enough to be able to predict the behavior and responses of biological systems – from cells to organisms so that they can best be used to develop biotechnology solutions that address DOE mission needs in energy, the environment, and national security. This research will lead to greatly improved computational strategies, tools, and resources that are central to the success of Genomics: GTL and, indeed, to all of biology, and that will be developed in partnership with the Advanced Scientific Computing Research program.

The broad goals of this research are shared with other agencies, such as the National Institutes of Health, the National Science Foundation, the Department of Agriculture, the Environmental Protection Agency, and private sector companies and will require coordination exceeding that of the Human Genome Project. The program focuses on scientific challenges that can be uniquely addressed by DOE and its National Laboratories in partnership with scientists at universities and in the private sector and will focus on high-throughput genomic-scale activities (e.g., DNA sequencing, complex computational analysis, imaging, and genomic protein-expression experimentation and analysis) that are beyond the reach of individual investigators or even small teams.

In FY 2006, the program continues to support a mix of large multidisciplinary research teams and smaller individual investigator projects to:

- characterize and develop computational models to describe the biochemical capabilities of microbial communities;
- develop high-throughput approaches for isolating and characterizing microbial molecular machines;
- develop computational models that accurately describe and predict the behavior of genetic regulatory networks;
- develop new technologies and strategies for imaging individual proteins and molecular machines inside microbes;
- develop new technologies for producing large numbers of microbial proteins and molecular tags to identify those proteins; and
- determine the societal and legal implications of genomics research and technology.

In FY 2006, research will also continue the high-throughput DNA sequencing of microbes and microbial communities. This DNA sequence information will continue to serve as the core of biological information needed to understand the control and function of molecular machines and complex microbial communities.

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

	FY 2004	FY 2005	FY 2006
▪ **Low Dose Radiation Research**	**17,820**	**17,496**	**17,496**

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

BER will continue to emphasize research that leads to a molecular level understanding of the biological effects of low doses of radiation exposure and the characterization of individual genetic susceptibility to radiation.

In FY 2006, BER will continue to emphasize the development and use of experimental *in vivo* systems that are more relevant to human risk from exposure to low doses of radiation. Only by understanding the effects of low doses of radiation in intact tissues or organisms can we hope to determine the health risks from those exposures.

BER will continue its emphasis on research that results from productive linkages between experimentalists and risk modelers, a relationship that lies at the critical interface between experimental science, risk analysis, and development of better risk management policies.

In particular, research will focus on:

- *Bystander effects* – the responses of cells that are not directly traversed by radiation but that respond with gene induction and/or production of potential genetic and carcinogenic changes. It is important to know if bystander effects can be induced by exposure to low linear energy transfer (LET) radiation delivered at low total doses or dose-rates. This bystander effect potentially "amplifies" the biological effects (and the effective radiation dose) of a low dose exposure by effectively increasing the number of cells that experience adverse effects to a number greater than the number of cells directly exposed to radiation. Scientists will be challenged to determine if bystander effects to low doses of ionizing radiation occur *in vivo*.

- *Genomic instability* – the loss of genetic stability, a key event in the development of cancer, is induced by radiation and expressed as genetic damage that occurs many cell divisions after the insult is administered. Current evidence indicates that DNA repair and processing of radiation damage can lead to instability in the progeny of irradiated cells. There is also evidence suggesting that individual susceptibility to genomic instability is under genetic control. However, there is virtually no information on the underlying mechanisms. The role

	(dollars in thousands)		
	FY 2004	FY 2005	FY 2006

of genomic instability in radiation-induced cancer remains to be determined experimentally.

It is also important to determine if genomic instability occurs at low total doses (<10 rads) or low dose rates. Scientists will be challenged to determine the extent to which low doses of radiation induce genomic instability *in vivo*.

- *Adaptive response* – the ability of a low dose of radiation to induce cellular changes that reduce the level of subsequent radiation-induced or spontaneous damage. If low doses of radiation regularly and predictably induce a protective response in cells to subsequent low doses of radiation or to spontaneous damage, this could have a substantial impact on estimates of adverse health risk from low dose radiation. The generality and the extent of this apparent adaptive response needs to be further investigated in *in vivo* systems.
- *Genetic factors that affect individual susceptibility to low dose radiation* – Research is also focused on determining whether genetic differences make some individuals more sensitive to radiation-induced damage since these differences could result in individuals or sub-populations that are at increased risk for radiation-induced cancer.
- *Mechanistic and risk models* – Novel research is supported that involves innovative collaborations between experimentalists and modelers to model the mechanisms of key radiation-induced biological responses and to describe or identify strategies for developing biologically based risk models that incorporate information on mechanisms of radiation-induced biological responses. This has been the most difficult and challenging component of the program. A comprehensive effort is underway to identify innovative new research strategies that will determine the extent to which the development of biologically based risk models for low dose radiation is possible. This will involve interactions between experimental and computational scientists and with scientists at regulatory agencies responsible for developing risk policy.

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

Human Genome	**63,578**	**64,572**	**64,226**
▪ **Joint Genome Institute**	**53,453**	**51,500**	**51,500**

Although research to understand the genes identified in the Human Genome Project continues, the Joint Genome Institute's (JGI) high-throughput DNA sequencing factory, the Production Genomics Facility, has transitioned away from human DNA sequencing to help meet the growing demand for DNA sequencing in the broader scientific community. The JGI has established a Community Sequencing Program (CSP) that devotes 60% of its sequencing capacity to the merit-reviewed sequencing needs of the broader scientific community, including the needs of other agencies. DNA sequencing targets are being chosen using a process of peer review of requests for sequencing submitted by individual scientists and other federal agencies. In FY 2006, the CSP will sequence approximately 20 billion base pairs of DNA from individual

	(dollars in thousands)		
	FY 2004	FY 2005	FY 2006

microbes, microbial communities, small plants and animals, and large plants and animals that will be selected by the CSP's merit review panel in FY 2005. Any large genomes selected for sequencing through the CSP will be required to meet the additional criteria of general relevance to DOE mission needs. Forty percent of the JGI's DNA sequencing capacity is being used to address DOE sequencing needs, including BER programs such as carbon sequestration research and bioremediation research, and other DOE and national needs. The substantial high-throughput DNA sequencing needs of the GTL program are supported at the JGI directly by the Genomics: GTL program and are not included here in funds for the JGI.

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

	FY 2004	FY 2005	FY 2006
▪ **Tools for DNA Sequencing and Sequence Analysis**	**8,000**	**11,225**	**11,126**

BER continues to develop the tools and resources needed by the scientific, medical, and industrial sector communities to fully exploit the information contained in complete DNA sequences, including the first human genome sequence. Unimaginable amounts of DNA sequencing, at dramatically increased speed and reduced cost, will still be required in the future for medical and commercial purposes and to understand the information in the DNA sequence that has already been determined. BER continues to further improve the efficiency and cost effectiveness of its own DNA sequencing factory at the JGI by improving the reagents used in DNA sequencing and analysis (including genome assembly and annotation); decreasing the costs of sequencing; increasing the speed of DNA sequencing; and developing more robust computational tools for genome-wide data analysis.

Use of sequence information to understand human biology and disease will also require new strategies and tools capable of high-throughput, genome-wide experimental and analytic approaches. BER will continue efforts to develop high-throughput approaches for analyzing gene regulation and function.

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

	FY 2004	FY 2005	FY 2006
▪ **Ethical, Legal, and Societal Issues (ELSI)**	**2,125**	**1,847**	**1,600**

The completion of the International Human Genome Project and the transition of BER's Human Genome research program from a human DNA sequencing program to a DNA sequencing user resource for the scientific community that focuses on the sequencing of scientifically important microbes, plants, and animals brings BER's Human Genome ELSI program to an end. In FY 2006, research will include activities applicable to Office of Science issues in biotechnology and nanotechnology such as environmental or human health concerns associated with Genomics: GTL or nanotechnology research. Research with these funds will be coordinated across the Office of Science.

	(dollars in thousands)		
	FY 2004	FY 2005	FY 2006
Health Effects	**9,924**	**10,237**	**7,321**
▪ **Functional Genomics Research**	**9,924**	**10,237**	**7,321**

Understanding the structure and function of the human genome. – Many individual genes and the regulatory networks that control them have been conserved during evolution in organisms as diverse as yeast and humans. Thus, model organisms including *Fugu* (puffer fish), *Ciona* (sea squirt), frog, and mouse can be used to efficiently understand the organization, regulation, and function of much of the human genome. Functional genomics research is a key link between human genomic sequencing, which provides a complete parts list for the human genome, and the development of information (a high-tech owner's manual) that is useful in understanding normal human development and disease processes. The mouse continues to be a major focus of our efforts and is an integral part of our functional genomics research program. Research at BER's newest user facility, the Center for Comparative and Functional Genomics at Oak Ridge National Laboratory serves as a national focal point for high-throughput genetic studies using mice. This facility creates and genetically characterizes new mutant strains of mice that serve as important models of human genetic diseases and for understanding gene function especially as they relate to the genetic information found on human chromosomes 5, 16, and 19 (DOE's chromosomes in the International Human Genome Project). It also develops high-throughput tools and strategies to characterize these mutant strains of mice. This mouse genetics research provides tools useful to the entire scientific community for decoding the functionality of the human genome as human DNA sequence becomes available.

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

SBIR/STTR	**0**	**5,367**	**5,379**

In FY 2004 $4,958,000 and $598,000 were transferred to the SBIR and STTR programs, respectively. FY 2005 and FY 2006 amounts are the estimated requirements for continuation of these programs.

