Biological and Environmental Research

Program Mission

For over 50 years the Biological and Environmental Research (BER) program has been advancing 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; 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. In addition, BER develops and delivers the knowledge needed to support the President's National Energy Plan and provides the science base in support of the Energy Policy Act of 1992.

Overview:

The Biological and Environmental Research (BER) program supports fundamental research in climate change, environmental remediation, genomics, proteomics, radiation biology, 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 most 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 predict climate over decades to centuries will enable us to develop science based solutions to reduce and minimize the impacts of climate change and to better plan for our Nation's future energy needs. BER will lead the way in discovering innovative approaches along unconventional paths to energy independence and environmental cleanup.

The Challenges:

Understanding and predicting climate – Can we understand the factors that determine Earth's climate well enough so that we can predict climate decades to centuries in the future? Advanced climate models are needed to describe and predict the roles of oceans, the atmosphere, ice and land masses on climate. So too, the role of clouds in controlling solar and thermal radiation onto and away from the Earth needs to be understood since it is the single 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 – Microbes have a remarkable capacity to thrive in almost every environment imaginable, even when heavily contaminated. Can we use Nature's own solutions to clean up sites contaminated from years of weapons research? These solutions seem ever closer as we study the molecular details of nature's own clean up strategies.

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 give 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, each with exquisitely precise and efficient functions and controls, will enable us to use and even redesign these molecular machines to address DOE and National needs.

The Investment Plan:

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.

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. A combination of novel, state-of-the-art user facilities coupled with large, well-integrated, interdisciplinary research teams will form the basis of a new approach for studying complex biological systems and for using those systems to solve problems in energy and the environment. Our ability to predict climate on global and regional scales and to develop strategies for the removal of excess carbon dioxide, a contributor to global warming, from the atmosphere will depend on the continued development of novel research tools and a close integration of experimental and computational sciences research. Because of DOE's diverse capabilities across a range of scientific disciplines, from engineering to chemistry to biology to computing, continued investments in advanced medical concepts will continue to provide the medical community with novel devices and technologies to improve our Nation's health.

The Benefits:

Basic biological and environmental research has broad impacts on our health, our environment, and our energy future. An ability to predict long-range and regional climate enables effective planning for future needs in energy, agriculture and land and water use. Biotechnology solutions are possible for DOE energy, environmental, and national security challenges by understanding complex biological systems and developing computational tools to model and predict their behavior. Understanding the global carbon cycle and the associated role and capabilities of microbes can lead to solutions for reducing carbon dioxide concentrations in the atmosphere. Biological solutions can be developed to help clean up metals and radionuclides contaminating former DOE weapons sites. Both normal and abnormal health - from development to cancer to brain function – can be understood using radiotracers and advanced imaging instruments. 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.

How We Work:

BER uses a variety of mechanisms for conducting, coordinating, and funding 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 in 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. 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, 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 International Human Genome Project, the U.S. Global Change Research Program, and the National Institutes of Health Bioengineering Consortium. Finally, BER consults regularly with groups like JASON and The Washington Advisory Group (WAG), 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 Human Genome 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 Office of Science and Technology Policy (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, peer 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, requested level of funding, and 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 Human Genome Program, the Global Change Research Program, and the structural biology research program, including reviews by Boards and Committees of the National Academy of Sciences.

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 entraining 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. Groups like JASON and The Washington Advisory Group (WAG), involving physicists, mathematicians, engineers, etc., are among the organizations that study 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 Human Genome program. The BER program is ideally positioned to facilitate and foster interactions between the physical sciences, the computational sciences, and the life sciences and aggressively pursues every opportunity to nurture collaborations at the interfaces between these scientific domains.

Planning and Priority Setting:

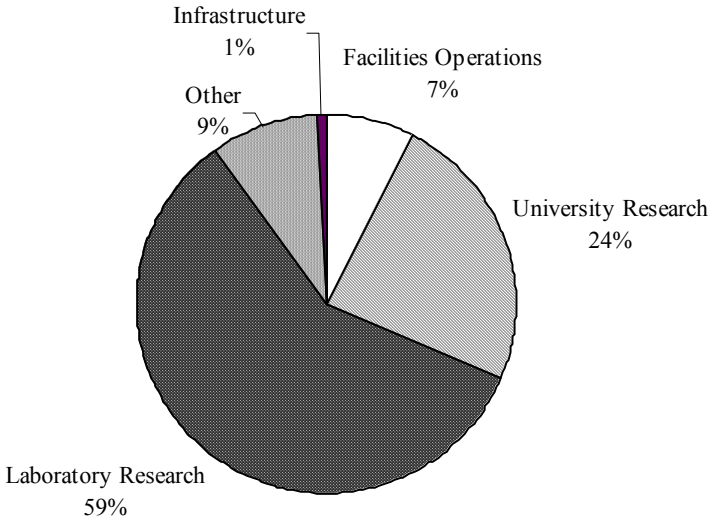
BER prides itself on supporting research and developing new research initiatives that lead the way across many fields of science and that effectively bring together many different disciplines, including biology, chemistry, engineering, computing, and the physical sciences. Peer reviews and user feedback 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, Genomes to Life, bioremediation research, and global climate change develop long-range program plans through coordinated efforts with BERAC and with other federal agencies.

How We Spend Our Budget:

The BER budget has three major components: basic research at universities (31%); basic research at national laboratories (53%); and user facility support (6%). Research at national laboratories also includes support for high throughput DNA sequencing at the Joint Genome Institute, Atmospheric Radiation Measurement Infrastructure, Unmanned Aerial Vehicles, and other elements that represent a research infrastructure for the scientific community, and primarily university scientists. BER's user facilities include the infrastructure at synchrotron and neutron sources for structural biology and operation and equipment for the Environmental Molecular Sciences Laboratory.

BIOLOGICAL AND ENVIRONMENTAL RESEARCH
FY 2004



Research:

In FY 2004, the BER program will support fundamental research in climate change, environmental remediation, genomics, proteomics, radiation biology, and medical sciences at 223 public and private research institutions in 43 states and at 16 DOE laboratories in 10 states. This research will be conducted in 1020 different research projects by over 2275 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 PhD-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 and other enabling research infrastructure such as the ARM program.

  All research projects supported by the BER program undergo regular peer review and evaluation based on the procedures set down in 10 CFR Part 605 for the extramural grant program (http://www.sc.doe.gov/production/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 more 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 and research infrastructure including the Environmental Molecular Sciences Laboratory, Atmospheric Radiation Measurement, Free Air Carbon Dioxide Enhancement, and AmeriFlux sites, Natural and Accelerated Bioremediation Research Field Research Center, the Joint Genome Institute, and the structural biology user facilities at the synchrotron and neutron sources.

All research projects supported by the BER program undergo regular peer 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

Program Strategic Performance Goals

Progress toward accomplishing BER's strategic goals will be measured by Program Strategic Performance Goals, Indicators and Annual Targets, as follows:

SC3-1: Identify and characterize the multiprotein molecular machines that carry out the biological functions of cells and determine the biochemical capabilities of complex microbial communities, information needed to develop biotechnology solutions for clean energy, carbon sequestration, and environmental cleanup.

Performance Indicator

Number of complex microbial communities and multiprotein molecular machines that can be characterized per year.

Annual Performance Results and Targets

FY 2002 Results	FY 2003 Targets	FY 2004 Targets
Determined DNA sequence from 41 microbes important for energy and environmental cleanup. [Exceeded Goal]	Develop methods for sequencing DNA from complex microbial communities. (SC3-1)	Determine biochemical capabilities of a complex microbial community needed to develop biological solutions for environmental cleanup. (SC3-1)

SC3-2: Determine the response of the Earth system to different levels of greenhouse gases in the atmosphere.

Performance Indicator

Climate model resolution.

Annual Performance Results and Targets

FY 2002 Results	FY 2003 Targets	FY 2004 Targets
Develop and test a fully coupled atmosphere-ocean-land-sea ice climate model that has twice the spatial resolution of coupled models available in 2000 as part of Climate Modeling and Prediction research. Support multi-disciplinary teams of scientists at multiple institutions using DOE supercomputers to perform model simulations, diagnostics, and testing. [Goal Met]	Improve precision of climate models – deliver a cloud submodel to reduce uncertainty in the atmospheric energy budget by 10 % and increase resolution of atmospheric/ocean submodels to 150 km & sea ice submodel to 75 km for a fully coupled climate model. (SC3-2)	Implement a climate model with new cloud model components developed using Atmospheric Radiation Measurement (ARM) data, which will be used to predict regional and global climate change. (SC3-1)
Completed analysis of physical factors that govern CO_2 and water vapor flux dynamics at AmeriFlux sites. Study identified improvements for low flux measurement, which continues to be under-estimated and may introduce bias of as much as $\pm$ 20% in estimates of net ecosystem exchange (NEE) of CO_2 for example. [Goal Met]	Document a range of net annual carbon gain in deciduous forest sites in eastern North America of 2 to 4 metric tons of carbon per hectare. (SC3-2)	Deliver quantitative estimates of net annual carbon exchange between the atmosphere and terrestrial ecosystems at five AmeriFlux sites in North America. (AmeriFlux is a network of research sites that measure exchange of CO_2, energy, and water between the atmosphere and terrestrial ecosystems.) (SC3-2) Establish a model terrestrial ecosystem containing simplified but hierarchical communities (higher plants, consumers of plant production, and soil microorganisms) and begin characterization of the proteome of the major species. (SC3-2)

SC3-3: Develop and demonstrate novel solutions to DOE's most challenging problems, including: 1) in situ treatment of contaminant plumes such as bioremediation and environmental reactive barriers; 2) new treatment options for complex wastes; 3) novel disposal options for complex wastes (e.g. alternative to borosilicate glass) and cost-effective contaminant plume characterization and monitoring techniques for long-term stewardship of sites; 4) improved predictive capabilities for contaminant fate and transport; and 5) basis for accurate assessment of risk factors.

Performance Indicator

Advanced environmental cleanup approaches delivered.

Annual Performance Results and Targets

FY 2002 Results	FY 2003 Targets	FY 2004 Targets
Radiation resistant superbug, *D. radiodurans* changes mobile uranium and technetium in ground water into an immobile state. [Goal Met]	Identify naturally occurring microbial populations responsible for transformation of metals and radionuclides at DOE contaminated sites. (SC3-3)	Quantify rates of immobilization of metals and radionuclides by natural populations of microorganisms at DOE contaminated sites and identify environmental factors regulating their community structure and function. (SC3-3)
Developed a portable immunoassay that determines the quantity and species of uranium. [Goal Met]	Field test novel, long-term monitoring systems for DOE contaminated sites that are less invasive and require minimal human resources. (SC3-3)	Use experimental results from Hanford subsurface contaminant flow and transport studies to verify model improvement. (SC3-3)

SC3-4: Develop innovative radiopharmaceuticals for diagnosis and treatment of human disease and develop novel imaging instrumentation and technologies to precisely visualize and measure biological functions, including gene expression, and more accurately detect human disease.

Performance Indicator

Number of novel imaging devices delivered.

Annual Performance Results and Targets

FY 2002 Results	FY 2003 Targets	FY 2004 Targets
Developed novel radiopharmaceutical tracers to image the brain in obesity and addictive disorders. [Goal Met]	Establish new infrastructure in radiochemistry to develop novel radiopharmaceuticals needed to image changes in the brains of patients with mental and neurological diseases. (SC3-4)	Develop 2-4 novel radiopharmaceuticals to be used to image the brains of patients suffering from mental, neurological diseases and cancer. (SC3-4)
Developed PET and technetium radiotracers that will be used to detect expression of specific genes. [Goal Met]	Develop technology to image gene expression in real time using *in vitro* systems – precursor of a new medical imaging tool for disease diagnosis and monitoring treatment efficacy. (SC3-4)	Develop technology to detect steady state levels of the products produced by genes in real time and complete first image of the expression of one gene using cells in culture.
Development of a low-density microelectronic array (prototype artificial retina) that was inserted into the eye of a dog. [Goal Met]	Design an artificial retina – a microelectronic array to be used for the treatment of blindness. (SC3-4)	Complete fabrication of prototype micro array for use as an artificial retina. (SC3-4)

FY 2002 Results	FY 2003 Targets	FY 2004 Targets
Development and modeling of the platform for a small biosensor for rapid diagnosis of specific infectious diseases. [Goal Met]	Design a small biosensor device for rapid diagnosis of specific infectious diseases, using tuberculosis as a model organism. This technology will have broad application including, for example, in vivo monitoring of blood glucose in diabetics. (SC3-4)	Complete fabrication of a compact device for the rapid diagnosis of tuberculosis. (SC3-4)

SC7-3: Manage facilities operations and construction to the highest standards of overall performance using merit evaluation with independent peer review. (BER)

Performance Indicator

Average operational downtime of facilities will not exceed 10% of total time scheduled, and construction and upgrades of facilities will be within 10% of baseline schedule.

Annual Performance Results and Targets

FY 2002 Results	FY 2003 Targets	FY 2004 Targets
Construction initiated on Laboratory for Comparative and Functional Genomics at Oak Ridge. [Goal Met]	Complete construction of Laboratory for Comparative & Functional Genomics at Oak Ridge. (SC7-1)	Begin operation of Laboratory for Comparative & Functional Genomics at Oak Ridge. (SC7-1)
Doubled capacity of the Production Genomics Facility (PGF) to sequencing 8 billion base pairs of DNA. [Exceeded Goal]	Increase capacity of Production Genomics Facility (PGF) to sequence 17 billion base pairs of DNA per year, an increase of approximately 50% from FY 2002. (SC7-1)	Begin operation of Production Genomics Facility as a user facility. (SC7-1)
Environmental Molecular Sciences Laboratory developed a new type of mass spectrometer that is 1000 times more sensitive than existing systems for identifying the proteome of organisms. [Goal Met]	Environmental Molecular Sciences Laboratory 's (EMSL) new high performance computer is fully operational. (SC7-1)	The Environmental Molecular Sciences Laboratory's 900 MHz Nuclear Magnetic Resonance (NMR) instrument will be fully operational and have an established user base. (SC7-1) Average operational downtime of BER facilities will not exceed 10% of total time scheduled. (SC7-1)

Program Assessment Rating Tool (PART) Assessment

The Office of Management and Budget's (OMB) PART assessment of the BER program rated the program highly for having "a well defined mission, merit-based reviews for awarding contracts and grants, and highly-regarded large project management practices." BER was rated lower for planning and results because of BER's "current lack of adequate long-term and annual performance measures" though it was acknowledged that "the program has made significant strides toward developing such measures despite the problems inherent in measuring and predicting scientific progress."

The BER program was found to be focused, well managed, and to have played a leading role in the genomics revolution. BER's coordination of research with other federal research agencies was acknowledged. The regular review of the BER program by panels of outside experts was also acknowledged. At OMB's suggestion, BER is examining its use of these outside expert panels and will identify by the end of FY 2003 ways to improve the efficiency of these reviews.

To address OMB's concern for BER's "current lack of adequate long-term and annual performance measures," BER is working with SC, the Chief Financial Officer, and OMB to reform its performance measures and goals to more accurately predict future scientific progress in a scientifically justifiable and meaningful manner.