Total, Life Sciences	**200,320**	**202,836**	**204,035**

Explanation of Funding Changes

	FY 2006 vs. FY 2005 ($000)
Structural Biology	
▪ Structural Biology research is reduced to support high-relevance, higher priority research on Genomics: GTL. Components that support characterization of multi-protein complexes will be funded under Genomics: GTL. Research will not be funded on the characterization of proteins and multi-protein complexes involved in DNA repair and the bioremediation of metals and radionuclides.	-6,592

	FY 2006 vs. FY 2005 ($000)
Molecular and Cellular Biology	
▪ Microbial Genomics research is phased out to support high-relevance, higher priority research that addresses the previously described goals of Genomics: GTL. Microbial research that will no longer be funded includes: (1) the development of improved and high-throughput approaches to functional characterization (e.g., transporters, environmental sensors, redox enzymes, cytoskeletal components, DNA repair systems, metal reductases, biodegradative enzymes, etc.) of microbial multi-protein complexes, (2) novel computational tools to increase the value of microbial genome sequence information, and (3) computational analyses to support existing techniques that would enable the more efficient finishing of draft sequences of microbial genomes.	-9,747
▪ Carbon Sequestration Research is restored to the FY 2004 level to use the poplar tree and/or microbial genomic sequences to enhance the partitioning of substantial amounts of carbon into components of trees or soil organic matter to develop methods for long term carbon sequestration.	+1,166
▪ Genomics: GTL is increased to support high-relevance, higher priority research to develop new methods to image molecular machines inside microbes, to alter the biochemical properties of complex microbial communities, to determine the proteome of complex microbial communities, to identify changes that cells make to its proteins once they are produced and to develop new methods for determining the sequence of a DNA molecule when starting with only one copy of the molecule, e.g., starting with only one microbial cell.	+19,622
Total Molecular and Cellular Biology	**+11,041**
Human Genome	
▪ Human Genome research is supported at near FY 2005 levels. Ethical, Legal, and Societal Issues Research will focus on issues in biotechnology and nanotechnology in cooperation with other programs in the Office of Science, such as environmental or human health concerns associated with Genomics: GTL or nanotechnology research	-346
Health Effects	
▪ Health Effects research is reduced to support high relevance, higher priority research on Genomics: GTL. Funding will be reduced for research to develop high relevance experimental models to understand the function and regulation of genes important in biological responses to injury, such as radiation damage, that provide an interface between unrealistic but commonly used two-dimensional cell culture models and research using experimental animals.	-2,916

	FY 2006 vs. FY 2005 ($000)
SBIR/STTR	
▪ Increases in SBIR/STTR due to increases in Life Sciences research funding	+12
Total Funding Change, Life Sciences	**+1,199**

Climate Change Research

Funding Schedule by Activity

	(dollars in thousands)				
	FY 2004	FY 2005	FY 2006	$ Change	% Change
Climate Change Research					
Climate and Hydrology	75,603	74,420	76,148	+1,728	+2.3%
Atmospheric Chemistry and Carbon Cycle	38,474	35,779	36,120	+341	+0.9%
Ecological Processes	15,847	18,729	18,726	-3	0.0%
Human Interaction	8,073	8,149	8,071	-78	-0.9%
SBIR/STTR	0	3,917	3,894	-23	-0.6%
Total, Climate Change Research	137,997	140,994	142,959	+1,965	+1.4%

Description

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

Benefits

This subprogram's research will reduce and resolve key uncertainties and provide the scientific foundation needed to predict, assess, and mitigate adverse effects of energy production and use on the environment through research in climate modeling and simulation, climate processes, carbon cycle and carbon sequestration, atmospheric chemistry, and ecological science.

Supporting Information

The Climate Change Research subprogram supports four contributing areas of research: Climate and Hydrology; Atmospheric Chemistry and Carbon Cycle; Ecological Processes; and Human Interactions. 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 energy production and use, primarily the emission of carbon dioxide from fossil fuel combustion. BER has designed and planned the research program to provide the 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, climate change.

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 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 carbon sequestration element of Atmospheric Chemistry and Carbon Cycle) represents DOE's contribution to the CCSP (USGCRP and

CCRI). The carbon sequestration element plus carbon sequestration activity in the Life Sciences subprogram are BER's contribution to the CCTP.

The CCRI is a set of cross-agency programs in areas of high priority climate change research where substantial progress is anticipated over the next three to five years. The specific focus areas include climate forcing (atmospheric concentrations of greenhouse gases and aerosols); climate feedbacks and sensitivity; climate modeling, including enabling research; regional impacts of climate change, including environment-society interactions; and climate observations. In FY 2006, BER will continue to participate in one of the specific research areas: climate forcing, which includes modeling carbon sources and sinks, especially those in North America. In FY 2006 BER will continue to support research to quantify the magnitude and location of the North American carbon sink, a high priority need identified in the interagency Carbon Cycle Science Plan, and on climate modeling, Atmospheric Radiation Measurement (ARM), and Integrated Assessment activities (BER's FY 2006 CCRI request is $26,924,000).

A major emphasis 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 changes in this balance due to increases in the concentration of greenhouse gases in the atmosphere may alter climate. Much of the research is focused on improving the quantitative models necessary to predict possible climate change at global and regional scales. Research in the ARM program will continue to focus on resolving the greatest scientific uncertainty in climate change prediction – the role of clouds and their interactions with solar radiation. ARM seeks to develop a better quantitative understanding of how atmospheric properties, including the extent and type of cloud cover and changes in aerosols and greenhouse gas concentrations, affect the solar and infrared radiation balance that drives the climate system.

BER's Climate Modeling program develops advanced, fully coupled, atmosphere-ocean-sea ice-land surface climate models and uses premier supercomputers to simulate and predict climate and climate change, including evaluating uncertainties in climate models due to changes in atmospheric levels of greenhouse gases on decade-to-century time scales.

The Atmospheric Science program was reconfigured in FY 2005 to focus on acquiring the data needed to understand the atmospheric processes that control the transport, transformation, and fate of energy-related aerosols emitted to the atmosphere and their radiative properties that affect climate. In FY 2006, the program will continue studies of the direct and indirect effects of aerosols on climate.

Research on the carbon cycle explores the movement of carbon on a global scale starting from natural and anthropogenic emissions to ultimate sinks in the terrestrial biosphere and the oceans. Experimental and modeling efforts primarily address the net exchange of carbon between major types of terrestrial ecosystems and the atmosphere.

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

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

Human Interactions research is focused on improving methods and models that can be used to assess the economic and societal costs and benefits of both human-induced climate change and possible response options or strategies for mitigating or adapting to climate change. It also includes support to archive and analyze climate change data and make it available for use by the broader climate change research community.

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

The full report and the BER response is available on the BER web site (http://www.science.doe.gov/ober/berac.html).

FY 2004 Accomplishments

Climate Model Software Improvements Double Performance. BER climate model software engineering, as part of the Scientific Discovery through Advanced Computing (SciDAC) program, markedly improved the performance of global climate models. Through a combination of an improved computer algorithm for inter-node communication on parallel processing computers and optimization of the numerical algorithms in the code of the atmospheric dynamical core and land surface submodels, the throughput (simulated years per day of computer time) of the Community Atmosphere Model (CAM), the atmospheric component of the Community Climate System Model (CCSM), was doubled. In addition, the new inter-node communications algorithm dramatically increased scalability, enabling the model to run more efficiently on computers with larger numbers of processors. These, and other BER improvements to climate model software (with a focus on the CCSM) are causing significant gains in throughput, and hence to the science accomplished with climate models.

New Cloud Submodel Improves General Circulation Model (GCM) Simulations. An evaluation of adding a so-called ARM "convective trigger" submodel to the National Center for Atmospheric Research (NCAR) Community Atmosphere Model (CAM2) showed that the added submodel resulted in significant improvements of CAM model simulations of global precipitation, high clouds, and zonally-averaged atmospheric temperature and moisture fields. Addition of the convective trigger submodel also resulted in a reduction of more than 50% in the simulated underestimate of tropospheric humidity compared to that predicted by the CAM2 model without the convective trigger.

New Diagnostic for Evaluating Climate Model Performance. A new model diagnostic, referred to as the Broadband Heating Rate Profile (BBHRP) was developed that helps reduce a significant obstacle to improving the predictive accuracy of climate models - the ability to accurately quantify the interaction of the clouds, aerosols, and gases in the atmosphere with radiation. The BBHRP, which is based on a fusion of detailed field measurements from the ARM program, provides a realistic estimate of the impact of clouds, aerosols, and greenhouse gases on radiative heating or cooling. Since direct observation of these interactions is extremely difficult, this diagnostic can be directly compared to the model-predicted impacts, thus enabling model uncertainties to be evaluated.

New Techniques Reduce Water Vapor Measurement Uncertainties. Researchers from the ARM program reduced the uncertainty of measurements of water vapor in the atmosphere from greater than 25% to less than 3%. Achieving the improved accuracy was done by using more accurate instruments, measurements using a microwave radiometer and a Raman lidar coupled with instrument intercomparisons, and validation of algorithms used to convert instrumental data to estimates of water vapor content. Because water vapor is by far the most abundant of the greenhouse gases, accurate water vapor measurements are essential for understanding atmospheric processes and accurately representing them in climate models.

Net Carbon Gain of Forests, Grasslands, Agricultural Crop Systems, and Tundra is Measured. AmeriFlux data from 37 terrestrial sites, including forest, grassland, agricultural crop, and tundra sites showed that the ratio of annual ecosystem respiration to gross photosynthesis averaged 0.83. The carbon that is re-emitted back to the atmosphere includes fluxes from respiration of living vegetation and the microbial decomposition of soil carbon. These results indicate that of the total amount of carbon assimilated in gross photosynthesis, an average of about 17% is retained in living biomass and soil components of the mostly forested ecosystems that have been measured. It is believed that a relatively small but yet unmeasured quantity of the retained carbon may also be lost from these systems by runoff to rivers or by carbon transport through the soil profile. Most of the measured sites represent developing or mature forests, so the percentage of carbon retained would likely be lower with young regenerating forest stands following disturbance by logging or wildfire. The results on net carbon gain by forests reported by the BER-funded researchers were recognized as an outstanding scientific contribution, and received a monetary award from the World Meteorological Organization in 2004.

Iron Input to Southern Ocean Affects Carbon Sequestration. The Southern Ocean Iron Experiment (SOFeX) (jointly funded by BER and NSF) tested the hypothesis that adding iron to the Southern Ocean would cause phytoplankton blooms that could increase uptake of carbon dioxide and the subsequent flux of carbon to the deep ocean was experimentally tested. Iron was added to two square patches of the Southern Pacific, 15 kilometers on a side, in order to increase iron levels about 100 times over the ambient conditions. The iron additions caused large phytoplankton blooms, which were visible in satellite images of the ocean. Each bloom consumed large amounts of atmospheric carbon dioxide, and some of that carbon fixed in the mixed surface layers sank to hundreds of meters in depth. This is important because long-term storage of atmospheric carbon in the ocean requires that it sink to the deep ocean where it is likely to remain for long periods of time. Carbon that remains near the surface is likely to be rapidly released back to the atmosphere. The results indicate that large-scale carbon sequestration would be possible through iron fertilization of the ocean. When compared to the rates of carbon released to the atmosphere globally from human activities, the flux of carbon to the deep ocean resulting from the iron fertilization experiment was relatively small. With the low carbon export efficiency of added iron (the ratio of carbon sequestered to iron added), the results indicate that iron fertilization as a strategy for mitigating the increase in atmospheric carbon dioxide would have to be done continuously over large areas of the ocean to have a significant impact on atmospheric carbon dioxide levels. Furthermore, the environmental effects of such a strategy on ocean biology, ecology, and chemistry are unknown.

Soil Restoration is a Significant Sink for Carbon Dioxide. Managing the organic matter (OM) content of cultivated soils is a recognized agricultural practice for sustaining soil quality and fertility. A novel (chronosequence) research approach was used to measure changes in soil organic matter over time under different land use types at the Fermilab National Environmental Research Park in northeastern Illinois. The results demonstrated that converting degraded agricultural soils to prairie ecosystems represents an important approach for enhancing soil carbon sequestration. When this practice was followed for a 23-year period, the rate of sustained soil carbon accrual was ½ metric tonne per hectacre per year. Further, by comparing agricultural soils to the near-equilibrium OM levels of native prairie remnants, the study found that Fermilab soils, which are typical of the Corn Belt Region, have a carbon storage potential of about 60 metric tonnes per hectacre. The data suggest that 50% of the potential soil carbon sink of native prairie would be achieved within 50 years if agricultural lands in the Corn Belt Region were allowed to return to native prairie.

Long-term Field Research Documents Potential Effects of Increasing Atmospheric Carbon Dioxide and Ozone on Forest Growth. BER constructed, maintains, and operates a large-scale field research facility in northern Wisconsin to study effects of experimentally elevated concentrations of carbon dioxide and ozone on growth of hardwood forests since concentrations of both carbon dioxide and ozone are increasing as by-products of energy production from fossil fuels. The forest being studied, a constructed mixture of aspen, birch, and maple trees has been fumigated with carbon dioxide and ozone since 1997. As expected, elevated carbon dioxide concentration enhanced tree growth, but for aspen, elevated ozone has counteracted the beneficial effects of carbon dioxide. For the first five years of the experiment, elevated ozone did not affect maple growth, but beginning in 2002, maple growth has slowed with elevated ozone. This latter result highlights the importance of long-term ecological research; longer-term forest responses to environmental change may only become apparent after several years in an altered environment.

Detailed Justification

	(dollars in thousands)		
	FY 2004	FY 2005	FY 2006
Climate and Hydrology	**75,603**	**74,420**	**76,148**
▪ **Climate Modeling**..	**28,377**	**27,076**	**27,141**

Model-based climate prediction provides the most scientifically valid way of predicting the impact of human activities on climate for decades to centuries in the future. BER will continue to develop, improve, evaluate, and apply the best coupled atmosphere-ocean general circulation models (GCMs) that simulate climate variability and climate change over these time scales. The goal is to achieve statistically accurate forecasts of future climate over regions as small as river basins using ensembles of model simulations. The ensembles will accurately incorporate the dynamic and thermodynamic feedback processes that influence climate, including clouds, aerosols, and greenhouse gas forcing. Current predictions are limited by computational resources and uncertainties in the model representations of key small-scale physical processes, especially those involving clouds, evaporation, precipitation, and surface energy exchange. BER will address both the computational and scientific shortcomings through an integrated effort. Support will continue to provide climate modelers access to the high-end computational resources needed to complete ensembles of climate simulations using present and future models. BER will emphasize research to develop and employ information technologies that can quickly and efficiently work with large and distributed data sets of both observations and model predictions to produce quantitative information suitable for the study of regional climate changes. BER will continue to fund the multi-institutional research consortia established in FY 2001 to further the development of comprehensive coupled GCMs for climate prediction that are of higher resolution and contain accurate and verified representations of clouds and other important climate processes. In FY 2006, BER will continue the partnership with the Advanced Scientific Computing Research program. This includes applying the computing resources for climate simulation and continuing climate model development efficiently across a wide variety of computing platforms. Additionally, BER will emphasize data assimilation methods so as to quickly make use of the high-quality observational data streams provided by ARM, satellite, and other USGCRP climate data programs to evaluate model performance.

In FY 2006, BER will provide important input to the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report, specifically model output for use by the IPCC Working Group I and others involved in climate change assessments. BER research will use the Community Climate System Model, version 3 (CCSM3) to produce ensembles of climate simulations based on IPCC scenarios of greenhouse gas emissions and other factors for the coming century. In FY 2006 the results of those simulations will be made available to and analyzed by researchers around the world, by storing model results at the IPCC Model Data archive maintained by the DOE Program for Climate Model Diagnosis and Intercomparison at Lawrence Livermore National Laboratory. These activities will be essential for understanding the state-of-the-science of U.S. climate modeling and uncertainties in simulating future climatic changes. BER will also continue to provide the infrastructure for evaluating the performance of major climate models and defining what changes may be needed to improve their performance. This will be done through continued support and coordination of model-data intercomparisons and the maintenance of test beds for evaluating model parameterizations.

In FY 2006, BER’s SciDAC program ($7,776,000) will focus on improving the models used for climate simulation and prediction. A dedicated effort will continue to provide a robust and extensible software engineering framework for the CCSM, a code used by hundreds of researchers on many different high-end computing platforms. Additional research will provide the prototype climate model of the future that will explore approaches to climate simulation and prediction for the next ten years.

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

	(dollars in thousands)		
	FY 2004	FY 2005	FY 2006

High performance computing resources are provided for development and implementation of advanced climate models.

▪ **Atmospheric Radiation Measurement (ARM) Research**	**12,861**	**13,170**	**14,833**

In FY 2006, the principal goal of the ARM scientific enterprise continues to be the development of an improved understanding of the radiative transfer processes in the atmosphere and to formulate better parameterizations of these processes in climate prediction models, referred to as General Circulation Models (GCMs). ARM research supports about 50 principal investigators involved in studies of cloud physics and the interactions of solar and infrared radiation with water vapor and aerosols (including black soot). University scientists form the core of the ARM science team that networks with the broader academic community as well as 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 both to the production of ARM data, e.g., as designers of cutting-edge remote sensing instrumentation, as well as consumers of the data produced at the three ARM sites. To facilitate the knowledge transfer from the ARM program to the premier modeling centers, the ARM program supports scientific "Fellows" at the NSF's National Center for Atmospheric Research, the NOAA's National Center for Environmental Prediction, and the European Center for Medium-Range Weather Forecasting in the U.K. In addition, a model parameterization test bed that was fully implemented in FY 2004 will be continued, to enable the testing and improvement of 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.

In FY 2006, the ARM program will undertake the Tropical Warm Pool – International Cloud Experiment (TWP-ICE) near Darwin, Australia. The experiment will be a collaborative effort between the ARM program, the ARM Unmanned Aerial Vehicle (UAV), the Australian Bureau of Meteorology, NASA, the European Commission DG RTD-1.2, and several United States, Australian, Canadian and European universities. TWP-ICE is aimed at describing the properties of tropical cirrus clouds and the convection that leads to their formation. Cirrus clouds are ubiquitous in the tropics and potentially have a large impact on climate but the properties of these clouds are poorly understood. A crucial product from this experiment will be a data set suitable for both estimating the forcing resulting from cirrus clouds and testing the performance of cloud resolving models and parameterizations in GCMs. This data set will provide the necessary link between cloud properties and the models that are attempting to simulate them.

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

The enhanced research funding will accelerate development and application of 2- and 3-D cloud resolving models in atmospheric GCMs to explore the capabilities, data, and computational needs of the superparameterization approach to climate modeling.

	(dollars in thousands)		
	FY 2004	FY 2005	FY 2006
▪ **Atmospheric Radiation Measurement (ARM) Infrastructure**	**31,441**	**31,441**	**31,441**

In FY 2006, the ARM infrastructure program will continue to develop, support, and maintain three stationary ARM Cloud Radiation Testbed (CART) facilities and associated instrumentation and a mobile ARM facility. BER will continue to operate over two hundred instruments (e.g., multifilter shadow band radiometers for aerosol measurements; Raman Lidar for aerosol and cloud measurements; radar wind profiler systems; radar cloud measurement systems; sky imaging systems; arrays of pyranometers, pyrgeometers, and pyrheliometers for atmospheric and solar radiation measurements; and standard meteorological measurement systems for characterization of the atmosphere) at the Southern Great Plains facility and will continue operations at the Tropical Western Pacific facility and the North Slope facility in Alaska. The ARM program will continue to provide data to the scientific community through the ARM Archive.

The ARM data streams will continue to be enhanced periodically by additional measurements at the ARM facilities during intensive field campaigns referred to as Intensive Operation Periods (IOPs). Ranging from two weeks to two months, the campaigns bring together teams of scientists testing cutting-edge remote-sensing instruments and coordinate measurements with airborne and satellite observations. The ARM facilities have become major testbeds of research in atmospheric processes serving as scientific user facilities for hundreds of scientists from universities and government laboratories. For example, both DOD and NASA have used the ARM facilities to “ground truth” some of their satellite instruments.

In conjunction with the ARM program, the UAV program will conduct a major field campaign to measure the effect of cirrus clouds on the absorption and scattering of downwelling radiation over the Western Tropical Pacific ARM-CART site.

The CCRI ARM program will continue to deploy a mobile climate observatory in a selected data-poor region (e.g., tropics) or a region that represents a location of opportunity for measuring the effects of atmospheric conditions on the radiation balance that are currently poorly understood (e.g., direct and indirect effects of aerosols). These atmospheric measurements are needed to fill data gaps and to develop the corresponding data products essential for evaluating and modeling the effects of atmospheric processes and properties on the radiation balance. The mobile climate observatory will be instrumented for cloud and radiation measurements. The primary siting criterion is to provide the measurements needed to address specific modeling needs that presently cannot be addressed by the permanent ARM sites. Activities are coordinated with other U.S. agencies and international partners, such as Australia, Japan, China, and European countries. Data products will be developed through collaborations with model developers. In FY 2006, the criteria for data products for evaluating precipitation processes will be established.