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 multiprotein 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.
- Develop cutting edge technologies, facilities, and resources, including animal models, for the Human Genome Project.
- Provide world leadership in low dose radiation research.
- Provide world-class structural biology user facilities and unique computational and experimental structural biology research emphasizing protein complexes involved in recognition and repair of DNA damage and remediation of metals and radionuclides.
- Provide world leadership in ground-based measurement of clouds and atmospheric properties to resolve key uncertainties in climate change, through the Atmospheric Radiation Measurement (ARM) program.
- Develop advanced predictive capabilities using coupled climate models on massively parallel 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 world-class scientific user facilities for environmental and climate change research.

- Provide world leadership in radiopharmaceutical development for wide use in the medical and research communities.
- Maintain world leadership in instrumentation development for medical and biological imaging.
- 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.
- Manage the Environmental Management Science Program (EMSP) in consultation with the Office of Environmental Management (EM) to identify and select the appropriate fundamental research activities.
- 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

For FY 2004, BER will focus on:

- Research to create the new generation of sophisticated high-throughput technologies that are required for translating the new biology, making them widely and readily available, and using them effectively to serve the community of national laboratories, academic, and industrial researchers. Research needed to develop these technologies is currently being funded as part of the Genomes to Life program. This research will be a key component of the design and development of future facilities needed in the Genomes to Life program for conducting Systems Biology research.
- With the completion of the high quality DNA sequence of human chromosomes 5, 16, and 19, DNA sequencing capabilities at the JGI will emphasize the DNA sequencing needs of the broader research community. Sixty percent of the JGI's sequencing capacity of 1 billion base pairs per month will be available to all scientists as a user service as determined by scientific peer review of nominations for DNA sequencing targets. The remaining sequencing capacity will continue to address DOE research on microbes for energy and the environment.
- In FY 2004, BER will continue to contribute to the Administration's Climate Change Research Initiative (CCRI) to deliver information useful to policy makers. The BER contribution to the CCRI will primarily be through focused research on the carbon cycle to help resolve the North American carbon sink question –What fraction of the excess carbon dioxide emissions are taken up by the U.S. terrestrial ecosystem? BER will also contribute to the CCRI in other areas, including climate change modeling, atmospheric composition, and regional impacts of climate change.
- In FY 2004, BER will initiate new ecological research to understand how the scales of response of complex ecosystems to the environment, including their underlying causal mechanisms and pathways, are linked, ranging from the proteomes of individual species to the whole ecosystem. The focus initially 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 will 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 perturbations caused by energy production and use.

- Bioremediation research will continue its focus on the biotransformation of radionuclides and metals at contaminated DOE sites, the community of microbes that affect the transformations in subsurface environments at the sites, and the development of strategies for using bioremediation to clean up or stabilize these contaminants at DOE sites.
- In FY 2003 the Environmental Management Science Program and the Savannah River Ecology Laboratory were transferred from the Office of Environmental Management (EM) to the Office of Science. BER manages these research activities according to Office of Science principles, with extensive input from EM.
- In FY 2003, $20,000,000 was proposed for transfer to the Department of Homeland Security to determine the DNA sequences of potential biothreat agents, to develop technologies to determine and compare the function of the genes coded for by these DNA sequences, and to develop computational tools and databases for the DNA sequencing and annotation of potential biothreat agents. These activities will be budgeted by the Department of Homeland Security in FY 2004.

Genomes to Life Research

The FY 2004 budget includes funds for the continued expansion of the Genomes to Life program—a program at the forefront of the biological revolution—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 multiprotein molecular machines found in selected DOE-relevant microbes and higher organisms and to determine the diverse biochemical capabilities, especially as they relate to potential biological solutions to DOE needs, found in populations of microbes isolated from DOE-relevant sites. In FY 2004, new capabilities will be developed for high throughput protein production and diverse imaging capabilities needed to characterize multiprotein complexes and gene regulatory networks and capabilities in high throughput proteomics will be enhanced well beyond current potential. Also in FY 2004, research and development that underpins future facilities needed by the Genomes to Life program will be conducted. Antiterrorism-related activities have been transferred to the Department of Homeland Security.

Climate Change Science Program

In 2003, the Administration launched a new Climate Change Research Initiative (CCRI) that is intended to focus research on areas where substantial progress in understanding and predicting climate change, including its causes and consequences, is likely over the next five years. DOE, in conjunction with its interagency partners, including NSF, NASA, NOAA, USDA, Interior, and EPA, will continue to focus its Climate Change Research in specific areas relevant to the CCRI. These areas include climate modeling, climate processes, carbon cycling, atmospheric composition, and regional impacts. The deliverables from this research will be targeted at information useful to policy makers. In FY 2004, DOE will also continue to contribute research to the CCRI research area for which additional funding was requested by the Administration for DOE in FY 2003, specifically carbon cycle research to resolve the magnitude and location of the North American carbon sink.

Scientific Discovery through Advanced Computing (SciDAC)

The Scientific Discovery through Advanced Computing (SciDAC) activity is a set of coordinated investments across all Office of Science mission areas with the goal of achieving breakthrough scientific advances through computer simulation that were impossible using theoretical or laboratory studies alone. The power of computers and networks is increasing exponentially. By exploiting advances in computing and information technologies as tools for discovery, SciDAC encourages and enables a new model of multi-discipline collaboration among the scientific disciplines together with computer scientists and mathematicians. The product of this collaborative approach is a new generation of scientific simulation codes that can fully exploit terascale computing and networking resources. The program will bring simulation to a parity level with experiment and theory in the scientific research enterprise as demonstrated by major advances in climate prediction, plasma physics, particle physics, astrophysics and computational chemistry.

Scientific Facilities Utilization

The Biological and Environmental Research request includes funds to maintain support of the Department's major scientific user facilities. Facilities include structural biology research beam lines at the synchrotron light sources and neutron sources and 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. 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 EMSL and the structural biology user facilities so that the unscheduled operating downtime will be less than 10%, on average, of total scheduled operating time.

User Statistics for the Environmental Molecular Sciences Laboratory[a]

	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Maximum hours	4,365	4,365	4,365	4,365	4,365
Scheduled hours	3,130	3,130	4,275	4,365	4,365
Unscheduled Downtime	5%	5%	5%	5%	5%

[a] Scientists use or remotely access some of the more than 100 instrumentation/computer systems in the EMSL 24 hours/day while other instruments are used only 10-12 hours/day. Maximum hours identified above are therefore based on a 12-hour day average estimate. Scheduled hours and downtime for each of the 100 instrument systems are also unique. As a result, the scheduled hours identified above are based on a 10-hour day average estimate. None of the major instrument systems within the EMSL have experienced any significant unscheduled downtimes.

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 program and are not repeated here.

Construction and Infrastructure:

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

Construction of Laboratory for Comparative and Functional Genomics at Oak Ridge National Lab

	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Total Project Cost	$520,000	$2,495,000	$11,405,000	0	0
Cost Variance	0	0	0	0	0
Schedule Variance	0	0	+$10,000,000[a]	-$10,000,000[a]	0
Major Milestones Completed	-	-	Construction started in 3rd quarter	Construction to be completed in 4th quarter	-

[a] Full funding for the construction of the Laboratory for Comparative and Functional Genomics was provided in FY 2002. By the end of FY 2003 construction of the Laboratory will be completed on schedule. This new facility will replace a 50-year old animal facility with rapidly escalating maintenance costs that is still in use at Oak Ridge National Laboratory.

Funding for capital equipment is increased to provide the capabilities essential for initiating the Genomes to Life program. For all other BER activities the capital equipment is held at near the FY 2003 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. Over 1,500 graduate students and post-doctoral investigators will be supported at universities and at National Laboratories in FY 2003. This number includes some 600 graduate students and post-doctoral investigators who conducted their research at the EMSL in FY 2002. BER will continue its support for graduate students and post-doctoral investigators in FY 2004. The number of graduate students and post-doctoral investigators will remain approximately at the FY 2003 level.

Graduate students and postdoctoral investigators use Office of Science user facilities. For example, they use the structural biology experimental stations on the beam lines at the synchrotron light sources and the instruments at the William R. Wiley Environmental Molecular Sciences Laboratory (EMSL). Using these unique research tools enables the graduate students and post-doctoral investigators to participate in

and conduct leading edge research. Approximately half of all of the facility users are graduate students and post-doctoral investigators. The graduate students and post-doctoral investigators are supported by resources from a wide variety of sponsors, including BER, other Departmental research programs, other federal agencies, and U.S. and international private institutions. Graduate students and post-doctoral investigators at the synchrotron light sources are included in the Basic Energy Sciences (BES) user facility statistics and are thus not included here. As noted above, some 600 graduate students and post-doctoral investigators conducted their research at the EMSL in FY 2002.

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 for structural biology at the synchrotron and neutron sources. They are also users of the Environmental Molecular Sciences Laboratory, and the Natural and Accelerated Bioremediation Research (NABIR) program's Field Research Center. University scientists also form the core of the Atmospheric Radiation Measurement (ARM) science team that networks with the broader academic community as well as with scientists at 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, global change research, bioremediation research, medical imaging, and radiopharmaceutical development. Furthermore, university scientists work in close partnership with scientists at National Laboratories in many BER programs including genomics, and carbon sequestration research.

DOE-BER Human Capital

	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
# University Grants	532	579	628	630[a]	630[a]
Size / Duration	$302,000/yr	$287,000/yr	$309,000/yr	$300,000/yr[a]	$300,000/yr[a]
	3 years	3 years	3 years	3 years	3 years
# Lab Projects	379	397	392	395[a]	400[a]
# Permanent PhDs[b]	1310	1370	1427	1491[a]	1489[a]
# Postdocs[c]	251	274	357	373[a]	372[a]
# Graduate Students[c]	438	443	491	481[a]	488[a]
# PhDs awarded[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]

[a] Estimated. Information on the number of research projects funded, the size of those projects, or the number of personnel involved cannot be known prior to the receipt of research applications or proposals, their peer review, and the completion of funding decisions.

[b] Estimated. Information is not readily available on the total number of permanent PhDs 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 PhD-level scientists who are funded collaborators. Information on scientific collaborators is not routinely tracked.

[c] Estimated for national laboratory projects.

[d] Information is not available on the number of PhDs awarded as a result of BER funded research at universities or national laboratories. Data will be collected in the future.

Funding Profile

(dollars in thousands)

	FY 2002 Comparable Appropriation	FY 2003 Request	FY 2004 Request	$ Change	% Change
Biological and Environmental Research					
Life Sciences	186,384	190,878	201,408	+10,530	+5.5%
Climate Change Research	125,847	137,959	142,959	+5,000	+3.6%
Environmental Remediation	111,849	109,530	109,320	-210	-0.2%
Medical Applications and Measurement Science	118,640	45,848	45,848	0	--
Subtotal, Biological and Environmental Research	542,720	484,215	499,535	+15,320	+3.2%
Construction	11,405	0	0	0	--
Total, Biological and Environmental Research	554,125[abcd]	484,215[b]	499,535	+15,320	+3.2%

Public Law Authorization:
Public Law 95-91, "Department of Energy Organization Act"
Public Law 103-62, "Government Performance and Results Act of 1993"

[a] Excludes $12,972,000 which was transferred to the SBIR program and $776,000 which was transferred to the STTR program.

[b] Excludes $2,128,000 in FY 2002 and $20,000,000 in FY 2003 and FY 2004 for Homeland Security activities that are funded in a separate Department of Homeland Security budget.

[c] Excludes $249,000 for the FY 2002 rescission contained in Section 1403 of P.L. 107-226 Supplemental Appropriations for further recovery from the response to terrorist attacks on the United States.

[d] Excludes $50,000 transferred to Safeguards and Security for a FY 2002 reprogramming.

Funding By Site[a]

(dollars in thousands)

	FY 2002	FY 2003	FY 2004	$ Change	% Change
Albuquerque Operations Office					
Los Alamos National Laboratory	23,545	19,245	19,717	+472	+2.5%
Sandia National Laboratories	5,334	3,757	5,846	+2,089	+55.6%
Albuquerque Operations Office	900	850	850	0	--
Total, Albuquerque Operations Office	29,779	23,852	26,413	+2,561	+10.7%
Chicago Operations Office					
Ames Laboratory	830	512	555	+43	+8.4%
Argonne National Laboratory – East	24,446	22,970	23,295	+325	+1.4%
Brookhaven National Laboratory	23,749	16,248	14,964	-1,284	-7.9%
Chicago Operations Office	137,618	46,146	50,394	+4,248	+9.2%
Total, Chicago Operations Office	186,643	85,876	89,208	+3,332	+3.9%
Federal Energy Technology Center	625	0	0	0	--
Idaho Operations Office					
Idaho National Engineering & Environmental Laboratory	2,428	2,205	3,400	+1,195	+54.2%
Idaho Operations Office	14,242	12,552	12,283	-269	-2.1%
Total, Idaho Operations Office	16,670	14,757	15,683	+926	+6.3%
Oakland Operations Office					
Lawrence Berkeley National Laboratory	72,102	42,786	53,055	+10,269	+24.0%
Lawrence Livermore National Laboratory	27,539	28,199	36,502	+8,303	+29.4%
Stanford Linear Accelerator Center	4,435	5,550	3,675	-1,875	-33.8%
Oakland Operations Office	54,058	38,386	47,293	+8,907	+23.2%
Total, Oakland Operations Office	158,134	114,921	140,525	+25,604	+22.3%

[a] On December 20 2002, the National Nuclear Security Administration (NNSA) disestablished the Albuquerque, Oakland, and Nevada Operations Offices, renamed existing area offices as site offices, established a new Nevada Site Office, and established a single NNSA Service Center to be located in Albuquerque. Other aspects of the NNSA organizational changes will be phased in and consolidation of the Service Center in Albuquerque will be completed by September 30, 2004. For budget display purposes, DOE is displaying non-NNSA budgets by site in the traditional pre-NNSA organizational format.

(dollars in thousands)

	FY 2002	FY 2003	FY 2004	$ Change	% Change
Oak Ridge Operations Office					
Oak Ridge Inst. For Science & Education	5,850	4,761	4,550	-211	-4.4%
Oak Ridge National Laboratory	58,549	37,495	38,448	+953	-2.5%
Thomas Jefferson National Accelerator Facility	832	500	0	-500	-100.0%
Oak Ridge Operations Office	869	352	352	0	--
Total, Oak Ridge Operations Office	66,100	43,108	43,350	+242	+0.6 %
Richland Operations Office					
Pacific Northwest National Laboratory	86,047	77,677	81,105	+3,428	+4.4%
Richland Operations Office	100	0	0	0	--
Total, Richland Operations Office	86,147	77,677	81,105	+3,428	+4.4%
Savannah River Operations Office					
Westinghouse Savannah River	239	0	0	0	--
Savannah River Operations Office	8,754	6,326	8,015	+1,689	+26.7%
Total, Savannah River Operations Office	8,993	6,326	8,015	+1,689	+26.7%
Washington Headquarters	1,034	117,698	95,236	-22,462	-19.1%
Total, Biological and Environmental Research	554,125 [abcd]	484,215 [b]	499,535	+15,320	+3.2%

[a] Excludes $12,972,000 which was transferred to the SBIR program and $776,000 which was transferred to the STTR program.

[b] Excludes $2,128,000 in FY 2002 and $20,000,000 in FY 2003 and FY 2004 for Homeland Security activities that are funded in a separate Department of Homeland Security budget.

[c] Excludes $249,000 for the FY 2002 rescission contained in Section 1403 of P.L. 107-226 Supplemental Appropriations for further recovery from the response to terrorist attacks on the United States.

[d] Excludes $50,000 transferred to Safeguards and Security for a FY 2002 reprogramming.

Site Description

Ames Laboratory

Ames Laboratory is a Multiprogram Laboratory located on 10 acres in Ames, Iowa. At Ames, BER supports research into new biological imaging techniques such as the study of gene expression in real time and fluorescence spectroscopy to study environmental carcinogens.

Argonne National Laboratory

Argonne National Laboratory (ANL) in Argonne, Illinois, is a Multiprogram Laboratory located on a 1,700 acre site in suburban Chicago. ANL has a satellite site located in Idaho Falls, Idaho. At ANL, BER supports the operation of a high-throughput national user facility for protein crystallography at the Advanced Photon Source. In support of climate change research, ANL coordinates the operation and development of the Southern Great Plains, Tropical Western Pacific, and North Slope of Alaska ARM sites. The principal scientist for the Atmospheric Chemistry program is at ANL, providing broad scientific integration to the program. Research is conducted to understand the molecular control of genes and gene pathways in microbes. ANL, in conjunction with ORNL and PNNL and six universities, co-hosts the terrestrial carbon sequestration research center, Carbon Sequestration in Terrestrial Ecosystems (CSiTE).

Brookhaven National Laboratory

Brookhaven National Laboratory (BNL) is a Multiprogram Laboratory located on a 5,200 acre site in Upton, New York. BER supports the operation of beam lines for protein crystallography at the National Synchrotron Light Source for use by the national biological research community, research in biological structure determination, and research into new instrumentation for detecting x-rays and neutrons. Research is also conducted on the molecular mechanisms of cell responses to low doses of radiation.

The radiotracer chemistry, radiopharmaceutical technology, and magnetic resonance imaging research and development programs support applications of novel techniques for imaging brain function in normal and diseased states, and to study the biochemical basis of disease.

Climate change research at BNL include the operation of the ARM External Data resource that provides ARM investigators with data from non-ARM sources, including satellite and ground-based systems. BNL scientists form an important part of the science team in the Atmospheric Sciences program, providing special expertise in atmospheric field campaigns and aerosol research. BNL scientists play a leadership role in the development of, and experimentation at, the Free-Air Carbon Dioxide Enhancement (FACE) facility at the Duke Forest used to understand how plants respond to elevated carbon dioxide concentrations in the atmosphere.

Idaho National Engineering and Environmental Laboratory

Idaho National Engineering and Environmental Laboratory (INEEL) is a Multiprogram Laboratory located on 572,000 acres in Idaho Falls, Idaho. Using unique DOE capabilities such as advanced software for controlling neutron beams and calculating dose, BER supports research into boron chemistry, radiation dosimetry, analytical chemistry of boron in tissues, and engineering of new systems for application of this treatment technique to tumors, including brain tumors. Research is also supported into the analytical chemistry of complex environmental and biological systems using the technique of mass spectrometry.

Lawrence Berkeley National Laboratory

Lawrence Berkeley National Laboratory (LBNL) is a Multiprogram Laboratory located in Berkeley, California. The Laboratory is on a 200 acre site adjacent to the Berkeley campus of the University of California. LBNL is one of the major national laboratory partners that comprise the Joint Genome Institute (JGI) whose principal goals are high-throughput DNA sequencing techniques and studies on the biological functions associated with newly sequenced human DNA. A significant component of the JGI's sequencing goal is the development and integration of instrumentation, automation, biological resources, and data management and analysis tools into a state-of-the-art DNA sequencing assembly line that is highly efficient and cost effective. The laboratory also conducts research on the molecular mechanisms of cell responses to low doses of radiation and on the use of model organisms to understand and characterize the human genome.

LBNL operates beam lines for determination of protein structure at the Advanced Light Source for use by the national and international biological research community, research into new detectors for x-rays, and research into the structure of proteins, including membrane proteins.

The nuclear medicine program supports research into novel radiopharmaceuticals for medical research and studies of novel instrumentation for imaging of living systems for medical diagnosis.

LBNL supports the Natural and Accelerated Bioremediation Research (NABIR) program and the geophysical and biophysical research capabilities for NABIR field sites. BER supports research at LBNL into new technologies for the detailed characterization of complex environmental contamination. LBNL also develops scalable implementation technologies that allow widely used climate models to run effectively and efficiently on massively parallel processing supercomputers. The carbon cycle field experiment at the ARM Southern Great Plains site is maintained and operated by LBNL.

Lawrence Livermore National Laboratory

Lawrence Livermore National Laboratory (LLNL) is a Multiprogram Laboratory located on an 821 acre site in Livermore, California. LLNL is one of the major national laboratory partners that comprise the Joint Genome Institute (JGI) whose principal goals are high-throughput DNA sequencing and studies on the biological functions associated with newly sequenced human DNA. A significant component of the JGI's sequencing goal is the development and integration of instrumentation, automation, biological resources, and data management and analysis tools into a state-of-the-art DNA sequencing assembly line that is highly efficient and cost effective. LLNL also conducts research on the molecular mechanisms of cell responses to low doses of radiation, and on the use of model organisms to understand and characterize the human genome.

Through the program for Climate Model Diagnostics and Intercomparison, LLNL provides the international leadership to understand and improve climate models. Virtually every climate modeling center in the world participates in this unique program.

Los Alamos National Laboratory

Los Alamos National Laboratory (LANL) is a Multiprogram Laboratory located on a 27,000 acre site in Los Alamos, New Mexico. LANL is one of the major national laboratory partners that comprise the Joint Genome Institute (JGI) whose principal goals are high-throughput DNA sequencing and studies on the biological functions associated with newly sequenced human DNA. A significant component of the JGI's sequencing goal is the development and integration of instrumentation, automation, biological resources, and data management and analysis tools into a state-of-the-art DNA sequencing assembly line that is highly efficient and cost effective. One of LANL's roles in the JGI involves the production of high quality "finished" DNA sequence. LANL also conducts research on the molecular mechanisms of cell responses to low doses of radiation and on research to understand the molecular control of genes and gene pathways in microbes. Activities in structural biology include the operation of an experimental station for protein crystallography at the Los Alamos Neutron Science Center for use by the national biological research community and research into new techniques for determination of the structure of proteins.

LANL provides the site manager for the Tropical Western Pacific ARM site. LANL also has a crucial role in the development, optimization, and validation of coupled atmospheric and oceanic general circulation models using massively parallel computers.

LANL also conducts research into advanced medical imaging technologies for studying brain function and research into new techniques for rapid characterization and sorting of mixtures of cells and cell fragments.

Oak Ridge Institute for Science and Education

Oak Ridge Institute for Science and Education (ORISE) is located on a 150 acre site in Oak Ridge, Tennessee. ORISE coordinates several research fellowship programs for BER. ORISE also coordinates activities associated with the peer review of most of the research proposals submitted to BER.

ORISE conducts research into modeling radiation dosages for novel clinical diagnostic and therapeutic procedures.

Oak Ridge National Laboratory

Oak Ridge National Laboratory (ORNL) is a Multiprogram Laboratory located on a 24,000 acre site in Oak Ridge, Tennessee. ORNL has a leadership role in research focused on the ecological aspects of global environmental change. The Throughput Displacement Experiment at the Walker Branch Watershed is a unique resource for long term ecological experiments. ORNL is the home of the newest FACE experiment supported by BER. ORNL also houses the ARM archive, providing data to ARM scientists and to the general scientific community. ORNL scientists provide improvement in formulations and numerical methods necessary to improve climate models. ORNL scientists make important contributions to the NABIR program, providing special leadership in microbiology applied in the field. ORNL also manages the NABIR Field Research Center, a field site for developing and testing bioremediation methods for metal and radionuclide contaminants in subsurface environments.

ORNL conducts research on widely used data analysis tools and information resources that can be automated to provide information on the biological function of newly discovered genes identified in high-throughput DNA sequencing projects. The laboratory also uses mice as model organisms to understand and characterize the human genome.

ORNL conducts research into the application of radioactively labeled monoclonal antibodies in medical diagnosis and therapy, particularly of cancer, as well as research into new instrumentation for the analytical chemistry of complex environmental contamination using new types of biosensors.

ORNL recently has upgraded the High Flux Isotope Reactor (HFIR) to include a cold neutron source that will have high impact on the field of structural biology. BER is developing a station for Small Angle Neutron Scattering at HFIR to serve the structural biology community.

ORNL, in conjunction with ANL and PNNL and six universities, co-hosts a terrestrial carbon sequestration research center, CSiTE.

Pacific Northwest National Laboratory

Pacific Northwest National Laboratory (PNNL) is a Multiprogram Laboratory located on 640 acres at the Department's Hanford site in Richland, Washington. PNNL is home to the William R. Wiley Environmental Molecular Sciences Laboratory (EMSL). PNNL scientists, including EMSL scientists, play important roles in both supporting the NABIR program and in performing research for NABIR.

PNNL operates the unique ultrahigh field mass spectrometry and nuclear magnetic resonance spectrometry instruments at the Environmental Molecular Sciences Laboratory for use by the national research community.

PNNL provides the lead scientist for the Environmental Meteorology Program, the G-1 research aircraft, and expertise in environmental field campaigns. PNNL provides the planning and interface for the Climate Change Prediction Program with other climate modeling programs. The ARM program office is located at PNNL, as is the ARM chief scientist and the project manager for the ARM engineering activity; this provides invaluable logistical, technical, and scientific expertise for the program.

PNNL conducts research into new instrumentation for microscopic imaging of biological systems and for characterization of complex radioactive contaminants by highly automated instruments.

PNNL conducts research on the molecular mechanisms of cell responses to low doses of radiation and on the development of high throughput approaches for characterizing all of the proteins (the proteome) being expressed by cells under specific environmental conditions.

PNNL, in conjunction with ANL and ORNL and six universities, co-hosts a terrestrial carbon sequestration research center, CSiTE.

PNNL also conducts research on the integrated assessment of global climate change.

In March 2001 the University of Maryland and Pacific Northwest National Laboratory created a Joint Global Change Research Institute in College Park, Maryland. The Institute investigates the scientific, social, and economic implications of climate change, both nationally and globally. BER funding supports research grants to the university and research projects to PNNL that have been successfully peer reviewed in open competition.

Sandia National Laboratory

Sandia National Laboratory (SNL) is a Multiprogram Laboratory, with a total of 3,700 acres, located in Albuquerque, New Mexico, with sites in Livermore, California and Tonopah, Nevada. SNL provides the site manager for the North Slope of Alaska ARM site. The chief scientist for the ARM-UAV program is at SNL, and SNL takes the lead role in coordinating and executing ARM-UAV missions. The laboratory conducts advanced research and technology development in robotics, smart medical instruments, microelectronic fabrication, and computational modeling of biological systems.

To support environmental cleanup, SNL conducts research into novel sensors for analytical chemistry of contaminated environments.

SNL conducts computational and biological research in support of the Genomes to Life research program.

Savannah River Site

The Savannah River Site complex covers 198,344 acres, or 310 square miles encompassing parts of Aiken, Barnwell and Allendale counties in South Carolina bordering the Savannah River. At the Savannah River Site, BER supports the Savannah River Ecology Laboratory (SREL), a research unit of the University of Georgia operating at the site for over forty years. The SREL conducts research aimed at reducing the cost of environmental cleanup and remediation while ensuring biodiversity to the restored environment.

BER supports the Savannah River Ecology Laboratory through a cooperative agreement with the University of Georgia. The ecological research activity is aimed at reducing the cost of cleanup and remediation while ensuring biodiversity to the restored environment.

Stanford Linear Accelerator Center

Stanford Linear Accelerator Center (SLAC) is a program-dedicated laboratory (High Energy Physics) located on 426 acres in Menlo Park, California, and is the home of the Stanford Synchrotron Radiation Laboratory (SSRL). The Stanford Synchrotron Radiation Laboratory was built in 1974 to utilize the intense x-ray beams from the SPEAR storage ring that was built for particle physics by the SLAC laboratory. Over the years, the SSRL grew to be one of the main innovators in the production and use of synchrotron radiation with the development of wigglers and undulators that form the basis of all third generation synchrotron sources. The facility is now comprised of 25 experimental stations and is used each year by over 700 researchers from industry, government laboratories and universities. Through the Stanford Linear Accelerator Center, BER (in coordination with the National Institutes of Health) is funding the operation of nine SSRL beam lines for structural biology. This program involves synchrotron radiation-based research and technology developments in structural molecular biology that focus on protein crystallography, x-ray small angle scattering diffraction, and x-ray absorption spectroscopy for determining the structures of complex proteins of many biological consequences.

Thomas Jefferson National Accelerator Facility

The Thomas Jefferson National Accelerator Facility (TJNAF) is a basic research laboratory located on a 200 acre site in Newport News, Virginia. BER supports the development of advanced imaging instrumentation at TJNAF that will ultimately be used in the next generation medical imaging systems.

All Other Sites

The BER program funds research at 223 institutions, including colleges/universities, private industry, and other federal and private research institutions located in 43 states.

BER supports a broad range of peer-reviewed research at America's universities, including institutions that traditionally serve minority communities. BER research opportunities are announced through public solicitations in the Federal Register for research applications from universities and the private sector.

BER's Life Sciences research is conducted at a large number of universities. For example research is conducted in support of high-throughput human DNA sequencing at the JGI, on the sequencing of entire microbial genomes with value to the DOE mission, to understand the molecular control of genes and gene pathways in microbes, on the use of model organisms to understand and characterize the human genome, and on the molecular mechanisms of cell responses to low doses of radiation.

In structural biology, universities provide new imaging detectors for x-rays, research in computational structural biology directed at the understanding of protein folding, and research into new techniques such as x-ray microscopy.

Peer-reviewed projects are supported in each element of the Climate Change Research subprogram, with very active science teams, in particular, in the Atmospheric Chemistry Program and the ARM program. Academic investigators are also essential to the Integrated Assessment portfolio.

In the NABIR program, academic and private sector investigators are performing research in areas that include mechanistic studies of bioremediation of actinide and transition metal contamination, the structure of microbial communities in the presence of uranium and other such contaminants, gene function in microorganisms with degradative properties, geochemical and enzymatic processes in microbial reduction of metals, and the use of tracers to monitor and predict metabolic degradative activity.

In the nuclear medicine program, universities conduct research into new types of radiopharmaceuticals, particularly those based on application of concepts from genomics and structural biology. BER places emphasis on radiopharmaceuticals that will be of use in advanced imaging techniques such as positron emission tomography. The research supports new instrumentation for medical imaging. The BER Measurement Science program supports research into novel types of biosensors for medical imaging and application in analytical chemistry of contaminated environments.

Life Sciences

Mission Supporting Goals and Measures

The goal of the Life Sciences subprogram is to deliver fundamental knowledge of biological systems that can be used to address DOE needs in clean energy, carbon sequestration, and environmental cleanup. Fundamental research is supported in structural biology, genomics, and the health effects of low dose radiation. Human, animal, and microbial 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 or sequester atmospheric carbon dioxide. Scientific tools and resources are developed and made widely available for determining protein structures and genomic DNA sequences and for understanding the structure, function, and regulation of multiprotein complexes from DOE-relevant organisms – information that can then be used to develop biotechnology solutions for DOE needs. Finally, low dose radiation research provides knowledge underpinning rigorous, cost-effective standards to protect the health of cleanup workers and the public and for science-based decisions on DOE site cleanup. In FY 2003 $20,000,000 related to genomic analysis of potential biothreat agents was transferred to the Department of Homeland Security.