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

	(dollars in thousands)		
	FY 2004	FY 2005	FY 2006
▪ **Atmospheric Radiation Measurement (ARM)/Unmanned Aerial Vehicles (UAV)**	**2,924**	**2,733**	**2,733**

The UAV program will conduct one major field campaign in conjunction with the ARM program to provide high altitude measurements of cloud properties and radiation balance.

	FY 2004	FY 2005	FY 2006
Atmospheric Chemistry and Carbon Cycle	**38,474**	**35,779**	**36,120**
▪ **Atmospheric Science**	**14,366**	**12,751**	**12,551**

The CCSP strategic plan has raised the priority of research dealing with the climate effects of atmospheric aerosols. As a result BER restructured the Atmospheric Science program in FY 2005 to focus entirely on the aerosol-climate connection.

In FY 2006, the Atmospheric Science Program (ASP) will continue to quantify the impacts of energy-related aerosols on climate. It will continue to be closely coupled with other components of DOE's climate change research, especially the ARM program. The ASP will also continue to be broadly coordinated with the air quality and global change research communities, including collaborations with the EPA, NASA, NOAA, and with the DOE Office of Fossil Energy's Airborne Fine Particulate Matter (PM) Research program. Regional patterns of aerosol distribution will be related to sources and sinks, and the information will feed the models that simulate the impacts of aerosols on climate.

The ASP acquires data to understand the atmospheric processes that control the transport, transformation, and fate of energy-related aerosols. Emphasis will be on processes relating to particulate matter and climate change. Field and laboratory studies will continue to be conducted in atmospheric chemistry and acquired data will be used to develop and validate predictive models of aerosol properties and their effect on radiative forcing of climate. The research will include studies of chemical and physical processes affecting sulfur and nitrogen oxides, gas-to-particle conversion processes, and the deposition and resuspension of associated aerosols. It will also include studies to improve understanding of the meteorological processes that control the dispersion of energy-related chemicals and particulates in the atmosphere. Much of this effort will involve multi-agency collaboration, and university scientists will play key roles. The information is essential for assessing the effects of energy production on climate and will contribute to the evaluation of science-based options for minimizing the impact of energy production on climate change.

The ASP will conduct a major collaborative field study in FY 2006 aimed at determining the sources, chemical and physical properties, and radiative effects of aerosols derived from major urban centers. One candidate location is Mexico City, the largest megacity in North America. As part of this field study, BER will support simultaneous ground and aircraft measurements to examine the chemical composition and radiative impacts of the aerosols that are in the Mexico City plume. Another candidate location for an ASP field study in FY 2006 is Houston, Texas, where the transport and transformations of aerosols in the Houston region that affect aerosol radiative forcing of climate would be examined in collaboration with NOAA.

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

	(dollars in thousands)		
	FY 2004	FY 2005	FY 2006
▪ **Terrestrial Carbon Processes and Ocean Sciences**	**15,439**	**14,521**	**16,613**

In FY 2006, BER will continue supporting the AmeriFlux program, a network of approximately 15 research sites that measure the net exchange of CO_2, energy, and water between the atmosphere and major terrestrial ecosystems in North America. These measurements are linked to field measurement campaigns across North America that will test how well point measurements represent larger areas and allow the estimation of carbon sources and sinks on a regional basis. This research supports the interagency Carbon Cycle Science Plan. The potential for measuring fluxes of other greenhouse gases, e.g., methane and nitrous oxide, will also be added to 5 to 10 AmeriFlux sites.

BER will also continue research to refine and test terrestrial carbon cycle models based on mechanistic representations 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.

The continuing focus of the ocean science element is on using microbiological tools to determine the linkages between the carbon and nitrogen cycles involving marine microbes. This research is conducted through partnerships between institutions with a tradition of research in oceanography (such as Skidaway Institute of Oceanography, U. of Washington, U. of Delaware, Rutgers U., U. of South Florida, Princeton U.), and institutions traditionally serving minority students (such as Lincoln U., Howard U., Savannah State U., U. of Puerto Rico, and San Francisco State University).

In FY 2006, BER CCRI activities on the carbon cycle will continue to explore the movement of carbon starting from natural and human-induced emissions to the atmosphere to ultimate sinks in the terrestrial biosphere and the oceans. The AmeriFlux sites supported by BER are essential to quantifying the net exchange of carbon between the atmosphere and major terrestrial ecosystems in North America. Hence, they are essential to documenting the magnitude and variation in the North American carbon sink and how it is affected by variation and changes in environmental factors such as climate. BER will continue measurements and process studies at the network of AmeriFlux sites across North America. This information, along with data from extensive measurements around the sites, will provide a sound scientific basis for extrapolating carbon flux measurements at AmeriFlux sites to landscape and regional scales. Hence, it will improve estimates of the magnitude of the North American carbon sink and identify the regions and ecosystem types that account for the sink.

In FY 2006, BER terrestrial carbon cycle research, as a partner in the Interagency North American Carbon Program (NACP), will provide data, modeling, and analysis products from the Mid-Continental Intensive (MCI) field campaign. Data on net ecosystem exchange (NEE) of carbon dioxide will be produced by about 15 of the AmeriFlux Network sites, and these data along with research on fundamental mechanisms and processes will help to validate remote sensing observations and model calculations of terrestrial sources and sinks for this region of North America. One important outcome of the NACP-MCI field study will be a test of the suite of methodologies on atmospheric observations, flux measurement, biometric inventory, and remote sensing methodologies. The key contribution of the BER AmeriFlux Program is unique NEE and biometric data and ecosystem carbon cycle analysis.

	(dollars in thousands)		
	FY 2004	FY 2005	FY 2006

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

▪ **Carbon Sequestration Research**	**8,669**	**8,507**	**6,956**

In FY 2006, terrestrial carbon sequestration research will develop an improved soil carbon model based on actual measurements of carbon in extractable and well-characterized components of soil. New information on soil aggregate formation and stability factors will be incorporated into extant models like Century, EPIC, and Rothamsted, to improve actual correspondence between model algorithms and the measured components of soil carbon in laboratory and field investigations. Simulations with improved soil carbon models will be a significant step forward in the development of a methodology to evaluate the effectiveness of carbon sequestration practices because it will allow direct comparisons between modeled results and observations.

New research on microbial processes that affect carbon transformation and sequestration in terrestrial soils using technologies, capabilities, and methods developed by the Genomics: GTL program will be initiated. The new research will leverage the DNA sequence information on naturally-occurring soil microbes and will focus on applying this and other information on gene functions, regulatory pathways, and process rates of soil microbes (e.g., bacteria, fungi in the rhizosphere) to understand how they can be altered to enhance carbon sequestration in soils, such as by stimulating or reducing *in situ* specific metabolic process rates that regulate the quantities and chemical forms of reduced carbon sequestered in soils in long-term, stable pools. This research leverages BER's more fundamental microbial systems biology research in Genomics: GTL and BER's Carbon Sequestration Research in the Life Sciences area to evaluate the potential of molecular-based options for terrestrial carbon sequestration.

In FY 2006, a coupled model of physical, chemical, and biological processes in the ocean will be used to determine to what extent increased carbon fixation in surface waters would result in increased carbon sequestration in the deep ocean, how long carbon added to the ocean would remain in the ocean, and the changes in natural biogeochemical cycles that could result from carbon sequestration through iron fertilization of surface waters. This research leverages the ocean modeling capabilities developed in BER's climate modeling program and completed field experiments. Surface Ocean carbon sequestration field experiments have been completed. Final results from the Southern Ocean Iron Experiment jointly funded with NSF will be published but no additional field research on ocean carbon sequestration will be supported by BER. Ocean carbon sequestration research will focus on the modeling activities discussed above.

Ecological Processes..	**15,847**	**18,729**	**18,726**

In FY 2006, new ecological research will continue to develop a more mechanistic understanding of the scales of response of complex ecosystems to environmental changes, including identifying the underlying causal mechanisms and pathways and how they are linked, ranging from the proteomes of individual species to the whole ecosystem. The focus will be on understanding the linkages of scales in model terrestrial ecosystems containing simplified but hierarchical communities (higher plants, consumers of plant production, and soil microorganisms). A key environmental factor such as temperature that is known to affect ecosystem functioning (e.g., carbon and nutrient cycling) will be experimentally manipulated and proteomic responses of individual species and the whole ecosystem will be measured. Advanced biologically based computational algorithms and ecosystem models will be developed to establish whether and how proteomic changes (in either single species or whole systems) explain the responses and behavior of complex ecosystems. Tools and principles developed from this research should have broad generality and eventual application to problems in carbon sequestration, ecological risk assessment, environmental restoration and cleanup, and early detection of ecological responses to climate change and other environmental factors.

BER will continue four Free-Air Carbon Dioxide Enrichment (FACE) experiments. They are located at facilities at Duke University (North Carolina), Rhinelander (Wisconsin), Oak Ridge (Tennessee), and Mercury (Nevada) on the Nevada Test Site. The experiments will improve understanding of the direct effects of experimentally elevated carbon dioxide and other atmospheric changes (such as elevated ozone) on the structure and functioning of various terrestrial ecosystems. Emphasis will be on understanding the cause of differential responses of plant species that may impact plant competition, succession, and productivity in terrestrial ecosystems. Research will explore changes, over time, in the effects of elevated atmospheric carbon dioxide concentrations on net primary productivity.

The long-term experimental investigation of altered precipitation at the Walker Branch Watershed in Tennessee will continue to improve the understanding of the direct and indirect effects of changes in the annual average precipitation amount on the functioning and structure of a southeastern deciduous forest ecosystem.

Both the FACE network and the Walker Branch Watershed represent scientific user facilities that have attracted scientists from both the academic community and government laboratories who use the facilities to test scientific hypotheses related to ecosystem responses, including carbon sequestration, to climatic and atmospheric changes.

In FY 2006, a synthesis will be completed of known effects of increasing atmospheric carbon dioxide concentration, warming, and other factors (e.g., increasing tropospheric ozone concentration) on the structure and functioning of terrestrial ecosystems as determined by multi-factor experiments. This synthesis will fulfill one of the milestones of the U.S. Climate Change Science Program 2003 Strategic Plan.

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

	FY 2004	FY 2005	FY 2006
Human Interactions	**8,073**	**8,149**	**8,071**

The Integrated Assessment program, with a strong academic involvement, will continue to support research that will lead to better estimates of the costs and benefits of possible actions to mitigate global climate change. The goal is to improve the integrated assessment models to include several greenhouse gases, carbon sequestration, and international trading of emission permits. The models will better represent the efficiency gains and losses of alternative emission reduction plans, including market adjustments to inter-regional differences among relative energy prices, regulations, and production possibilities in the international arena. Integrated assessment models will be modified to include carbon sequestration as an alternative mitigation option. The carbon sequestration element of the model will include both options to enhance natural carbon storage in the terrestrial biosphere, as well as engineering

	(dollars in thousands)		
	FY 2004	FY 2005	FY 2006

options, such as the capture of carbon dioxide and storage in geologic formations.

The research will include integrating a new land and ocean carbon submodel in a large integrated assessment model. The submodel includes a detailed representation of direct human influence (mainly agriculture and forestry) on the terrestrial biosphere. In addition to providing a more accurate representation of the global carbon cycle, the improvement will ensure consistent accounting of carbon-sink projects and the carbon uptake that occurs as a result of other land-use changes and the effects of climate change and carbon fertilization. A second integrated assessment model will be used to simulate the effect of (1) climate on crop yields and (2) the amount of crop and pasture land necessary to provide (a) a sufficient diet in developing countries under climate change and (b) the likely increase in dietary requirements as developing countries become richer.

The Integrated Assessment research program will fund research to develop internally consistent sets of scenarios that can be used for national-scale decision-making. The scenarios will be evaluated in selected integrated assessment models, also funded by the Integrated Assessment program. In FY 2006, the Integrated Assessment research program will deliver an integrated assessment model that incorporates a global multi-country, multi-sector economics model and a 2-dimensional (2-D) model of the atmosphere (latitude and height) fully coupled with a 3-D ocean model and a 2-D (latitude and longitude) model of the terrestrial biosphere. To better address regional issues, this system will be extended to integrate fully coupled 3-D models of both the atmosphere and oceans. This much improved earth system model will allow, for the first time, an analysis of climate impacts at the regional level using an integrated model that includes both emissions data and climate responses. These analyses will facilitate, for example, regional studies of climate effects on human health and agriculture.

The Information and Integration element stores, evaluates, and quality-assures a broad range of global environmental change data, and disseminates those data to the broad research community. BER will continue the Quality Systems Science Center for the tri-lateral (Mexico, United States, and Canada) NARSTO (formally known as the North American Strategy for Tropospheric Ozone), a public partnership for atmospheric research in support of air quality management. The Center serves a diverse set of users, including academic and laboratory scientists and policy makers across North America.

The Global Change Education program supports DOE-related research in global environmental change for both undergraduate and graduate students, through the DOE Summer Undergraduate Research Experience (SURE), and the DOE Graduate Research Environmental Fellowships (GREF).

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

SBIR/STTR..	**0**	**3,917**	**3,894**

In FY 2004 $3,454,000 and $403,000 were transferred to the SBIR and STTR programs, respectively. For FY 2005 and FY 2006, amounts are the estimated requirements for continuation of these programs.

Total, Climate Change Research	**137,997**	**140,994**	**142,959**

Explanation of Funding Changes

	FY 2006 vs. FY 2005 ($000)
Climate and Hydrology	
▪ The increased funding will accelerate development and application of 2- and 3-D cloud resolving models in atmospheric GCMs to explore the capabilities, data, and computational needs of the superparameterization approach to climate modeling.	+1,728
Atmospheric Chemistry and Carbon Cycle	
▪ Terrestrial carbon sequestration research maintained at near FY 2005 level.	+341
Ecological Processes	
▪ Ecological Processes research maintained at near FY 2005 level.	-3
Human Interaction	
▪ Integrated assessment research maintained at near FY 2005 level.	-78
SBIR/STTR	
▪ SBIR/STTR reduced due to research program reductions.	-23
Total Funding Change, Climate Change Research	**+1,965**

Environmental Remediation

Funding Schedule by Activity

	(dollars in thousands)				
	FY 2004	FY 2005	FY 2006	$ Change	% Change
Environmental Remediation					
Environmental Remediation Sciences Research	59,929	58,111	48,600	-9,511	-16.4%
General Purpose Equipment (GPE)	959	959	403	-556	-58.0%
General Plant Projects (GPP)	4,811	5,584	6,140	+556	+10.0%
Facility Operations	39,059	37,228	37,138	-90	-0.2%
SBIR/STTR	0	2,574	2,413	-161	-6.3%
Total, Environmental Remediation	104,758	104,456	94,694	-9,762	-9.3%

Description

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

Benefits

The fundamental research supported in this subprogram will reduce the costs, risks, and schedules associated with the cleanup of the DOE nuclear weapons complex; extend the frontiers of methods for remediation; discover the fundamental mechanisms of contaminant transport in the environment; develop cutting edge molecular tools for investigating environmental processes; and develop an understanding of the ecological impacts of remediation activities. In addition much of the work performed for the cleanup program will provide fundamental knowledge that applies to a broad range of remediation problems, as well as to the development of advanced nuclear waste management approaches, and the prediction and avoidance of environmental hazards for future nuclear energy options.

Supporting Information

Research priorities include bioremediation, contaminant fate and transport, nuclear waste chemistry and advanced treatment options, and the operation of the William R. Wiley Environmental Molecular Sciences Laboratory (EMSL). The EMSL is supported as a national user facility providing advanced molecular tools to the scientific community in areas such as environmental remediation sciences, biology and genomics, atmospheric science and physical chemistry. In FY 2006, unique EMSL facilities, such as the newly upgraded Molecular Science Computing Facility, 900 MHz nuclear magnetic resonance (NMR) spectrometers, and the High-Field Mass Spectrometry Facility will expand both their scientific scope and their user base.

The Environmental Remediation Sciences subprogram was reviewed by a BERAC Committee of Visitors (COV) in 2004. The COV has issued its final report. The COV report was supportive of the subprogram and the approach to selecting and funding research projects. The major recommendation of the COV was that the Environmental Remediation subprogram integrate all research activities. The COV found Environmental Remediation activities well focused on the key science needs for DOE clean-up, e.g., the role of living organisms in the mobility of DOE-specific contaminants and high-level waste issues. While the Environmental Remediation subprogram was found to be well managed, the COV noted the need for improved documentation of funding decisions. BER has acted on the findings and recommendations by implementing a policy to consistently document the bases of funding decisions, expanding the documentation and providing summaries of the outcome of solicitations and to make these available to future COVs. The full report and the BER response is available on the BER web site (http://www.science.doe.gov/ober/berac.html).

At the recommendation of the BERAC COV, the Environmental Remediation subprogram has been reorganized. This new organization integrates research previously conducted under the Natural and Accelerated Bioremediation Research (NABIR) program, Environmental Management Science Program (EMSP), and the Savannah River Ecology Laboratory (SREL). Furthermore, the SREL will compete for funding within the Environmental Remediation subprogram rather than be included as a separately funded research activity. The integrated approach will provide complementary knowledge and capabilities that will optimize the research results over the structure that was established when three separate research activities from the Office of Science (BER) and the Office of Environmental Management were combined to form the subprogram in FY 2003.

The Environmental Remediation subprogram will develop fundamental understanding of biological, chemical and physical phenomena from molecular to field scales, that will enable resolution of DOE problems in environmental clean-up and stewardship, including: contaminant fate and transport; *in situ* remediation; radioactive waste treatment; characterization and performance monitoring. This will be accomplished by soliciting and funding a range of projects from lab-based, single investigator research to integrated multi-disciplinary activities to larger, field-based programs. This broad-based, tiered approach responds to the recommendations of the BERAC Environmental Remediation subcommittee and the COV. This restructuring removes artificial boundaries between programs that were legacies of having been developed in different DOE offices. This integration will enable the program to better address the BER long-term environmental remediation measure. Periodic retrospective analysis will be employed to evaluate the accumulation of knowledge and validate specific outcomes.

FY 2004 Accomplishments

Native Microbes Immobilize Waste Plume Contaminant. Field applications of laboratory-derived scientific advances are critical to real world evaluation of their potential value. Scientists from Pacific Northwest National Laboratory in collaboration with Stanford University have characterized the chemical nature of a mixed waste plume (including chromium and radionuclides) contaminating large volumes of soil beneath the Hanford waste tanks. These NABIR-funded researchers found that naturally occurring microbes in Hanford soils had immobilized nearly 50% of the chromium in the contaminated plume. These findings will help in the development of management strategies for the remaining contamination.

Microbes Remove Uranium from Contaminated Groundwater. The potential for removing uranium from contaminated groundwater by stimulating the activity of naturally microorganisms was evaluated in a uranium-contaminated aquifer located at an UMTRA (Uranium Mill Tailings Remedial Action) site in Rifle, Colorado. Acetate (a microbial energy source) was injected into the subsurface over a 3-month period. Uranium concentrations decreased in as little as 9 days after acetate injection was begun, and within 50 days uranium had declined below the prescribed treatment level in some of the monitoring wells. Analysis demonstrated that the initial loss of uranium from the groundwater was associated with an enrichment of a particular bacterial population (*Geobacter*) in the treatment zone. Subsequent monitoring showed a shift in the microbial community, associated with a decrease in the uranium immobilization effect. These results demonstrate that *in situ* bioremediation of uranium-contaminated groundwater is feasible and raise research questions into mechanisms to better maintain the long-term uranium removal activity of the resident *Geobacter* species.