BER supports research in five areas of the Life Sciences: structural biology; low dose radiation; molecular/systems biology; human genome; and biological research.

- BER develops and supports user facilities for the Nation's structural biologists at synchrotron, nuclear magnetic resonance (NMR), and neutron sources. BER also determines the structures of proteins important for the bioremediation of metals and radionuclides or of proteins that are involved in the repair of DNA damage.
- BER supports research on the biological effects of low doses of ionizing radiation and 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.
- BER supports systems biology research in the Genomes to Life program by developing the experimental and, together with the Advanced Scientific Computing Research program, computational resources, tools, and technologies needed to understand the complex behavior of complete biological systems – from single microbes to complex microbial communities. This information can be used to develop innovative solutions for energy production, waste cleanup, and carbon management.
- BER takes advantage of the remarkable high throughput and cost-effective DNA sequencing capacity it developed as part of the International Human Genome Project to meet future DNA sequencing needs of DOE and other agencies. BER also develops resources, tools, and technologies needed to analyze and interpret DNA sequence data from entire organisms and to study the ethical, legal, and social implications (ELSI) of information and data resulting from genome projects.

- BER develops resources, tools, and technologies to understand the function of human genes that it identifies as part of the International Human Genome Project using model organisms such as the mouse, *Fugu* (the puffer fish), and *Ciona* (the sea squirt).

The Life Sciences subprogram provides fundamental knowledge building to long-term outcomes that underpin the Program Strategic Performance Goals and the Office of Science's Strategic Objectives. Periodic retrospective analysis will be employed to evaluate the accumulation of knowledge and validate specific outcomes. This program was reviewed as part of a BERAC review of the entire BER program in FY 2001. The next scheduled comprehensive review of the Life Sciences subprogram by BERAC will be in FY 2004. The following are recent scientific accomplishments that highlight program progress.

- *First Tree Genome to be Sequenced.* The genome of *Populus balsamifera* ssp. *trichocarpa,* commonly known as the black cottonwood, a species of Poplar tree will be the first tree genome ever sequenced. Scientists working on tree genetics and tree productivity and product utilization are highly enthusiastic about the sequencing of this tree species because it represents an important first step in understanding the genome of a common, commercially important tree species with potential impacts that could include improved carbon sequestration and biomass for energy. This effort is being led by a consortium of scientists from the University of Washington, Oregon State University, Pennsylvania State University, the British Columbia Genome Sequence Center, the Swedish University of Agricultural Sciences, the National Center for Genome Research in New Mexico, the DOE Joint Genome Institute (JGI), the Oak Ridge National Laboratory, and other institutions. The sequencing will be carried out at DOE's high throughput DOE sequencing facility, the JGI.
- *Pufferfish Helps Scientists Understand the Human Genome.* The first public assembly of an animal genome, the genome of the Japanese pufferfish *Fugu rubripes,* has been completed by the DOE JGI. Although the *Fugu* genome contains essentially the same genes and regulatory sequences as the human genome, it carries those genes and regulatory sequences in approximately 365 million bases as compared to the 3 billion bases that make up human DNA. With far less so-called "junk DNA" to sort through, the information can then be used to help identify genes and regulatory sequences in the human genome. This effort was led by an international research consortium that included the JGI, the Singapore Biomedical Research Council's Institute for Molecular and Cell Biology, the Human Genome Mapping Resource Centre of the United Kingdom's Medical Research Council, the Cambridge University Department of Oncology, and the Institute for Systems Biology in Seattle, Washington. The consortium's sequencing efforts were bolstered by two US companies, Celera Genomics of Rockville, Maryland and Myriad Genetics, Inc. of Salt Lake City, Utah.
- *First ever DNA sequence of an algae.* The genomic DNA sequence of a unicellular green algae has been determined by the JGI – the first algae to be sequenced. Chlamydomonads have a 100 million base pair genome (compared to 3 billion for humans and 365 million for the *Fugu* described above) and are a genus of unicellular green algae (Chlorophyta) found nearly everywhere - in soil, fresh water, oceans, and even in snow on mountaintops. Algae in this genus have a cell wall, a chloroplast for photosynthesis, an "eye" that perceives light, and two flagella with which they can swim using a breast-stroke type motion. More than 500 different species of Chlamydomonas have been described. The most widely used laboratory species is *Chlamydomonas reinhardtii.* DOE is interested in *Chlamydomonas* because of its widespread global distribution and its ability to carry out photosynthesis, the most powerful biological technology for carbon dioxide capture from the atmosphere.

- *First DNA sequence of a marine diatom.* The first ever genomic DNA sequence of a marine diatom, *Thalassiosira pseudonann*, has been determined by the JGI. Diatoms, or marine phytoplankton, are important model organisms for carbon sequestration and are found in all of Earth's oceans. They display an incredible and intriguing variety of shapes and are major players in the Earth's carbon cycle responsible for much of the ocean's ability to move carbon dioxide captured in the near surface regions by photosynthesis to deep ocean compartments. The shapes, growth rates, and carbon management processes of diatoms are all under genetic control and could be exploited to enhance its carbon processing capabilities as a step towards partial mitigation of global warming. Additionally, the silicate shells of many diatoms are engineering and material science marvels and could provide important insights for nanoscience activities.
- *JAZZing up genomes.* Because of the sequencing process, the DNA sequences of organisms large and small are determined in hundreds or thousands of small pieces. A new graphical algorithm, JAZZ, has been developed for stitching these pieces back together into a complete DNA sequence. JAZZ has been used at the JGI to put together the genomes of many microbes, a fungal genome, the genomes of the sea squirt C*iona intestinalis* and the pufferfish *Fugu rubripes*.
- *Another record-breaking year of microbial DNA sequencing.* The JGI has again surpassed expectations in microbial DNA sequencing in FY 2002 by determining high quality draft sequences of 41 microbes important to DOE needs in energy, environmental cleanup, and counter terrorism. Twelve of these organisms are pathogens or their close genetic relatives that were sequenced as part of a coordinated interagency effort to quickly characterize as many potential threat agents as possible.
- *International Scientists Celebrate at Sea Squirt Genome Jamboree*. Fifty scientists from around the world gathered in San Francisco to celebrate, by staying glued to their computers to analyze the DNA sequence of *Ciona intestinalis*, a sea squirt. *Ciona* is an organism with the smallest genome of any experimentally manipulable chordate and is a good system for exploring the evolutionary origins of the chordate lineage, from which vertebrates, including man, sprouted. The complete genome sequence of *Ciona* was determined by DOE's JGI and will provide a foundation for genome-scale analysis of regulatory networks through development. Genes that have survived in humans since the sea squirt's evolution have surely been preserved for good reasons. By comparing the human genome to the genomes of different creatures, researchers can pinpoint which genes have survived hundreds of millions of years of evolution. Those that have survived throughout evolution are likely to have important functions. In other words, they compare these animal genomes to the human genome to see the similarities and differences—and eventually discover the secrets of evolution and disease.
- *First Call for Candidate Microbes for DNA Sequencing*. DOE's JGI will now be available as a resource to all scientists for determining the DNA sequences of microbes or communities of microbes relevant to DOE mission needs including waste remediation, carbon management, and energy production. Microbes nominated by scientists for genomic sequencing will be prioritized by a panel of scientific experts, including representatives from the American Society for Microbiology. All DNA sequence data determined by the JGI will be publicly available to all scientists. This call for nominations for DNA sequencing at the JGI is the first in what is anticipated to be an ongoing series of public calls for DNA sequencing that will effectively make the JGI's considerable DNA sequencing capabilities available to scientists as a public resource.

- *New Neutron User Facility for Structural Biologists* - DOE user facilities for structural biologists at the synchrotron light sources enable scientists to determine high resolution electron density maps of protein crystals needed to determine their three dimensional structure. In some cases, neutrons provide additional information critical to understand protein structure by providing vital insights into the locations of hydrogen bonds and the nature of macromolecular-solvent interactions. A new protein crystallography station at the Los Alamos Neutron Science Center (LANSCE) will be available by the end of 2002. This is the only neutron crystallography station for structural biologists in the U.S.
- *New Ultrasensitive Mass Spectrometer for Proteomics* - Pacific Northwest National Laboratory has developed a new electrospray ionization fourier transform ion cyclotron resonance mass spectrometer (ICR), the highest field and most sensitive ICR mass spectrometer currently available. This new machine is approximately 1000 fold more sensitive than conventional instruments, has a resolution 100-1000 fold greater than conventional instruments and can measure peptides at a level less than or equal to 1 part per million. At this level, most peptides are unique and can be assigned to a specific protein in the genome. In contrast, conventional instruments measure at approximately the 500 parts per million level.

Subprogram Goals

Identify and characterize the multiprotein molecular machines that carry out the biological functions of cells and determine the biochemical capabilities of complex microbial communities, information needed to develop biotechnology solutions for clean energy, carbon sequestration, and environmental cleanup.

Performance Indicator

Number of complex microbial communities and multiprotein molecular machines that can be characterized per year.

Annual Performance Results and Targets

FY 2002 Results	FY 2003 Targets	FY 2004 Targets
(Structural Biology – Basic Research)	(Structural Biology – Basic Research)	(Structural Biology – Basic Research)
New research emphasis in Structural Biology basic research. First awards given based on competitive peer review. [Goal Met]	Develop one new computational model that can successfully predict which proteins interact with protein complexes involved in DNA damage recognition and repair or bioremediation of metals and radionuclides from analysis of DNA sequence.	Develop two new computational models that can successfully predict which proteins interact with protein complexes involved in DNA damage recognition and repair or bioremediation of metals and radionuclides from analysis of DNA sequence. Demonstrate accuracy of new model from FY 2003 by experimentally determining the fraction of proteins known to interact with these complexes that are correctly predicted by the model.

FY 2002 Results	FY 2003 Targets	FY 2004 Targets
(Microbial Genomics) Determined high quality draft sequences of 41 microbes important to DOE needs in energy and environmental cleanup. [Exceeded Goal]	(Microbial Genomics) Draft genomic sequence of more than 30 microorganisms of high DOE relevance and scientific research; improve the computational tools for predicting gene function; and develop methods for sequencing unculturable microbes and microbial consortia.	(Microbial Genomics) Determine the frequency of lateral gene transfer among 5 different groups of microbes, improve the efficiency of computational tools for predicting the function of newly identified microbial genes by 50%, and develop new strategies for the rapid comparison of closely related microbial DNA sequences that are twice as efficient as current methods
(Carbon Sequestration Research) The first ever genomic DNA sequence of a marine diatom, *Thalassiosira pseudonann*, has been determined by the JGI, well ahead of the original schedule for completion. [Goal Met]	(Carbon Sequestration Research) Complete DNA sequence of a member of the genus *Populas* (trees like poplar, aspen, etc.). In addition, determine the draft DNA sequence of *Thalassiosira*, a diatom important in oceanic sequestration.	(Carbon Sequestration Research) Identify genes and proteins in the poplar that are important for carbon utilization and initially characterize microbes that live in the poplar rhizosphere.
(Genomes to Life) New research program in FY 2002.	(Genomes to Life) In conjunction with ASCR and using data produced by BER and BES-sponsored microbial cell project researchers, develop new computational tools for the analysis and simulation of biological processes. For 3-5 of the over 70 microbial genomes sequenced by DOE, begin the difficult, comprehensive integration of genomic, biochemical, structural and physiological information on DOE relevant functionalities (e.g., bioremediation, carbon sequestration and/or biomass to fuel). Develop working conceptual and numerical models to describe these functionalities. Sequence one or more consortia of microorganisms that will provide information on how microbes function and interact in the environment, such as at DOE legacy waste sites.	(Genomes to Life) Produce 1000 distinct proteins in quantities of 2 milligrams each in highly purified form and use those proteins to develop tags that enable detection and imaging of 500 of these molecules. These capabilities will be used to address the following GTL goals: (1) imaging the molecular machines of life; (2) imaging to characterize gene regulatory networks; and (3) imaging to characterize complex microbial communities in model and natural environments at the molecular level.

Characterize the biological effects of low doses of ionizing radiation (less than annual DOE exposure limit) to assist policy makers in developing science-based health protection standards to protect DOE cleanup workers and the public and to strengthen the scientific basis for making decisions on radiation exposure limits for DOE site cleanup operations.

Performance Indicator

Eighty percent of all new research projects will be peer reviewed and deemed excellent and relevant, and ongoing projects will be subject to triennial peer review with merit evaluation.

Annual Performance Results and Targets

FY 2002 Results	FY 2003 Targets	FY 2004 Targets
(Low Dose Radiation Research)	(Low Dose Radiation Research)	(Low Dose Radiation Research)
BERAC report (March 2001) states that "the program has gotten off to an excellent start and is funding a number of scientifically sound and important projects."	Research results will be incorporated into the National Academy of Sciences Biological Effects of Ionizing Radiation VI report.	By the end of FY 2004, the program will demonstrate for the first time the effects of ionizing radiation on neighbors of irradiated cells in vivo.

Develop high throughput methods for rapidly predicting, characterizing, and understanding the control and functions of genes identified from genomic DNA sequencing.

Performance Indicator

DNA base pairs sequenced per year.

Annual Performance Results and Targets

FY 2002 Results	FY 2003 Targets	FY 2004 Targets
(Human Genome)	(Human Genome)	(Human Genome)
The first public assembly of an animal genome, the genome of the Japanese pufferfish *Fugu rubripes,* has been completed by the DOE JGI. With far less so-called "junk DNA" to sort through, the information can then be used to help identify genes and regulatory sequences in the human genome. [Goal Met] A new graphical algorithm, JAZZ, has been developed for stitching small pieces of DNA sequence back together into a complete DNA sequence. JAZZ has been used at the JGI to put together the genomes of many microbes, a fungal genome, the genomes of the sea	Establish at least 30 diverse collaborations for high throughput DNA sequencing with scientists outside the JGI and with programs at other federal agencies.	Produce 12 billion base pairs of high quality DNA sequence at the JGI. Approximately 7.2 billion base pairs of the total will be genomes for outside users based on a peer-review selection process. The remaining sequencing capacity will be used to complete the draft sequence and assembly of the *Xenopus* (frog) genome, a model organism for the Human Genome Project, that will contribute to understanding human development.

FY 2002 Results	FY 2003 Targets	FY 2004 Targets
squirt *Ciona intestinalis*, and the pufferfish *Fugu rubripes*. [Goal Met] As of July 2002 the Department of Energy' Joint Genome Institute (JGI) has completed the high quality sequencing of human chromosome 19 and approximately 80% of human chromosome 16. The JGI has also produced seven billion bases of sequences completing the draft sequencing of *Fugu* (the pufferfish) and Ciona (the sea squirt) as its contribution to the Human Genome Program. [Goal Met]		

Manage all BER facility operations to the highest standards of overall performance, using merit evaluation with independent peer review.

Performance Indicator

Average operational downtime of BER facilities will not exceed 10% of total time scheduled.