Teaming to Solve Large Scientific Problems at the Environmental Molecular Sciences Laboratory. The EMSL has formed Collaborative Access Teams (CATs) consisting of scientists from PNNL, industry, universities, and other laboratories who work together using EMSL's facilities and equipment to rigorously focus on one area of high-impact research, such as oxide chemistry or structural biology. Results of this focused team concept will help solve larger scientific problems, bring new science capability to EMSL, and provide opportunities for expanding EMSL's user base. The first two CATs include: a Catalysis CAT (an integrated experimental and theoretical approach to a molecular-level understanding of oxide-catalyzed chemical transformations) and an Atmospheric Chemistry CAT (formed to lead the EMSL research thrust to address “atmospheric chemistry for the future”).

Linking Biological Impacts with Specific Environmental Contamination. Chromatographic/spectrometric methods were used to demonstrate that selenium was present as selenomethionine in proteins extracted from tadpoles isolated from the Savannah River Site. The results support the hypothesis that selenium might be a cause of recorded abnormalities in these amphibians. SREL scientists hypothesize that selenomethionine (a non-essential selenium amino acid) might substitute for methionine in protein synthesis.

Light Sources Reveal Signatures of Contaminants in Trees. X-ray spectroscopy, using a beam line at the National Synchrotron Light Source at Brookhaven National Laboratory, is being used to determine metal speciation and contaminant distributions in soils, sediments, plants, and animals. Synchrotron x-ray fluorescence mapping of tree rings from a Savannah River Site with high soil concentrations of contaminants shows that trees collected from contaminated areas contain a “signature” of the metals within their annual rings. However, the study also revealed an important caveat. A tree growing in the middle of a contaminated settling pond with very high levels of nickel showed a dramatic peak in metal concentration in only one year suggesting that the tree had been able to avoid taking up excess nickel for most of its life. The sudden increase in nickel uptake observed in this study suggests that a branch of the tree’s root system may have grown into a grossly contaminated “hot spot,” taking up a potentially toxic level of nickel; one which would have almost certainly killed the root system in which it was in contact.

World’s Largest Nuclear Magnetic Resonance (NMR) Spectrometer. The world’s largest, highest-performance nuclear magnetic resonance (NMR) spectrometer is now operational at the EMSL. The 900-MHz NMR spectrometer fulfills a key part of the vision for EMSL by allowing scientists to conduct projects of large size or complexity that require the additional resolution and sensitivity a 900 MHz field can provide. The spectrometer will also be able to detect rare nuclei and to obtain orientation data from protein structures relative to solid surfaces. Probes for the NMR are being fine-tuned and the instrument is being “road-tested” prior to general use. The testing process has included evaluation of peptide lipid complexes and protein complexes ranging in size from 25 to 65 kilodaltons. Proposals for general use of EMSL’s 900-MHz NMR spectrometer will be accepted in FY 2005.

EMSP Investigators Take Advantage of ORNL Clean Up Site Closure Activities. EMSP investigators adapted their research project to take advantage of ORNL’s remediation scheme to cap buried waste. The scientists negotiated with the site to keep 14 multi-level wells and injection ports, extending them through the capping surface. Because the site had an extensive, long-term data set for fate and transport of material, these wells will allow study of the effects on the changes in hydrology, geochemistry, and microbial communities that occur with site capping. With capping likely to be a remediation method considered more frequently, such a study is both timely and unique.

Detailed Justification

	(dollars in thousands)		
	FY 2004	FY 2005	FY 2006
Environmental Remediation Sciences Research..	**59,929**	**58,111**	**48,600**

The Environmental Remediation Sciences Research activity will address critical questions of fundamental environmental remediation science at the interfaces of biology, chemistry, geology and physics. Research results will provide the scientific foundation for the solution of key challenges and uncertainties at scales ranging from molecular to field, including the fate and transport of contaminants in the environment; strategies and opportunities for *in situ* remediation; strategies for the treatment of radioactive waste; and long-term characterization and monitoring of the performance of various remediation strategies.

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

This integrated research effort will lead to the development of improved models to predict, based on real-life observations, the transport of contaminants in the environment. Knowledge of the factors controlling contaminant mobility in the environment is essential to understand their long term behavior, before, during, and after remediation, and is a necessary step to achieve the long-term BER Program Goal. In FY 2006, the program will initiate new field-based research that complements ongoing work at the Oak Ridge Field Research Center (FRC). This new field-based research will allow scientists to bring concepts and hypotheses that can only be addressed at field scale, for example the coupled biological, chemical and hydrologic processes of subsurface contaminant behavior across multiple scales, to the field environment for real-world evaluation. The field research will focus on conditions and environmental problems extant at DOE sites that differ from those at the FRC site and will have broad applicability to existing research programs on heavy metals and radionuclides. It also will emphasize the interplay between experiment and model development as a critical component of both experimental design and model development and validation. The expanded field research activities will be used to evaluate and validate the results of laboratory-based science and predictive modeling efforts.

	(dollars in thousands)		
	FY 2004	FY 2005	FY 2006

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

In FY 2006, BER will increase its focus on Genomics: GTL and Climate Change research in support of the DOE goals and objectives. The Environmental Remediation research subprogram will focus research efforts on subsurface science and high level radioactive waste in support of high priority DOE goals and objectives for environmental cleanup. As a result, research funding for surficial science including radioecology and surficial fate and transport will be phased out in FY 2005 and terminated in FY 2006.

General Purpose Equipment (GPE)....................	**959**	**959**	**403**

GPE funding will continue to provide general purpose equipment for PNNL and ORISE such as information system computers and networks, and instrumentation that supports multi-purpose research.

General Plant Projects (GPP)	**4,811**	**5,584**	**6,140**

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

Facility Operations..	**39,059**	**37,228**	**37,138**
▪ **Operating Expenses**	**33,790**	**32,039**	**35,149**

The EMSL is a scientific user facility located at the Pacific Northwest National Laboratory focused on conducting interdisciplinary, collaborative research in molecular-level environmental science. Operating funds are used for maintenance of buildings and instruments; utilities; staff support for users; environment, safety and health compliance activities; and communications. With over 55 leading-edge instruments and a supercomputer system, the EMSL annually supports approximately 1,600 users. University scientists form the core of the EMSL science team that networks with the broader academic community as well as with scientists at DOE National Laboratories and at other agencies. EMSL users have access to unique instrumentation for environmental research, including a new Linux-based supercomputer, a 900 MHz NMR spectrometer that adds to the suite of NMRs in EMSL, a suite 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.

	(dollars in thousands)		
	FY 2004	FY 2005	FY 2006

In FY 2006 EMSL operations funding is provided to accommodate an anticipated large increase in the number of EMSL users conducting high-throughput proteomics and NMR-based protein structure research as part of the new multi-institutional, targeted research efforts in membrane biology and biogeochemistry. The large volume of data to be generated will be accommodated by the increased data storage capabilities in EMSL.

▪ **General Plant Projects (GPP)**	**1,250**	**3,200**	**0**

The GPP (TEC $4,450,000) for EMSL's Molecular Science Computing Facility (MSCF) adds approximately 4,000 sq. ft of additional space. The additional MSCF space is needed to meet the demand for new data storage systems due to the volume of data being generated by EMSL's high-throughput mass spectrometer, nuclear magnetic resonance (NMR) and other systems.

▪ **Capital Equipment**	**4,019**	**1,989**	**1,989**

Capital equipment support for the EMSL enables instrument modifications needed by collaborators and external users of the facility as well as the purchase of state-of-the-art instrumentation to keep EMSL capabilities at the leading edge of molecular-level scientific research.

SBIR/STTR	**0**	**2,574**	**2,413**

In FY 2004 $2,457,000 and $296,000 were transferred to the SBIR and STTR programs, respectively. FY 2005 and FY 2006, amounts are the estimated requirements for continuation of these programs.

Total, Environmental Remediation	**104,758**	**104,456**	**94,694**

Explanation of Funding Changes

	FY 2006 vs. FY 2005 ($000)
Environmental Remediation Sciences Research	
Environmental Remediation Sciences reduced based on fiscal constraints in FY 2006. BER will focus research activities on GTL and Climate Change in support of the DOE goals and objectives. The Environmental Remediation research subprogram will focus research efforts on subsurface science and high level radioactive waste in support of high priority DOE goals and objectives for environmental cleanup. As a result, research funding for surficial science including radioecology and surficial fate and transport will be phased out in FY 2005 and terminated in FY 2006.	-9,511
General Purpose Equipment (GPE)	
GPE is reduced to make funds available for necessary GPP	-556

	FY 2006 vs. FY 2005 ($000)
General Plant Projects (GPP)	
GPP is increased for minor new construction and other capital alterations and additions needed to maintain safe, reliable, and productive operations of PNNL facilities................	+556
Facility Operations	
▪ EMSL Operations increased to accommodate an anticipated large increase in the number of EMSL users conducting high-throughput proteomics and NMR-based protein structure research as part of the new multi-institutional, targeted research efforts in membrane biology and biogeochemistry. The large volume of data to be generated will be accommodated by the increased data storage capabilities at EMSL.	+3,110
▪ EMSL GPP decreased with the completion of the Molecular Science Computing Facility GPP project.	-3,200
Total, Facility Operations	-90
SBIR/STTR	
▪ SBIR/STTR decreases with reduction in research.	-161
Total Funding Change, Environmental Remediation	**-9,762**

Medical Applications and Measurement Science

Funding Schedule by Activity

(dollars in thousands)

	FY 2004	FY 2005	FY 2006	$ Change	% Change
Medical Applications and Measurement Science					
Medical Applications	174,893	114,320	13,608	-100,712	-88.1%
Measurement Science	6,080	5,952	0	-5,952	-100.0%
SBIR/STTR	0	3,434	392	-3,042	-88.6%
Total, Medical Applications and Measurement Science	180,973	123,706	14,000	-109,706	-88.7%

Description

The mission of the Medical Applications and Measurement Science subprogram is to deliver the scientific knowledge and discoveries that will lead to new diagnostic and therapeutic tools and technology for disease diagnosis and treatment, non-invasive medical imaging technology, and bioengineering solutions to medical challenges.