Annual Performance Results and Targets

FY 2002 Results	FY 2003 Targets	FY 2004 Targets
(Structural Biology – Infrastructure) New neutron crystallography user facility opened at LANL's LANSCE. An estimated 2000 users used the structural biology instruments at the DOE national user facilities (end of year data not yet available for FY 2002). [Goal Met]	(Structural Biology – Infrastructure) More than 2,500 highly satisfied users will use the structural biology instruments at the DOE national user facilities. Ten external user groups will use the LANSCE protein crystallography station. The installation of the new station at HFIR for use by structural biologists to determine the structures of protein complexes will be completed.	(Structural Biology – Infrastructure) More than 3,000 highly satisfied users will use the structural biology instruments at the DOE national user facilities. Have five structural biology user groups from outside ORNL complete experiments at the HFIR by the end of FY 2004. Add at least 4000 new structure data sets to the Protein Data Bank during FY 2004. Produce a pixel array detector, with at least 100x100 pixel size, deployed at a DOE synchrotron by the end of FY 2004 (TEC less than $1 million).

Funding Schedule

(dollars in thousands)

	FY 2002	FY 2003	FY 2004	$ Change	% Change
Structural Biology	29,536	27,847	27,809	-38	-0.1%
Molecular and Cellular Biology	55,041	71,195	93,500	+22,305	+31.3%
Human Genome	90,075	76,805	64,572	-12,233	-15.9%
Health Effects	11,732	10,260	10,260	0	0%
SBIR/STTR	0	4,771	5,267	+496	+10.4%
Total, Life Sciences	186,384	190,878	201,408	+10,530	+5.5%

Detailed Program Justification

(dollars in thousands)

	FY 2002	FY 2003	FY 2004
Structural Biology	**29,536**	**27,847**	**27,809**
▪ **Basic Research**	**12,307**	**12,547**	**12,509**

In FY 2004, BER will continue to invest in structural biology research relevant to DOE missions. In carrying out their functions within cells, proteins form complexes with other proteins (forming molecular machines) and interact with a variety of structural and regulatory molecules on which proteins carry out their functions. Understanding how molecular machines carry out their biological functions requires that we observe dynamic changes in protein structure and study protein modifications, translocations, and subcellular concentrations. Starting with DNA sequencing information, research is supported to predict or identify the proteins that are involved in the recognition or repair of radiation-induced DNA damage or in the bioremediation of metals and radionuclides that could lead to reduced clean up costs; and to determine the high-resolution three-dimensional structures of those proteins. To fully understand the mechanisms underlying the behavior of the molecular machines that carry out these functions, research is conducted and computer simulation models are developed: (1) on the dynamic changes in protein structure associated with protein modification and with protein-protein and protein-nucleic acid interactions that occur in these molecular machines; (2) to develop instrumentation that enables imagery of molecular machines in real-time at high levels of resolution; and (3) to precisely measure their intracellular compartmentalization and translocation.

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

(dollars in thousands)

	FY 2002	FY 2003	FY 2004
▪ **Infrastructure Development**	**17,229**	**15,300**	**15,300**

BER develops beamlines and instrumentation at the Department's national user facilities for the Nation's structural biologists and supports access by these scientists to these experimental stations. It coordinates with the NIH and the NSF management of experimental stations at DOE synchrotrons [Advanced Photon Source (APS), Advanced Light Source (ALS), Stanford Synchrotron Radiation Laboratory (SSRL) and National Synchrotron Light Source NSLS)] 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 BES facility user reports. BER also supports access to unique high performance mass spectrometry and nuclear magnetic resonance spectrometry user facilities at the EMSL that are used for both proteomic and structural biology research. DOE investment in structural biology facilities is having a large impact on basic research investments being made by other agencies. These facilities will be used to conduct the research described above. In addition, DOE investments in structural biology user facilities at synchrotron light sources and at the EMSL have enabled the National Institute of General Medical Sciences at the National Institutes of Health (NIH) to make a large investment (over $30,000,000 per year from FY 2001 to FY 2005) in pilot projects for NIH's Protein Structure Initiative to develop high throughput methods for determining protein structure. Six of the nine pilot projects funded by NIH include partners from DOE Laboratories and nearly all make heavy use of DOE user facilities. BER also supports development of new instrumentation that will make more effective use of the intense x-ray beams at the DOE synchrotrons. A new x-ray detector technology is being supported in cooperation with the NIH called the pixel-array detector (PAD). This technology would allow much more rapid acquisition and read-out of x-ray crystallographic data and would enable collection of complete data sets for protein structure determination in minutes, avoiding problems with decomposition of the protein crystals that occur over longer time periods. The total estimated cost for each detector is estimated at less that $1,000,000.

Molecular and Cellular Biology	**55,041**	**71,195**	**93,500**
▪ **Microbial Genomics**	**10,997**	**10,987**	**9,838**

Microbial genomics research underpins DOE research programs - Fundamental microbiology research will continue to underpin DOE's need to exploit the capabilities of microbes to address mission needs. Begun in 1994 with DOE's first sequencing of a complete microbial genome, microbial genomics research continues to provide support for individual investigator initiated projects that provide a fundamental understanding of microbes.

Microbial genomics research serves to strengthen the fundamental research foundation that underpins other BER and DOE programs, including: Genomes to Life; bioremediation research; and carbon sequestration. The underlying scientific justification remains a central principle of the BER genome programs – complete genomic sequences yield answers to fundamental questions in biology. Knowing the complete DNA sequence of a microbe provides important insights to the

biological capabilities of that organism and is the first step in developing strategies to more efficiently detect, counteract, use, or reengineer that microbe to address DOE needs.

Microbial genomics research includes:

Development of novel strategies to obtain and compare microbial DNA sequences. Research is being conducted on new methods to accelerate sequence comparisons without resequencing the entire genome of the related organism from scratch. Emphasis is being placed on novel uses of proven technologies with a particular emphasis on the identification of specific DNA sequence features that are associated with phenotypic differences between the microbes being compared.

Research on microbial genomic plasticity, including the normal ability of microbes to exchange genetic information in nature. Current microbial DNA sequence data strongly suggest that entire blocks of genes have been transferred between microbes during evolution. Research is being conducted to assess the frequency, mechanisms, and circumstances of lateral gene exchanges among microbes. This understanding is important for interpreting microbial DNA sequence data and for designing novel strategies for using microbes to address DOE mission needs.

Development of bioinformatics tools for analyzing microbial DNA sequence information. More than a third of the more than 100 publicly available genomic sequences of archaea and bacteria are a result of DOE Microbial Genome program funding. Novel computational tools are being developed to increase the value of microbial genomic information, such as identifying distant relationships of genes, understanding microbial evolution, predicting gene function, identifying and modeling gene expression networks, and extracting longer stretches of useable DNA sequence from raw sequence data.

In FY 2003 $2,128,000 was transferred for genomic analysis of potential biothreat agents to the Department of Homeland Security.

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

- **Carbon Sequestration Research** **7,057** **7,138** **7,127**

Microbes and plants play substantial roles in the global cycling of carbon through the environment. In FY 2004 the program continues to leverage new genomic DNA sequence information on microbes important to the global carbon cycle by characterizing key biochemical pathways or genetic regulatory networks in these microbes. The information on the DNA sequence, key reaction pathways, and genetic regulatory networks will be used to develop strategies to use microbes and other organisms capable of carbon sequestration more efficiently or to even reengineer these organisms to enhance their capacity to sequester excess atmospheric carbon.

Research will also leverage the genomic DNA sequence of the poplar tree, completed in FY 2003, by developing high throughput experimental and computational methods for understanding the poplar genome and proteome, especially as related to carbon utilization. Research will also focus on microbes that live in the poplar rhizosphere (root zone) with the intent of understanding the role

(dollars in thousands)

FY 2002	FY 2003	FY 2004

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 would serve to 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.

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

- **Genomes to Life** **18,696** **34,547** **59,039**

Genomes to Life is a program at the forefront of the biological revolution - a systems approach to biology at the interface of the biological, physical, and computational sciences. It will take advantage of solutions that nature has already devised to solve many of our most pressing and expensive problems. It will help us design and use complex systems to produce clean energy, mitigate climate change, and clean up the environment.

This new biological era – the era of systems biology – will enable us to understand entire living organisms and their interactions with the environment. Scientists have long tried to understand the workings of individual genes or small groups of genes. This new era in biology will focus on entire networks of genes and even biological systems – small, single celled organisms at first and later more complex creatures including humans.

This dramatic advance is possible, in large part, because of the scientific and technical successes of the Human Genome Project. Information and technology now available to all scientists working on the human genome and on a growing list of other organisms from microbes to plants to mice gives us new perspectives on the inner workings of biological systems and provides opportunities to use this knowledge to solve problems confronting DOE.

Genomes to Life offers the possibility of biotechnology solutions that can give us abundant sources of clean energy yet control greenhouse gases like carbon dioxide, a key factor in global climate change, and that can help us clean up past contamination of the environment.

Genomes to Life is a comprehensive, systems-level, interdisciplinary research program at the interfaces of the biological, physical, and computational sciences. It 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, in the end, enable us to predict responses of biological systems to their environments and to use that predictive capability to generate solutions to complex and expensive DOE and National challenges including –

- *Clean Energy* - Within 10 years advances in systems biology, computation, and technology may contribute to increased biology-based energy sources. In the long-term, they could contribute to energy security through a major new bioenergy industry.

(dollars in thousands)

FY 2002	FY 2003	FY 2004

- *Reduced Carbon Dioxide in the Atmosphere* - Within 10 years advances in systems biology, computation, and technology may help us understand earth's carbon cycle and design ways to enhance carbon dioxide (CO_2) capture. In the long-term, they could help us stabilize atmospheric carbon dioxide to counter global warming.
- *Cleanup of the Environment* - Within 10 years advances in systems biology, computation, and technology may lead to cost-effective ways for environmental cleanup. In the long-term, new technology could save billions in waste cleanup/disposal.

Over billions of years of evolution, nature has created a remarkable array of molecular machines and complex microbial community structures with exquisitely diverse, precise, and efficient functions and controls. The goal of Genomes to Life 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 Genomes to Life will be measured by scientific breakthroughs that lead to predictive computational models for –

- Natural, multiprotein molecular machines of complex living systems.
- Complex networks that control the assembly and operation of these machines.
- The organization 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 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 Genomes to Life 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 will focus 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.

Multidisciplinary research teams funded in FY 2003 will pursue the characterization of the biochemical capabilities of microbial communities. *In FY 2004, the program will increase its emphasis on research to characterize the function and control of molecular machines and on the development of broad capabilities for large scale protein production and diverse imaging approaches for these molecular machines. In FY 2004, the program will also increase its emphasis on 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*

(dollars in thousands)

FY 2002	FY 2003	FY 2004

control and function of molecular machines and complex microbial communities. DNA sequencing for the Genomes to Life program will be conducted at the Joint Genome Institute's Production Sequencing Facility.

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

- **Human Frontiers Science** **1,000** **1,000** **0**

BER has completed its funding of the Human Frontiers Science program, an international program of collaborative research to understand brain function and biological function at the molecular level.

- **Low Dose Radiation Research** **17,291** **17,523** **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 that is critical to adequately, and appropriately, protect people and to make the most effective use of our national resources.

BER will continue to emphasize the use of new tools such as microbeam irradiators developed in the program in prior years that enable scientists to irradiate specific parts of an individual cell such as the nucleus or the cytoplasm, the use of molecular tools such as gene and protein expression chips to describe biological responses to low doses of radiation, and the characterization of individual susceptibility to radiation.

In FY 2004, emphasis will be placed on the development and use of experimental systems that enable scientists to make a transition from the use of highly quantifiable but less relevant *in vitro* systems for studying low doses of radiation to *in vivo* systems that are more relevant to human risk from exposure to low doses of radiation but in which it has been very difficult to quantify results.

BER will continue to forge closer, more 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 effect* – the response of cells that are not directly traversed by radiation but 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 LET (linear energy transfer) 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*.

(dollars in thousands)

FY 2002	FY 2003	FY 2004

- *Genomic instability* – is the loss of genetic stability, a key event in the development of cancer, induced by radiation and expressed as genetic damage that occurs many cell divisions after the insult is administered. Current evidence suggests that DNA repair and processing of radiation damage can lead to instability in the progeny of irradiated cells and that susceptibility to instability is under genetic control but there is virtually no information on the underlying mechanisms. Its role 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 if low doses of radiation induce genomic instability *in vivo*.
- *Adaptive response* – is 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 quantified and extended to *in vivo* systems.
- *Endogenous versus low dose radiation induced damage* – The program will continue to investigate the similarities and differences between endogenous oxidative damage and damage induced by low levels of ionizing radiation as well as an understanding of the health risks from both. This information was not previously attainable because critical resources and technologies were not available. Today, technologies and resources such as those developed as part of the human genome program and at the National Laboratories have the potential to detect and characterize small differences in damage induced by normal oxidative processes and low doses of radiation. Research in this aspect of the program will be concluded by the end of FY 2004.
- *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. In FY 2004, a comprehensive effort will be undertaken 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 a possibility. This will involve interactions between experimental and computational scientists and with scientists at regulatory agencies responsible for developing risk policy.

(dollars in thousands)

FY 2002	FY 2003	FY 2004

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

Human Genome **90,075** **76,805** **64,572**

In FY 2003 $13,765,000 was transferred for genomic analysis of potential biothreat agents to the Department of Homeland Security.

- **Joint Genome Institute** **57,200** **57,200** **51,480**

With the completion of the high quality DNA sequences of human chromosomes 16 and 19 in CY 2002 (with chromosome 5, DOE's share of the international effort to sequence the human genome), the Joint Genome Institute (JGI) will continue, at a reduced level, to use its DNA sequencing capacity to address the challenges of understanding the human genome, to address DOE mission needs in energy, carbon sequestration, and bioremediation, and as a resource for our Nation's scientists. *Beginning in FY 2004, the JGI will devote 60% of its sequencing capacity to peer reviewed sequencing needs of the broader scientific community, including the needs of other agencies. DNA sequencing targets will be chosen using a process of peer review of requests for sequencing submitted by individual scientists and other federal agencies. Forty percent of the JGI's DNA sequencing capacity will be 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 Genomes to Life Program are supported directly by the Genomes to Life Program and are not included in funds for the Joint Genome Institute.*

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

- **Tools for DNA Sequencing and Sequence Analysis** **30,396** **16,900** **11,245**

BER continues to develop the tools and resources needed by the scientific, medical, and private sector communities to fully exploit the information contained in the first complete human DNA sequence. As a result of the success in sequencing the human genome, several research activities were reduced or eliminated in FY 2003 (e.g., optical mapping of chromosomes, gene library preparation, gene sequencing, etc.). 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. In FY 2004, BER continues research to further improve the efficiency and cost effectiveness of its

(dollars in thousands)

FY 2002	FY 2003	FY 2004

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. In FY 2004, 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 National Laboratories, universities, and private institutions and selected through competitive and peer-reviewed processes.

- **Ethical, Legal, and Societal Issues (ELSI)** **2,479** **2,705** **1,847**

The DOE and NIH human genome programs agreed at the outset to dedicate a fraction of their human genome program funding to understanding the ELSI associated with the genome program. DOE's ELSI research program represents three percent of the DOE human genome program. The DOE ELSI program supports research focused on issues of: (1) the use and collection of genetic information in the workplace especially as it relates to genetic privacy; (2) the storage of genetic information and tissue samples especially as it relates to privacy and intellectual property; (3) genetics and ELSI education; and (4) the ELSI implications of advances in the scientific understanding of complex or multigenic characteristics and conditions.