Benefits

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

Supporting Information

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

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

Coordination with NIH is provided through joint participation of NIH research staff and management on BERAC Subcommittees, and NIH technical staff participation on BER merit review panels to reduce the possibility of undesirable duplications in research funding. DOE and NIH also organize and sponsor workshops in common areas of interest, for example: a joint workshop on Optical and X-ray Imaging, and Nanomedicine. Members of the Medical Sciences Program staff are formal members of the National Cancer Advisory Board, the BioEngineering Consortium (BECON) of NIH Institutes, and are on critical committees of the recently established National Institute of Bioimaging and Bioengineering (NIBIB). Program staff also participate in interagency activities such as the Multi Agency Tissue Engineering Science (MATES) working group that includes representatives of seven agencies and the Office of Science Technology Policy.

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

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

FY 2004 Accomplishments

New Radiotracer to Image Heart Repair. A new PET radiotracer, fluorine-18 labeled pencyclovir has been developed at Stanford University for imaging transplantation of cells into the damaged heart to significantly improve heart function. This technology will allow imaging techniques to more precisely monitor the success of therapeutic interventions to treat heart attacks.

First Images of Gene Messages in Animals. Images of whole animals that detect the expression of three cancer genes were obtained for the first time by investigators in the Imaging Gene Expression Project at Thomas Jefferson University and the University of Massachusetts Medical Center. This advanced imaging technology will lead to the detection of cancer in humans using cancer cell genetic profiling.

New Radiolabeled Probes for Imaging Gene Expression. A consortium from BNL, LBNL and Ames has developed three unique classes of radiolabeled and fluorescent mRNA-binding probes capable of imaging mRNA in living cells. These tracers hold promise for the eventual imaging of gene messages of normal health and disease *in vivo* using PET.

A New Targeted Radiotherapeutic for Brain Tumors. Astatine-211 labeled chimeric anti-tenascin monoclonal antibody, has been developed at Duke University. This radiopharmaceutical has shown great promise for the treatment of brain tumors, including glioblastoma multiforme, and also might be valuable for treating other tumors that over express tenascin such as lymphoma.

New Radiotracer for Imaging Neurotransmission Function. A new PET radiotracer, C-11 labeled methylreboxetine, has been developed at BNL for imaging the brain *norepinephrine transporter (NET*) system. The use of this highly specific radiotracer will allow a better understanding of the neurotransmitter interactions in attention deficit hyperactivity disorder (ADHD), substance abuse, depression, and Alzheimer's disease.

Brain Imaging Method to Explore Human Desire for Food. Using PET with fluorine-18 labeled glucose (FDG) and a newly developed food stimulation paradigm, scientists at BNL have demonstrated that smelling and tasting food without actually eating it increases brain metabolism. The PET images pinpointed the metabolic activity in the brain region that is involved in drug addiction. The research may help explain why people are so susceptible to even the suggestive effects of food in advertisements and may suggest new ways of dealing with the growing problem of obesity in this country.

LBNL Laser Wakefield Accelerator Technology. A new laser accelerator technology capable of accelerating electrons and subsequently protons to high energies (up to 100 MeV) in as little distance as a few millimeters for production of radioisotopes has been developed at LBNL. The technology represents a reduction in particle acceleration distance of nearly three orders of magnitude versus cyclotrons and linear accelerators. The technology has already been used to produce positron emitting isotopes, and holds promise for leading the development of table top accelerators for radioisotope production for medical diagnosis and treatment.

Magnetoencephalography (MEG) Technology for Acquiring Magnetic Resonance (MR) Images. MEG uses Superconducting Quantum Interference Device (SQUID) sensor technology for probing tiny magnetic fields in the brain generated from the currents that flow in the neuronal network. A team of scientists from LANL, using SQUID sensors, has for the first time measured the MEG signal from brain activity simultaneously with measurement of the magnetic resonance signal at ultra-low magnetic fields that can be used to generate MR images. This approach may prove important for people who cannot be subjected to the huge magnetic fields necessary to make a traditional MRI image.

Prototype for Mobile PET Scanner Developed. A PET scanner, small and light enough to sit on the top of the head of a rat, has been developed at Brookhaven National Laboratories through the BER advanced imaging technologies program. The scanner has advanced design microelectronics and small positron detectors. The goal of the program is to develop mobile PET scanners to detect psycho-neurological disorders in children.

New DOE Design for Artificial Retina. The development of a pliable, biocompatible 60 electrode artificial retina containing advanced microelectronics has undergone successful *in vitro* and acute safety testing in animals. Long term testing of the device in animals under long-term conditions that will be used in the eyes of blind patients are ongoing.

Progress in Helping the Blind to See. The institutions comprised by the DOE artificial retina program (ORNL; SNL; LANL; ANL; LLNL; DOE Vision Laboratory at the University of Southern California-Doheny Eye Institute; University of California, Santa Cruz; and North Carolina State) have signed a Cooperative Research and Development Agreement (CRADA) with the Second Sight Corporation of California. The CRADA will facilitate the translation of DOE supported advanced technology to devices that will satisfy FDA testing requirements for placement into blind patients.

Detailed Justification

(dollars in thousands)

	FY 2004	FY 2005	FY 2006
Medical Applications	**174,893**	**114,320**	**13,608**
▪ **Medical Applications**	**39,011**	**36,941**	**13,608**

In FY 2006 BER supports basic research that builds on unique DOE capabilities in physics, chemistry, engineering, biology, and computational science. It supports fundamental imaging research, maintains core infrastructure for imaging research and development, and develops new technologies to improve the diagnosis and treatment of psycho-neurological diseases and cancer and the function of patients with neurological disabilities, such as blindness and paralysis. BER research develops new metabolic labels and imaging detectors for medical diagnosis; tailor-made

	(dollars in thousands)		
	FY 2004	FY 2005	FY 2006

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, biosensors, and medical implants.

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

BER support for Boron Neutron Capture Therapy dosimetry, support programs at INEEL, and the core programs at Cornell University and INEEL to determine boron concentrations in biologic specimens is terminated after FY 2005. Molecular nuclear medicine research, research and technology development activities in imaging gene expression, magnetoencephalography, biosensors, PET instrumentation for human clinical applications, MRI and neuroscience research, radiation dosimetry for therapeutic dose estimation, and targeted molecular radionuclide therapy are curtailed in FY 2005 and terminated in FY 2006.

	FY 2004	FY 2005	FY 2006
▪ **Congressional Direction**	**135,882**	**77,379**	**0**

Congressional direction was provided in FY 2004 for University of Alabama-Huntsville Climate Action Project; University of South Alabama Cancer Center; Judson College library, academic and service center; Functional genomics research by the University of Kentucky and the University of Alabama; St. Joseph Hospital in Arizona; University of Arizona Institute for Biomedical Science and Biotechnology; Derby Center for Science and Mathematics at Lyon College; Southern California Water Education Center; St. Joseph Hospital technology upgrade in California; University of Southern California Center for Excellence in Neurogenetics; Vanguard University Science Center; National Childhood Cancer Foundation; Tahoe Center for Environmental Sciences; Christiana Comprehensive Cancer Initiative; Clean Energy Research at the University of Delaware; Eckerd College Science Center; Jacksonville University Environmental Science Center; Earth University Foundation in Georgia; Georgia State University Science Research & Teaching Lab; Mercer University Critical Personnel Development Program; Material research for energy security in Idaho; Cancer Center at Edward Hospital; Illinois Museum of Science and Industry; Northwestern University Institute of Bioengineering and Nanoscience in Medicine; Rush-Presbyterian-St. Luke's Medical Center; St. Francis Medical Center Rapid Treatment Unit in Illinois; St. Francis Hospital Emergency Services Department; Genomics research at Indiana University; Notre Dame Multi-Discipline Engineering Center; Tri-State University Technology Center; University of Dubuque Environmental Science Center; University of Northern Iowa building design and engineering; Biomedical Engineering Laboratory at the Center for Biomedical Engineering in Louisiana; Mary Bird Perkins Cancer Center; Morgan State University Center for Environmental Toxicology; Experimental Medicine Program at the Dana Farber Cancer Institute; Nuclear Resonance Mass Spectrometer at the University of Massachusetts Medical School; University of Massachusetts at Boston Multidisciplinary Research Facility and Library; Green power technology development at Grand Valley State University; Michigan Research Institute life sciences research; Michigan Technology Center for Nanostructure and Light Weight Materials; Augsburg College; CHP project at Mississippi State University; University of Missouri Cancer Center; Advanced bioreactor technology development in Montana; Boulder City Hospital Emergency Room Expansion; Digitalization of the Cardiac Cath Lab at the University Medical Center of Southern Nevada; Mega Voltage Cargo Imaging Development Applications for the Nevada Test Site; Nevada Cancer Institute; Research

	(dollars in thousands)	
FY 2004	FY 2005	FY 2006

Foundation at the University of Nevada-Las Vegas to assess earthquake hazards and seismic risk in Southern Nevada; Research Foundation at the University of Nevada-Las Vegas to conduct safety and risk analyses, simulation and modeling, systems planning, and operations and management to support radioactive and hazardous materials transportation; Space Grant Consortium at the Desert Research Institute; University of Nevada-Reno to conduct nuclear waste repository research in the areas of materials evaluation, fundamental studies on degradation mechanisms, alternate materials and design, and computational and analytical modeling; University of Nevada-Reno to expand the earthquake engineering and simulation facility; Upgrade the Grover C. Dils Medical Center; Upgrade the Pahrump Medical Center; Hackensack medical building in New Jersey; Hackensack University Medical Center; Robert Wood Johnson University Hospital; Upgrade the Drew University Hall of Science in New Jersey; Mental Illness and Neuroscience Discovery Institute; University of New Mexico medical building; Bronx Community Center for Sustainable Energy; College of Mount St. Vincent Science Hall; Comparative Functional Genomics at New York University; Genomics Laboratory at SUNY-Oneonta; University of Buffalo Center of Excellence in Bioinformatics; Rensselaer Polytech Center for Quantitative Bioscience; Structural Biology Research Center at the Hauptman-Woodward Medical Research Institute; Syracuse University Environmental Systems Center; Carolinas Medical Center; Western Carolinas Biotechnology Initiative; Community Improvement Corporation of Springfield-Clark County for a computing and data management center; Middletown Regional Hospital in Ohio; Ohio State University for environmental research in cooperation with Earth University; Carnegie Mellon University Green Chemistry Project; Urban Education Research Center in Pennsylvania; Clafin University Science Center; Coastal Research Center at the Medical University of South Carolina; University of South Carolina study of groundwater contamination; Life Sciences Facility, Tennessee State University; T3 MRI for St. Jude’s Children Research Hospital in Tennessee; University of Tennessee Climate Change Research Initiative; Center for Advanced Research in Texas; San Antonio Cancer Therapy and Research Center; Surgical robotics research at the Keck Cancer Center with the Cleveland Clinic; Huntsman Cancer Institute; Swedish American Regional Cancer Center; Adventist Health Care; Environmental Control and Life Support Project; UCLA - New Molecular Imaging Probes; Cedars Sinai Gene Therapy Research; Hartford Hospital Interventional Electro-Physiology Project; De Paul University – Biological Sciences; Coralville-Iowa Project on Alternative Renewable Energy Resources; and Western Michigan University – Nanotechnology Research and Computation Center.