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

A table follows displaying both DOE and NIH genome funding.

U.S. Human Genome Project Funding

(dollars in millions)

	Prior Years	FY 2002	FY 2003	FY 2004
DOE Total Funding (FY 87-01)	864.5	90.1	76.8	64.6
NIH Funding (FY 88-01)	2,241.6	431.0[a]	467.0 [a]	TBD
Total U.S. Funding	3,106.1	521.1	543.8	TBD

[a] Estimate from NIH.

	(dollars in thousands)		
	FY 2002	FY 2003	FY 2004
Health Effects	**11,732**	**10,260**	**10,260**
▪ **Functional Genomics Research**	**11,732**	**10,260**	**10,260**

Understanding the structure and function of the human genome. – Many individual genes, large families of genes, and the regulatory networks that control these genes have been conserved during evolution in organisms as diverse as yeast and humans. Thus, model organisms including *Fugu* (puffer fish), *Ciona* (sea squirt), 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, that 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. This effort is greatly enhanced by the completion of the Center for Comparative and Functional Genomics at Oak Ridge National Laboratory in FY 2003 that will serve as a national focal point for high throughput genetic studies using mice. BER creates and genetically characterizes new mutant strains of mice that serve as important models of human genetic diseases and for understanding gene function. It also develops high-throughput tools and strategies to characterize these 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. Research to develop new high-throughput strategies for using model organisms such as the mouse, *Fugu*, and *Ciona* to understand the function of human genes increases in FY 2004.

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

In FY 2003 $4,107,000 was transferred for genomic analysis of potential biothreat agents to the Department of Homeland Security.

SBIR/STTR	**0**	**4,771**	**5,267**

In FY 2002 $4,458,000 and $256,000 were transferred to the SBIR and STTR programs, respectively. FY 2003 and FY 2004 amounts are estimated requirements for continuation of these programs.

Total, Life Sciences	**186,384**	**190,878**	**201,408**

Explanation of Funding Changes

	FY 2004 vs. FY 2003 ($000)
Structural Biology	
▪ Maintain structural biology research at near FY 2003 levels.	-38
Molecular and Cellular Biology	
▪ Decrease in Microbial Genomics research decreases capability to obtain and compare microbial DNA sequences	-1,149
▪ Maintains carbon sequestration research at near FY 2003 level	-11
▪ Increase for Genomes to Life research with focus on characterization of molecular machines and on development of broad capabilities for large scale protein production and diverse imaging approaches. Increase in high throughput DNA sequencing of individual microbes and microbial communities. Funding provided for Homeland Security in FY 2003 is budgeted by the Department of Homeland Security in FY 2004.	+24,492
▪ BER Human Frontier Science Program completed ……..	-1,000
▪ Maintains Low Dose Radiation Research at near FY 2003 levels.	-27
Total, Molecular and Cellular Biology	+22,305
Human Genome	
▪ Decrease in JGI and Tools for Sequencing and Sequencing Analysis reflects completion of human DNA sequencing for the International Human Genome Program and support for DNA sequencing needs of the Genomes to Life program within that program. JGI DNA sequencing capacity is shifted to address the needs of the broader scientific community.	-11,375
▪ Decrease in ethical, legal, and societal issues program (approximately 3% of human genome funding) due to overall decrease in human genome funding	-858
Total, Human Genome	-12,233
SBIR/STTR	
Increase in SBIR/STTR due to increase in research funding for the Life Sciences program and increased STTR allocation.	+496
Total Funding Change, Life Sciences	+10,530

Climate Change Research

Mission Supporting Goals and Measures

The goal 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. 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.

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. The BER Climate Change Research subprogram (excluding the carbon sequestration element) represents DOE's contribution to the interagency U.S. Global Change Research Program proposed by President Bush in 1989 and codified by Congress in the Global Change Research Act of 1990 (P.L. 101-606). It also contributes to the Administration's Climate Change Research Initiative (CCRI).

In FY 2003, the Administration launched a new CCRI. The CCRI is a set of cross-agency programs in areas of climate change research of high priority and where substantial progress is anticipated over the next three to five years. The specific focus areas of the research are 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 2003 funding allows DOE 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 2004 ($25,335,000) BER will continue to support research to quantify the magnitude and location of the North American carbon sink, a high priority need in the interagency Carbon Cycle Science Plan and expand its CCRI research to include climate modeling, Atmospheric Radiation Measurement, and Integrated Assessment activities.

The National Institute for Global Environmental Change (NIGEC) is integrated throughout the subprogram (FY 2004 Request is $8,749,000). NIGEC regional centers are located at the University of California, Davis (Western Region), the University of Nebraska, Lincoln (Great Plains Region), Indiana University, Bloomington (Northeast Region), Tulane University, New Orleans (Southcentral Region), and the University of Alabama, Tuscaloosa (Southeastern Region). The national NIGEC center is located at the University of California, Davis.

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 the 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 Atmospheric Radiation Measurement (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 climate models and uses massively parallel 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 is focused on acquiring the data to understand the atmospheric processes that control the transport, transformation, and fate of energy-related chemicals and particulate matter emitted to the atmosphere. BER is emphasizing research on processes relating to new air quality standards for tropospheric ozone and particulate matter and relationships between air quality and climate change.

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. This research includes DOE's contribution to the Climate Change Research Initiative, an interagency effort on specific areas of climate change research in which substantial progress in understanding and modeling is expected over the next five years.

The BER 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 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 in carbon sequestration.

The Ecological Processes research is focused on experimental and modeling studies to understand and simulate the effects of climate and atmospheric changes on the biological structure and functioning of terrestrial ecosystems. The research also seeks to identify the potential feedback effect of ecosystem responses on 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.

Within Ecological Processes, new research will be initiated to develop a mechanistic understanding of how complex ecosystems respond to environmental changes, including the causal mechanisms and pathways underlying observed responses. The focus will be on documenting and understanding the causal mechanisms and pathways of biological and ecological responses ranging from the proteome of individual species to the whole ecosystem. The initial focus will be to understand the responses of a model terrestrial ecosystem containing simplified but hierarchical communities (higher plants, consumers of plant production, and soil microorganisms) to changes in a key environmental factor such

as temperature that is known to affect ecosystem functioning (e.g., carbon and nutrient cycling). Advanced biologically based computational algorithms and ecosystem models will be developed to establish whether and how changes in the proteome, in either single species or whole systems, can explain the responses and behavior of complex ecosystems.

The 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.

The Climate Change Research subprogram provides fundamental knowledge building to long-term outcomes that underpin the Program Strategic Performance Goals and the Office of Science's Strategic Objectives. 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 Climate Change Research subprogram by BERAC will be in FY 2005. The following are recent scientific accomplishments that highlight program progress.

- *Model results provide further evidence that 20th century warming is caused by greenhouse gas.* Scientists from BER's Climate Change Prediction Program have provided further evidence that the observed climate warming in the twentieth century is due to human induced forcing of the climate system. The scientists compared results from two ensembles of twentieth century climate simulations with observational temperature records. The climate forcing conditions in the climate model used to produce one ensemble included all known sources of natural variability, including temporal changes in solar output and the cooling effects of volcanic dust. A model used to produce a second series of runs also included anthropogenic effects on the atmosphere, i.e., increased greenhouse gas concentrations and aerosols. The ensemble from the model that included anthropogenic forcings closely matched the observed record and was a statistically significant 0.3 C warmer at the end of the century than the runs from the model that contained only natural variability.
- *Anomalous Absorption of Solar Radiation Question is Resolved.* BER's Atmospheric Radiation Measurement (ARM) program resolved a long-standing scientific question concerning the transfer of solar radiation through the atmosphere. A considerable body of scientific literature indicates that measurements of the absorbed solar energy in cloudy atmospheres exceed theoretical calculations. A group of papers published in 1995 claimed that the ratio of measured to calculated absorption was as large as 1.4 or 1.5. If the ratio were this large, it would require a substantive reevaluation of our understanding of atmospheric radiation physics because such a large increase could not be explained by any reasonable extrapolation of currently understood physics. To test this, the ARM Program conducted field campaigns utilizing ground and aircraft borne instruments coordinated with satellite measurements. Results show that measured solar absorption in a cloudy atmosphere is within a few to 15% of absorption computed from state-of-the-art radiative transfer models. These results indicate that anomalous absorption occurs only at the level of 15% or less and can be explained by conventional atmospheric physics.

- *ARM Develops New Parameterization for Ice Crystals in Cirrus Clouds.* Using detailed information from the Atmospheric Radiation Measurement (ARM) site in the Southern Great Plains, ARM researchers have improved how the scattering of sunlight by ice crystals in cirrus clouds is represented in models. The new parameterization was incorporated into a model that simulates the atmosphere over the ARM site. Actual measurements from the ARM sites were used to assess the realism of the model simulations, and the model version that used the new treatment showed excellent agreement. Comparison between the new model and a numerical weather forecasting model with observations also shows that the new model is more accurate. The use of the new cloud parameterization improved the computed rates at which the atmosphere cools radiatively by as much as 20 percent when averaged over a season. Larger improvements occurred for specific days.
- *New Understanding of Air Pollution Phenomena Leads to Advances in Air Pollution Control Strategies.* Through coordinated field research, laboratory measurements, and modeling studies in a variety of areas around the U.S. such as Nashville, Phoenix, Salt Lake City, and Houston, the Atmospheric Sciences Program (ASP) provided new insights into the diversity of factors that affect air quality and showed that a "one-approach-fits-all" strategy for air quality management does not work. The research demonstrated that reducing industrial emissions of volatile organic compounds in Houston could reduce ozone concentrations there, but this strategy would be less effective in the southeastern U.S., where reactive volatile organic compounds tend to be dominated by natural emissions from vegetation. In Phoenix, on the other hand, emissions of hydrocarbons from vegetation and industrial sources are minimal, so the focus should be on reducing emissions from vehicles. Since most of the emissions associated with energy production and use are to the atmosphere, understanding how such emissions are transported, transformed, and removed from the atmosphere is essential for understanding their environmental consequences, in terms of air quality, climate change, and health effects. Research results from the Atmospheric Science Program are provided well beyond the research community, both to industry and to state authorities for use in assessing and developing air pollution control strategies.
- *New Method Developed for Measuring Total Soil Carbon.* Laser-induced breakdown spectroscopy (LIBS) is a new method for measuring soil carbon content that significantly advances research on the cycling and sequestration of carbon in soil. LIBS was developed by researchers at the Los Alamos National Laboratory and further tested by ORNL and USDA/ARS Laboratories The method directly measures soil carbon by "shooting" a small laser beam into the soil matrix in the field, and spectra of soil organic matter broken down by the laser are resolved to estimate the quantity of carbon present in the soil matrix. LIBS analyzes the sample in less than one minute, and results exhibit excellent precision and accuracy when correlated with conventional dry-combustion techniques for measuring soil carbon content. The field-portable LIBS device has been tested with a number of natural soil configurations and morphologies, and has been found to perform faster and more efficiently than conventional approaches. LIBS offers the potential of revolutionizing soil carbon measurement, where fast determinations are useful for many practical applications of soil carbon inventory, management and sequestration. Research is continuing jointly with the USDA to determine effects of other soil properties such as texture, mineralogy and moisture content on performance of LIBS.

- *Iron Fertilization Makes Ocean Bloom.* The Southern Ocean Fertilization Experiment (SOFeX) jointly funded by BER and the National Science Foundation demonstrated that carbon fixation by ocean phytoplankton in the Southern Ocean south of New Zealand is iron limited and can be enhanced by fertilizing ocean surface water with iron. Data from SOFeX demonstrate that iron fertilization may offer a potential approach for enhancing carbon sequestration in the ocean by increasing the rate of carbon fixation by ocean phytoplankton. The SOFeX data will be used to constrain estimates of the amount of carbon in particles, including phytoplankton that is exported downward into the deep ocean where it is isolated from the atmosphere, a prerequisite for ocean carbon sequestration. In January-February 2002, over 100 scientists and 3 research vessels fertilized the surface ocean water in two 15 square kilometer study areas with dissolved iron and inert chemical tracers. The latter was to tag the ocean water in the two areas fertilized so as to be able to distinguish the areas and volumes of water fertilized from those not fertilized. Addition of the iron produced a bright green phytoplankton bloom in the two areas fertilized that could be seen from space by ocean color satellites, evidence that the addition of iron enhances the growth and carbon fixation by phytoplankton in the Southern Ocean.

- *First Field Test of Multiple Ecological Models with Three Years of Independent Data.* BER's Program on Ecosystem Research recently completed a rigorous evaluation and testing of nine terrestrial ecosystem models in collaboration with NASA, NSF, and the Canadian government by comparing model simulations with independent field data. It was discovered that more complex models tended to provide more accurate predictions of short-term (i.e., daily) water and carbon dioxide exchange rates, but that model complexity was apparently unrelated to accuracy of monthly and annual predictions. This type of model evaluation is essential to understanding uncertainties and limitations of ecological models used to predict and assess effects of global and regional environmental changes on the structure and functioning of terrestrial ecosystems. Several model improvements have already resulted from this work.

  The models (which represented a wide range of model complexity) were compared to three years of field data collected on ecosystem water use, net primary production, gross primary production, net ecosystem production, and soil carbon dioxide release in a boreal spruce forest. This was the most extensive test of forest ecosystem models using independent field data conducted to date, and represented forest responses to natural climatic variability in interior Canada.

Subprogram Goals

Determine the response of the Earth system to different levels of greenhouse gases in the atmosphere.

Performance Indicator

Climate model resolution.

Annual Performance Results and Targets

FY 2002 Results	FY 2003 Targets	FY 2004 Targets
(Climate and Hydrology) A new coupled model was released in May 2002, with an average resolution of 280 km in the atmosphere and 60 km in the ocean. The previous version had a resolution of 280 km and 200 km, respectively. An 800-year equilibrium climate simulation was executed at the National Energy Research Supercomputer Center. [Goal Met] Addition of new cloud submodel for cirrus clouds improved climate model computed rates at which atmosphere cools radiatively by 20%. [Goal Met]	(Climate and Hydrology) Increase the realism of the coupled modeling system through both increases in spatial resolution and improvements in the physical parameterizations. More objective and systematic methods for evaluating model performance will be implemented and applied to the model components (atmosphere, ocean, land and sea ice) as well as to the coupled modeling system. Model productivity will be increased by completing a larger number of scenarios of climate change forcing and making the results available to researchers in the broader community. This will be made possible by a significant effort in software engineering and algorithm development so that the model is able to exploit new computing technology rapidly and efficiently.	(Climate and Hydrology) By the end of 2004, incorporate climate data rapidly into climate models to allow testing of the performance of submodels (e.g., cloud resolving module) and model parameters by comparing model simulations with real world data from the ARM sites**.**
(Atmospheric Chemistry & Carbon Cycle) Coordinated field and laboratory measurements and modeling experiments in diverse regions demonstrate that regional air quality management strategies must be designed for the specific regional environment, e.g., one size does not fit all. [Goal Met]	(Atmospheric Chemistry & Carbon Cycle) Evaluate preliminary findings from field measurement campaigns in both atmospheric chemistry and environmental meteorology and the extent to which scientific results are incorporated into models to predict and assess air quality. Produce quality micrometeorological data, net carbon dioxide exchange data, and biometric data from 20 of 45 active AmeriFlux sites, and synthesize results from these sites.	(Atmospheric Chemistry & Carbon Cycle) The program will incorporate respiration functions into biophysical carbon cycle models for terrestrial ecosystems calculating carbon exchange for three woody ecosystems. Independent data will be used to evaluate model improvement.
Data from the Southern Ocean Iron Fertilization Experiment demonstrated that iron added to the ocean may enhance carbon sequestration by ocean phytoplankton. [Goal Met]	Analyze and publish results from the Southern Ocean Iron Fertilization Experiment (SOFeX) that will study the export of particulate organic carbon below the mixed layer in high and low silicate waters following the experimental addition of iron to a large area of the ocean's surface.	Data from the Southern Ocean Iron Fertilization Experiment (SOFEX) will be incorporated into coupled biogeochemical models to evaluate the effectiveness of ocean fertilization as a carbon sequestration strategy. New field studies will be initiated to examine the fate of carbon exported from the surface ocean to intermediate depths (100m-1000m) and the carbon sequestration potential.