Congressional direction was provided in FY 2005 for a science building at Waubonsee Community College in Illinois; digital playback hardware and software for Recording for the blind and dyslexic; All Children’s Hospital in Florida; Eckerd College in Florida; Applied Research and Technology Park electrical and communication infrastructure improvements in Springfield, Ohio; a Multiple Sclerosis, Alzheimer’s, Parkinson’s, Lou Gehrig’s Imaging System at the Cleveland Clinic in Ohio; Duchenne Muscular Dystrophy research-related equipment at Children’s National Medical Center in the District of Columbia; Duchenne Muscular Dystrophy research-related equipment at the University of Washington-Seattle; the Northeast Regional Cancer Center in Scranton, Pennsylvania; Ohio State University for environmental research in cooperation with Earth University; the University of Akron, Ohio, Polymer Center; the Ohio Northern University, Ada, Ohio, Science and Pharmacy Building; the Alabama A&M University; University of Texas at Arlington optical medical imaging equipment; the Missouri Alternative and Renewable Energy Technology Center, Crowder

	(dollars in thousands)	
FY 2004	FY 2005	FY 2006

College; the San Antonio, Texas, Cancer Research and Therapy Center; the University of South Alabama Cancer Center; the Virginia Commonwealth University Massey Cancer Center; the Saint Francis Hospital, Delaware, Cardiac Catheterization Lab; the Jacksonville University Environmental Science Center; the Houston, Texas, Alliance for Nanohealth; the Virginia Science Museum; the Polly Ryon Memorial Hospital, Texas; the St. Thomas University Minority Science Center, Miami, Florida; Project Intellicare, Roseville, California; the Virginia Polytechnic Institute Center for High-Performance Learning Environment; Georgia State University; the Michigan Research Institute for life science research; the University of Arizona Environment and Natural Resources Phase I1 Facility; the Children's Hospital of Illinois ambulatory care project; the Loma Linda University, California, Medical Center synchrotron expansion; the University of Dubuque, Iowa, Environmental Science Center; the Ball State University, Indiana, Bioenergetics Research Initiative; the Clearfield Area School District, Pennsylvania, Energy Initiative; Digital Cardiology equipment at Children's Hospital and Research Center, Oakland, California; the National Childhood Cancer Foundation; the Roswell Park Cancer Institute, New York, Center for Genetics and Pharmacology; Bucknell University, Pennsylvania, Materials Science Laboratory; the Science Center at Mystic Seaport, Connecticut; the Saratoga Hospital, New York, radiation therapy center; the San Joaquin Community Hospital, Bakersfield, California; the Syracuse University, New York, Environmental Systems Center; the University of Tennessee Sim Center; the St. Mary's Hospital, Kankakee, Illinois; the Derby Center for Science and Mathematics at Lyon College in Arkansas; the Rush Presbyterian St. Lukes Medical Center in Illinois; Medical Research and Robotics at the University of Southern California; the Advanced Building Efficiency Testbed at Carnegie Mellon University; DePaul University Biological Sciences; the Philadelphia Educational Advancement Alliance; Northwestern University Institute of Bioengineering and Nanoscience in Medicine; the Rensselaer Polytechnical Institute Center for Bioscience; St. Peter's Biotechnical Research in New Jersey; the Berkshire Environmental Center in Massachusetts; the Center for the Environment at the University of Massachusetts; technical upgrades at St. Joseph Hospital in Arizona; the Center for Science at the University of San Francisco in California; Augsburg College in Minnesota; the Bronx Community Center for Sustainable Energy; Marquette General Hospital in Marquette, Michigan; the Illinois-Indiana Super-Grid Program connecting Argonne National Laboratory and Purdue and Notre Dame Universities; the Purdue Calumet Water Environmental Institute; the Multi-Discipline Engineering Institute at Notre Dame in Indiana; the Energy Efficiency Project at Valparaiso University in Indiana; the Mental Illness and Neuroscience Discovery Institute in New Mexico; Military Spirit in New Mexico; the Academic Center Sustainable Design Project at St. Francis College, New York; the University of Louisville Pediatric Clinical Proteomic Center; the University of Louisville Institute for Advanced Materials; the Advanced Bioreactor located in Butte, Montana; to expand the Center for Integrated and Applied Environmental Toxicology at the University of Southern Maine; the University of Tennessee Cancer Institute; St. Jude Children's Research Hospital in Tennessee; the Huntsman Cancer Institute; the Mega-Voltage Cargo Imaging Development Applications for the Nevada Test Site; the California Hospital Medical Center PET /CT Fusion Imaging System; the Luci Curci Cancer Center Linear Accelerator; Project Intellicare in California; the University Medical Center in Las Vegas, Nevada; the Southern California Water Education Center; Live Cell Molecular Imaging System at the University of Connecticut; the St. Francis Hospital Wilmington, Delaware, MRI and Cardiac Catherization Laboratory; the University of Delaware for the Delaware Biology Institute; the University of Nevada-Las Vegas School of Public Health; the Latino Development and

	(dollars in thousands)		
	FY 2004	FY 2005	FY 2006

Technology Center; the Swedish American Health Systems; DePaul University Chemistry Lab Renovation Project; the Edward Hospital Cancer Center; the Mary Bird Perkins Cancer Center; the Morgan State University Center for Environmental Toxicology; the Suburban Hospital in Montgomery County, Maryland; the University of Massachusetts at Boston Multidisciplinary Research Facility and Library; the Martha's Vineyard Hospital; the Nevada Cancer Institute; the Mercy Hospital Grayling, Michigan Rural Healthcare Advancement Initiative; the Health Sciences Complex at Creighton University; the Hackensack University Medical Center Women and Children's Pavilion; the Kennedy Health System Linear Accelerator; the University of Buffalo Center of Excellence in Bioinformatics; the Hospital for Special Surgery National Center for Musculoskeletal Research; the New University in New York City; the Radiochemistry research facility at the University of Nevada-Las Vegas; the Hauptman-Woodward Medical Research Institute; the Vermont Institute of Natural Science; and the Tahoe Center for Environmental Services.

Measurement Science	**6,080**	**5,952**	**0**

Measurement Science Research is integrated with Medical Applications in FY 2006.

SBIR/STTR..	**0**	**3,434**	**392**

In FY 2004 $4,672,000 and $568,000 were transferred to the SBIR and STTR programs, respectively. FY 2005 and FY 2006 amounts are the estimated requirements for continuation of these programs.

Total, Medical Applications and Measurement Science..	**180,973**	**123,706**	**14,000**

Explanation of Funding Changes

	FY 2006 vs. FY 2005 ($000)
Medical Applications	
The Medical Applications and Measurement Science research activities are integrated into a single subelement. Research will focus on fundamental imaging research (including radiopharmaceuticals for imaging), core infrastructure for imaging research and development, 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. Molecular nuclear medicine research, research and technology development activities in imaging gene expression, magnetoencephalography, biosensors, PET instrumentation for human clinical applications, MRI and neuroscience research, radiation dosimetry for therapeutic dose estimation, and targeted molecular radionuclide therapy are curtailed in FY 2005 and terminated in FY 2006.	-23,333
Congressional Direction	
Completion of Congressionally-directed projects.	-77,379
Measurement Science	
Measurement Science Research is integrated with Medical Applications.	-5,952
SBIR/STTR	
SBIR/STTR decreases as research program decreases	-3,042
Total Funding Change, Medical Applications and Measurement Science	**-109,706**

Construction

Funding Schedule by Activity

	(dollars in thousands)				
	FY 2004	FY 2005	FY 2006	$ Change	% Change
Construction					
Project Engineering Design, Genomics: GTL	0	9,920	0	-9,920	-100.0%

Description

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

Benefits

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

Detailed Justification

	(dollars in thousands)		
	FY 2004	FY 2005	FY 2006
▪ **Project Engineering and Design**	**0**	**9,920**	**0**

Project Engineering and Design (PED) funding for the Genomics: GTL Facility for the Production and Characterization of Proteins and Molecular Tags was initiated in FY 2005. This will be a cost-effective, high-throughput facility for the production of proteins, along with molecular tags for their identification. The proteins will mostly be from microbes and will be produced directly from the DNA sequences of microbes previously determined by BER. These proteins and molecular tags are necessary for the high-throughput characterization of molecular machines in DOE-relevant microbes with applications to DOE energy and environmental needs.

Explanation of Funding Changes

	FY 2006 vs. FY 2005 ($000)
▪ **Project Engineering and Design**	
Funding was provided for Project Engineering and Design for the Genomics: GTL Facility for the Production and Characterization of Proteins and Molecular Tags in FY 2005	-9,920
Total Funding Change, Construction	**-9,920**

Capital Operating Expenses and Construction Summary

Capital Operating Expenses

(dollars in thousands)

	FY 2004	FY 2005	FY 2006	$ Change	% Change
General Plant Projects	6,061	8,784	6,140	-2,644	-30.1%
Capital Equipment	33,221	15,436	18,105	+2,669	+17.3%
Total Capital Operating Expenses	39,282	24,220	24,245	+25	+0.1%

Construction Projects

(dollars in thousands)

	Total Estimated Cost (TEC)	Prior Year Appro-priations	FY 2004	FY 2005	FY 2006	Unappro-priated Balance
PED, 05-SC-004 Production and Characterization of Proteins and Molecular Tags	9,920	0	0	9,920	0	0