FY 2002 Results	FY 2003 Targets	FY 2004 Targets
New method developed for measuring soil carbon will provide faster and more accurate measurement of soil carbon, data that are needed for carbon cycle modeling in diverse ecosystems. [Goal Met]	Apply an ecosystem framework to estimate annual rates of actual carbon gain by vegetation and soil. Enhanced sequestration will be estimated relative to baseline carbon quantities established for the range of ecosystems investigated by the CSiTE Consortium.	CSiTE will estimate the biophysical potential of terrestrial carbon sequestration for one specific region of the U.S. New field data, analysis of full carbon accounting, and improved carbon cycle models will demonstrate how existing carbon stocks of terrestrial vegetation and soil could be increased.
(Ecological Processes)	(Ecological Processes)	(Ecological Processes)
Nine ecological models tested with three years of independent field data provide the framework for understanding model limits for predicting ecosystem responses to environmental change. [Goal Met]	Complete synthesis of data collected during 8-9 years of a unique experimental manipulation of precipitation received by a large-statured forest on the Oak Ridge reservation in a published book. This will include using the data collected in the experiment to evaluate (test) up to 15 ecosystem models.	Establish a model terrestrial ecosystem in a controlled and controllable environment that contains simplified but hierarchical communities (higher plants, consumers of plant production, and soil microorganisms) and begin the characterization of the proteome of the major species.
(Human Interactions)	(Human Interactions)	(Human Interactions)
Integrated assessments provided a basis for quantifying the potential significance of enhancing carbon sequestration in terrestrial ecosystems, ocean, and/or geologic formations with the goal of reducing CO_2 concentrations. Sequestration strategies that have limited lifetimes, either because of constraints on the amount of carbon sequestered or on the expected residence time before re-release, can be compared economically with other strategies that may be more expensive, such as premature replacement of capital stocks. [Goal Met] 15 undergraduate summer fellowships were awarded. In addition, 27 graduate students were supported, 7 first year, 6 second year, 7 third year, and 7 fourth year students. All granduate and undergraduate students worked with DOE-funded scientists and/or at DOE facilities. [Goal Met]	Integrate a new land and ocean carbon sub-model in one of the two large integrated assessment models. 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 change will ensure consistent accounting of carbon-sink projects and the carbon uptake that occurs as a result of other land-use change and the effects of climate change and carbon fertilization. The other integrated assessment model will 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.	Performance will be measured by the sustaining the number, quality, and diversity of students enrolled in the program and by end-of-summer evaluations by students and their mentors.

FY 2002 Results	FY 2003 Targets	FY 2004 Targets
	Performance will be measured by the number, quality, and diversity of students enrolled in the program and by end-of-summer evaluations by students and their mentors.	

Manage all BER facility operations to the highest standards of overall performance, using merit evaluation with independent peer review.

Performance Indicator

Average operational downtime of BER facilities will not exceed 10% of total time scheduled.

Annual Performance Results and Targets

FY 2002 Results	FY 2003 Targets	FY 2004 Targets
(Climate and Hydrology) ARM instruments averaged over a 95% up time in 2002 and successfully completed 7 IOP's. [Goal Met]	(Climate and Hydrology) Achieve a downtime of less than five percent for the principal ARM instruments and successfully conduct five IOPs across the three ARM sites.	(Climate and Hydrology) Achieve a downtime of less than five percent for the principal ARM instruments and successfully conduct five IOPs across the three ARM sites.

Funding Schedule

(dollars in thousands)

	FY 2002	FY 2003	FY 2004	$ Change	% Change
Climate and Hydrology	70,353	74,669	74,559	-110	-0.1%
Atmospheric Chemistry and Carbon Cycle	34,735	37,764	37,707	-57	-0.2%
Ecological Processes	12,817	13,888	18,726	+4,838	+34.8%
Human Interaction	7,942	8,084	8,071	-13	-0.2%
SBIR/STTR	0	3,554	3,896	+342	+9.6%
Total, Climate Change Research	125,847	137,959	142,959	+5,000	+3.6%

Detailed Program Justification

	(dollars in thousands)		
	FY 2002	FY 2003	FY 2004
Climate and Hydrology	**70,353**	**74,669**	**74,559**
▪ **Climate Modeling**	**26,999**	**27,181**	**27,138**

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 the inadequacy of 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 2004, 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 and application through the use of collaboratory technologies. 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.

For CCRI the research will provide ensemble projections of multi-century climate change using the Community Climate System Model through the Climate Change and Assessment Working Group. Additionally, the program will provide the infrastructure for major model evaluation and model improvement research through the coordination of model intercomparisons and the maintenance of model testbeds for parameterization testing. In FY 2004 ($15,347,000) climate model experiments will provide scenarios, such as carbon dioxide (CO_2) stabilization scenarios.

In FY 2004 BER's SciDAC program ($7,776,000) is focused on improving the models used for climate simulation and prediction. A major effort is dedicated to providing a robust and extensible software engineering framework for the Community Climate System Model, 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 at private institutions and are selected through competitive and peer-reviewed processes.

In FY 2004, NIGEC will continue to support research to evaluate the reliability of using isotopic signatures of trace gases in ice cores for interpreting past climate variation and change and the relationship between greenhouse gas concentrations and climate change (FY 2004 Request is $2,187,000).

- **Atmospheric Radiation Measurement (ARM) Research** **13,310** **13,310** **13,247**

In FY 2004, 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 testbed initiated in FY 2003 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.

- **Atmospheric Radiation Measurement (ARM) Infrastructure** .. **27,306** **31,441** **31,441**

In FY 2004, the Atmospheric Radiation Measurement (ARM) infrastructure program will continue to develop, support, and maintain the three ARM sites and associated instrumentation. BER will continue to operate over two hundred instruments (e.g., multifilter shadowband 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 site and will continue operations at the Tropical Western Pacific station and at the North Slope site in Alaska. The ARM program will continue to provide data to the scientific community through the ARM Archive.

(dollars in thousands)

FY 2002	FY 2003	FY 2004

The ARM data streams will continue to be enhanced periodically by additional measurements at the ARM sites 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 sites 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 sites to "ground truth" their satellite instruments.

The UAV program will conduct a major field campaign in conjunction with the ARM program 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 deploy a mobile climate observatory to provide new atmospheric measurements needed to fill data gaps and will develop the corresponding data products needed for evaluating and modeling the effects of atmospheric processes and properties on the radiation balance and for developing and evaluating the models. In FY 2004 ($4,100,000) a mobile Cloud and Radiation Testbed (CART) facility will be deployed 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). The mobile site will be instrumented for cloud and radiation measurements. The primary siting criterion is to provide those measurements needed to address specific modeling needs that presently cannot be addressed by the permanent ARM sites. Activities will be 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 2004 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 at private institutions and are selected through competitive and peer-reviewed processes.

- **Atmospheric Radiation Measurement (ARM)/Unmanned Aerial Vehicles (UAV)** **2,738** **2,737** **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.

	(dollars in thousands)		
	FY 2002	FY 2003	FY 2004
Atmospheric Chemistry and Carbon Cycle	**34,735**	**37,764**	**37,707**
▪ **Atmospheric Science**	**13,161**	**12,571**	**12,551**

The Atmospheric Science project will continue to acquire data to understand the atmospheric processes that control the transport, transformation, and fate of energy-related chemicals and particulate matter. Emphasis is placed on processes relating to new air quality standards for tropospheric ozone and particulate matter and relationships between air quality and climate change. Field and laboratory studies will continue to be conducted in both atmospheric chemistry and environmental meteorology and acquired data will be used to develop and validate predictive models of atmospheric processes. The research will include studies of chemical and physical processes affecting air pollutants such as sulfur and nitrogen oxides, tropospheric ozone, gas-to-particle conversion processes, and the deposition and resuspension of associated aerosols. It also includes 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 involves multi-agency collaboration, and university scientists play key roles. New information will document both the contribution of energy production to regional haze in the U.S. and the relationship between urban and regional air pollution processes and continental, intercontinental, and global scale phenomena. The information is essential for assessing the effects of energy production on air quality and will contribute to the evaluation of science-based options for minimizing the impact of energy production on visibility.

In FY 2004 BER will continue the Tropospheric Aerosol Program (TAP) to quantify the impacts of energy-related aerosols on climate, air quality, and human health. TAP will be closely coupled with other components of DOE's climate change research, especially the Atmospheric Radiation Measurement (ARM) program. TAP will also be broadly coordinated with the air quality and global change research communities, including collaborations with the EPA, NASA, and 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 air quality and climate.

In FY 2004 the Atmospheric Sciences subprogram will, in general, focus on the evaluation of findings from field measurement campaigns in both atmospheric chemistry and environmental meteorology.

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

In FY 2004, NIGEC will support research to quantify the effects of natural processes on atmospheric composition, including the exchange of energy-related trace gases between the atmosphere and the terrestrial biosphere (FY 2004 Request is $2,187,000).

(dollars in thousands)

FY 2002	FY 2003	FY 2004

- **Terrestrial Carbon Processes and Ocean Sciences** **13,056** **16,636** **16,613**

  In FY 2004, BER will continue supporting the AmeriFlux program, a network of approximately 25 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 fluxes of other greenhouse gases, e.g., methane and nitrous oxide, will also be measured at 5 to 10 AmeriFlux sites.

  BER will also continue research to refine and test carbon cycle models (based on mechanistic representations and carbon accounting). The models will be used to estimate potential carbon sequestration in response to changes in environmental factors, including climate.

  The continuing focus of the ocean science element is on using microbiology 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 University, U. of South Florida, Princeton University), and institutions traditionally serving minority students (such as Lincoln U., Howard U., Savannah State U., U. of Puerto Rico, and San Francisco State).

  In FY 2004 (FY 2003 $2,920,000; FY 2004 $2,916,000) 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 2004 the research will deliver an intercomparison of estimates of the net annual exchange of CO_2 between terrestrial ecosystems and the atmosphere for a region of the U.S. with independent estimates using atmospheric sampling and inverse modeling.

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

	(dollars in thousands)		
	FY 2002	FY 2003	FY 2004

- **Carbon Sequestration Research** **8,518** **8,557** **8,543**

  In FY 2004, BER will continue support for one carbon sequestration research consortium, led by ORNL, PNNL, and ANL, and involving six collaboratory universities, that focuses on terrestrial sequestration, Carbon Sequestration in Terrestrial Ecosystems (CSiTE) ($3,000,000). The consortium develops the information to enhance the natural sequestration of carbon in terrestrial soils and vegetation. BER will also continue the support of research at universities and DOE laboratories on ocean carbon sequestration ($2,000,000). The focus of the research on terrestrial and ocean sequestration will continue to be on cellular and biogeochemical processes that control the rate and magnitude of carbon sequestration in terrestrial and oceanic systems, including the identification of pathways and processes that could be modified to enhance the net flow of carbon from the atmosphere to terrestrial plants and soils, and to the ocean surface and, ultimately, to the deep ocean. Also, BER will support the research needed to assess the environmental implications of enhancing carbon sequestration and storage in the ocean and in terrestrial systems. BER research on carbon sequestration in terrestrial ecosystems will improve the scientific understanding of mechanisms of sequestration and how to alter them to enhance sequestration. The CSiTE activity will conduct research that specifically examines those plant and soil processes that capture and retain carbon in chemical and physical forms that are resistant to decay. The data will inform new models for estimating carbon sequestration in terrestrial ecosystems. New technologies will be developed by the BER-supported ocean carbon sequestration research to facilitate the export of carbon to the deep ocean and for re-mineralization of organic carbon at depth. Such technologies are vital to assessing accurately the potential of enhancing ocean carbon sequestration. Initial *in situ* experiments will be designed to determine the feasibility and potential environmental impacts of deep ocean injection of carbon dioxide (CO_2). Associated research will include determination of chemical reactions at depth, stability of products, and effects of those products on marine organisms.

  In FY 2004, university scientists will continue the analyses of research results on the effects of iron fertilization on plankton communities in the Southern Ocean. The ocean surrounding Antarctica is the largest high-nutrient, low-chlorophyll region in the world. The joint DOE-NSF Southern Ocean Iron Enrichment Experiment (SoFEX) will help scientists understand the potential to enhance ocean carbon sequestration through iron enrichment.

Ecological Processes **12,817** **13,888** **18,726**

In FY 2004, new ecological research will be initiated 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 initially 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 at Duke University (North Carolina), Rhinelander (Wisconsin), Oak Ridge (Tennessee), and Mercury (Nevada) on the Nevada Test Site to improve understanding of the direct effects of elevated carbon dioxide and other atmospheric changes 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 elevated productivity of terrestrial plants exposed to elevated atmospheric carbon dioxide (CO_2) concentrations.

The long-term experimental investigation at the Walker Branch Watershed in Tennessee will continue to improve the understanding of the direct and indirect effects of alterations in the annual average precipitation 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 develop new instrument methodologies and test scientific hypotheses related to ecosystem responses, including carbon sequestration, to climate and atmospheric changes.

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

In FY 2004, NIGEC will support experimental studies to document how climate warming and increasing CO_2 levels in the atmosphere affect biophysical processes in terrestrial ecosystems (FY 2004 Request is $2,625,000).

Human Interactions	**7,942**	**8,084**	**8,071**
▪ **Human Interactions**	**7,942**	**8,084**	**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 alternate 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. This representation will include both options to enhance natural carbon storage in the terrestrial biosphere, as well as engineering options, such as the capture of carbon dioxide and storage in geologic formations.

The research will include integrating a new land and ocean carbon sub-model 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 change 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.

In FY 2004, NIGEC will support research to develop and test new methods involving the use of large regional databases and coupled climate-impact-economic models to conduct integrated assessments of the effects of climate change on regionally important resources in the U.S. (FY 2004 Request is $1,750,000).

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 2004 ($2,972,000) the Integrated Assessment program will produce at least four scenarios to provide alternatives to the scenarios that were published by the Intergovernmental Panel on Climate Change. These scenarios will include forecasts of such items as economic productivity, population, and energy use by global region. They will serve as input to the Integrated Assessment Models and will be used as input to decision support analysis in the new CCRI.

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), the DOE Graduate Research Environmental Fellowships (GREF), and collaboration with the NSF Significant Opportunities in Atmospheric Research and Science (SOARS) program.

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

	(dollars in thousands)		
	FY 2002	FY 2003	FY 2004
SBIR/STTR	**0**	**3,554**	**3,896**
In FY 2002 $3,152,000 and $188,000 were transferred to the SBIR and STTR programs, respectively. FY 2003 and FY 2004 amounts are the estimated requirements for continuation of these programs.			
Total, Climate Change Research	**125,847**	**137,959**	**142,959**

Explanation of Funding Changes

	FY 2004 vs. FY 2003 ($000)
Climate and Hydrology	
▪ Held at near FY 2003 level. Change is due to increase in STTR allocation	-110
Atmospheric Chemistry and Hydrology	
▪ Held at near FY 2003 level. Change is due to increase in STTR allocation.	-57
Ecological Processes	
▪ The increase will support new research on scaling from the molecular level in individual organisms up to the aggregate ecosystem scale. The focus is on research to understand and model how complex ecosystems respond to the environment, including the causal mechanisms and pathways underlying observed responses, ranging from the proteome of individual species to the whole system. Tools and principles developed from this research will have 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 perturbations caused by energy production and use.	+4,860
▪ Traditional Ecological Processes research held at near FY 2003 levels.	-22
Total, Ecological Processes	+4,838
Human Interactions	
▪ Held at near FY 2003. Decrease is due to increase in STTR allocation	-13

	FY 2004 vs. FY 2003 ($000)
SBIR/STTR	
▪ Increase in SBIR/STTR due to increase in STTR allocation and increase in research funding for the Climate Change Research program.	+342
Total Funding Change, Climate Change Research	+5,000

Environmental Remediation

Mission Supporting Goals and Measures

The mission of the Environmental Remediation subprogram is to deliver the scientific knowledge, technology and enabling discoveries in biological and environmental research to reduce the costs, risks, and schedules associated with the cleanup of the DOE nuclear weapons complex; to extend the frontiers of biological and chemical methods for remediation; to discover the fundamental mechanisms of contaminant transport in the environment; to develop cutting edge molecular tools for investigating environmental processes; and to 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 to the development advanced nuclear waste management approaches and predicting and avoiding environmental hazards for future nuclear energy options.

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) and the Savannah River Ecology Laboratory (SREL).

Bioremediation activities are centered on the Natural and Accelerated Bioremediation Research (NABIR) program, a basic research program focused on determining how and where bioremediation may be applicable as a reliable, efficient, and cost-effective technique for cleaning up or containing metals and radionuclides in contaminated subsurface environments. In the NABIR program, research advances will continue to be made from molecular to field scales in the Biogeochemical Dynamics element; on genes and proteins used in bioremediation through the Biomolecular Science and Engineering element; in non-destructive, real-time measurement techniques in the Assessment element; in overcoming physico-chemical impediments to bacterial activity in the Acceleration element; on species interaction and response of microbial ecology to contamination in the Community Dynamics and Microbial Ecology element; and in understanding microbial processes for altering the chemical state of metallic and radionuclide contaminants through the Biotransformation element. In analogy with the Ethical, Legal, and Social Implications component of the Human Genome program, the Bioremediation and its Societal Implications and Concerns component of NABIR is exploring societal issues surrounding bioremediation research and promoting open and interactive communication with stakeholders to help ensure understanding and acceptance of bioremediation as a potential solution to remediating contaminants. All NABIR elements and EMSL activities have a substantial involvement of academic scientists.

The Clean Up Research and Environmental Management Science Programs (EMSP) focus on a variety of solutions for the DOE weapons complex cleanup effort. Three primary elements include: contaminant fate and transport in the subsurface, nuclear waste chemistry and advanced treatment option, and novel characterization and sensor tools. In addition, studies on bioremediation of organic contaminants are conducted in EMSP, complementing the NABIR program, which focuses on metals and radionuclides. This program works closely with related programs in the Basic Energy Sciences program and with related programs of other agencies. The SREL is managed through a cooperative

agreement with the University of Georgia and performs ecological research aimed at ensuring that environmental cleanup operations do not disturb the biodiversity at the restored environment.

Within Facility Operations, support of the EMSL national user facility operations is focused on providing advanced molecular tools to the scientific community in such areas as environmental remediation sciences, biology and genomics, and atmospheric science. In FY 2004, unique EMSL facilities, such as the newly upgraded Molecular Science Computing Facility, the new (in FY 2003) 900 MHz NMR, and the High-Field Mass Spectrometry Facility will expand both their scientific scope and their user base.

The Environmental Remediation subprogram provides fundamental knowledge building to long-term outcomes that underpin the Program Strategic Performance Goals and the Office of Science's Strategic Objectives. Periodic retrospective analysis will be employed to evaluate the accumulation of knowledge and validate specific outcomes. This program was reviewed as part of a BERAC review of the entire BER program in FY 2001. The next scheduled comprehensive review of the Environmental Remediation Sciences subprogram by BERAC will be in FY 2003. The following are recent scientific accomplishments that highlight program progress.

- *EMSP Project Results in Commercialized D&D Tool for use at DOE Sites.* An Environmental Management Science Program project "Atmospheric-Pressure Plasma Cleaning of Contaminated Surfaces" has just been licensed and is being commercialized by APJet Inc. The project, collaboration between Los Alamos National Laboratory (LANL) and University of California, Los Angeles (UCLA), began at LANL out of basic research on cold plasmas at atmospheric pressures. The commercialized product will be used for removing contaminants from surfaces during D&D operations at DOE sites.
- *Theoretical Work Results in Advanced Separations Agents for Nuclear Wastes.* Using theoretical methods and the computing capabilities at EMSL, a new class of designer molecules that are highly organized for selective complexation with transuranic elements has been designed. In this EMSP project, preliminary experimental results suggest that these new molecules, called bicyclic diamides exhibit distribution coefficients for certain transuranics that are 10 *million times* larger than conventional diamides used in the current Purex process for separating transuranics from high-level nuclear waste media.
- *Some Microorganisms can "sniff out," produce flagella, and swim toward metal oxides.* Natural and Accelerated Bioremediation Research Program *(*NABIR) funded studies show that microorganisms that use insoluble metal oxides to drive energy metabolism play important roles in the bioremediation of metal and organic contaminants in groundwater. Although iron oxides are often present in subsurface environments, microbes must find and access these insoluble substrates to live. A surprising finding in the genetic code of a common bacterium, *Geobacter*, led to the discovery of an unusual strategy for survival in subsurface environments. The genome of *Geobacter metallireducens* was sequenced through the Microbial Genome Program at the Joint Genome Institute. The sequence data revealed that *Geobacter,* previously thought to be immobile, can produce flagella that allow it to swim toward metal oxides. Thus, *Geobacter* appears to have a built-in sensor that allows it to "sniff out" and find metals oxides. *Geobacter* is of great interest to the DOE because it can precipitate uranium, and therefore offers a potentially efficient and economic solution to removing uranium from contaminated groundwater through *in situ* immobilization.

- *Innovative Sensors for Field Detection of Environmental Contaminants Developed*. A novel handheld sensor for detecting uranium in the environment has been developed in the NABIR program using a monoclonal antibody with specificity for uranium and an instrument developed by Sapidyne Instruments, Inc. The prototype "immunosensor" has been shown to detect soluble uranium oxide at extremely low concentrations (2.5 to 24 ppb). These portable sensors yield reliable data in real time (< 1 hour), are field ready (simple, durable, accurate) and inexpensive (<$5,000 per instrument). Work is underway to develop new monoclonal antibodies for chromium and mercury for detection in the environment.
- *EMSL Users and Scientists Conduct Computational Science Studies with New Linux-Based Supercomputer* - A new 8.3 teraflop, Linux-based supercomputer at the EMSL has been made available for grand challenge teams of scientists to apply computational science to study complex chemical problems that form the basis for new discoveries in areas such as subsurface transport, atmospheric chemistry, materials design, life sciences and systems biology, and combustion. The new massively parallel system is more than 30 times faster, has 50 times more disk space and holds 10 times as much memory as EMSL's original supercomputer.
- *900 MHz Nuclear Magnetic Resonance (NMR) Spectrometer at the EMSL Provides Improved Resolution of Protein Structures* - EMSL users and scientists are obtaining high resolution data on the atomic structures of large and unstable proteins using EMSL's 900 MHz wide-bore NMR. Because certain types of proteins are difficult to crystallize, and therefore not amenable to structure determination using DOE's light sources, the EMSL's 900 MHz NMR is proving to be the only alternative to resolving the structure of these "difficult" proteins. In addition, because the proteins are examined in a solution state, the resolved structures may be more "realistic" than crystallized samples.

Subprogram Goals

Develop and demonstrate novel solutions to DOE's most challenging problems, including 1) in situ treatment of contaminant plumes such as bioremediation and environmental reactive barriers, 2) new treatment options for complex wastes, 3) novel disposal options for complex wastes (e.g. alternative to borosilicate glass); cost-effective contaminant plume characterization and monitoring techniques for long-term stewardship of sites, 5) improved predictive capabilities for contaminant fate and transport, and 6) basis for accurate assessment of risk factors.

Performance Indicator

Advanced environmental cleanup approaches delivered.

Annual Performance Results and Targets

FY 2002 Results	FY 2003 Targets	FY 2004 Targets
(NABIR & Bioremediation Research) Using data from genomic sequences of key bioremediation microorganisms such as *Geobacter, Deinococcus* and *Shewanella*, a molecular level understanding of the detection and transformation of metals and radionuclides is being achieved. Physiological studies of microorganisms have shown that common soil microorganisms produce organic compounds that interact with radionuclides, including plutonium. Research at Uranium Mill Tailings Remedial Action sites has demonstrated the potential to use biostimulation to reduce and immobilize uranium in the subsurface. In partnership with EM-50, two new projects have been initiated at Hanford to study the use biostimulation (addition of nutrients) to remove chromium and technetium from ground water. [Goal Met]	(NABIR & Bioremediation Research) Complete two critical field experiments at the NABIR Field Research Center near the Y-12 area at the Oak Ridge Reservation. The first experiment will use "push-pull" technology to probe the structure and function of undisturbed microbial communities in the subsurface contaminated with uranium and nitrate. This will be the first time this new technology has been tested in a radionuclide-contaminated site. The second experiment will provide valuable information on the use of bioremediation to remove uranium from groundwater in which nitrate is a co-contaminant-- a common problem at DOE sites Demonstrate, in partnership with the Office of Environmental Management, the reliability of new biologically based technologies for monitoring radionuclides contaminants and the microbial communities that can bioremediate those contaminants. These include antibody-based sensors for detecting uranium and certain metals, as well as nucleic acid based technologies for assessing the structure and function of microbial communities in contaminated environments.	(NABIR & Bioremediation Research) By the end of FY 2004, demonstrate whether certain nutrient additions stimulate subsurface microorganisms to immobilize uranium, thereby reducing its concentration and transport in soil water and groundwater. The field experiment will be in a contaminated subsurface environment where the co-contaminant nitrate is also present and will confirm the potential of biotechnology for environmental remediation of radionuclides**.** Successful demonstrate, in partnership with the Office of Environmental Management's Science and Technology program, the reliability of new biologically based technologies for monitoring radionuclide contaminants and the microbial communities that can bioremediate those contaminants. These include antibody-based sensors for detecting uranium and certain metals, as well as nucleic acid based technologies for assessing the structure and functioning of microbial communities in contaminated environments.
(Environmental Management Science Program) Performed analysis of program scope and management and developed a strategic plan for incorporating EMSP into Environmental Remediation Sciences in preparation for the FY 2003 transfer from the Office of Environmental Management as requested in the President's FY 2003 budget. [Goal Met]	(Environmental Management Science Program) Begin integration of EMSP into Environmental Remediation Sciences, including coordination with ongoing NABIR research. Develop two new activities with EMSP: (1) develop plan with SRS and EMSP investigators for a Bioremediation Project at the Savannah River Site. Assess the needs for user facilities and capabilities for	(Environmental Management Science Program) Complete integration of EMSP into Environmental Remediation Sciences, including coordination with ongoing NABIR research. Initiate R&D projects to support SRS Bioremediation Project. Start development of user facility enhancements.

FY 2002 Results	FY 2003 Targets	FY 2004 Targets
	environmental research, including the synchrotron light sources, neutron scattering facilities, and computation centers.	
(Savannah River Ecology Laboratory)	(Savannah River Ecology Laboratory)	(Savannah River Ecology Laboratory)
Performed analysis of program scope and management and developed strategic plan for incorporating SREL into Environmental Remediation Sciences in preparation for the FY 2003 transfer from the Office of Environmental Management as requested in the President's FY 2003 budget. [Goal Met]	Develop a plan, working with the University of Georgia and the Savannah River Site to increase the scope of ecology research and education programs at SREL.	Initiate new peer reviewed ecology research programs at the Savannah River site and new education programs at SREL.

Manage all BER facility operations to the highest standards of overall performance, using merit evaluation with independent peer review.

Performance Indicator

Average operational downtime of BER facilities will not exceed 10% of total time scheduled.

Annual Performance Results and Targets

FY 2002 Results	FY 2003 Targets	FY 2004 Targets
(Environmental Molecular Sciences Laboratory)	(Environmental Molecular Sciences Laboratory)	(Environmental Molecular Sciences Laboratory)
First phase of new high performance computer delivered and meeting performance benchmarks, achieving 1 Tflop in FY 2002. The number of FY 2002 users increased by approximately 10% over FY 2001. Unscheduled downtimes on the major instrument / computer systems did not exceed 10%. Successful receipt and testing of the 900 MHz NMR was completed. [Goal Met]	(1) Initiate operation of a new high performance computer at the EMSL reaching 9 Tflop performance and (2) unscheduled operational downtime on EMSL instrumentation and computational resources will not exceed 10 percent.	(1) Full operation at 9 Tflop of the new supercomputer at the EMSL and (2) unscheduled operational downtime on EMSL instrumentation and computational resources not to exceed 10 percent.

Funding Schedule

(dollars in thousands)

	FY 2002	FY 2003	FY 2004	$ Change	% Change
Bioremediation Research	29,320	30,700	29,867	-833	-2.7%
Clean Up Research	44,915	38,190	39,470	+1,280	+3.4%
Facility Operations	37,614	37,948	37,138	-810	-2.1%
SBIR/STTR	0	2,692	2,845	+153	+5.7%
Total, Environmental Remediation	111,849	109,530	109,320	-210	-0.2%

Detailed Program Justification

(dollars in thousands)

	FY 2002	FY 2003	FY 2004
Bioremediation Research	**29,320**	**30,700**	**29,867**
▪ **NABIR and Bioremediation Research**	**23,365**	**24,720**	**24,097**

In FY 2004, NABIR will continue to increase the understanding of the intrinsic bioremediation (natural attenuation) of DOE relevant metal and radionuclide contaminants, as well as of manipulated, accelerated bioremediation using chemical amendments. Laboratory and field experiments will be conducted to explore the fundamental mechanisms underlying chemical processes and complexation/transformation of contaminants. The NABIR Field Research Center is in operation at the Oak Ridge National Laboratory. Field site characterization of this Field Research Center and distribution of research samples to investigators will continue. In FY 2004, science elements in the NABIR program continue fundamental research on the following subjects: (1) Biotransformation (microbiology to elucidate the mechanisms of biotransformation of metals and radionuclides); (2) Community Dynamics and Microbial Ecology (structure and activity of subsurface microbial communities); (3) Biomolecular Science and Engineering (molecular and structural biology to enhance the understanding of bioremediation and identify novel remedial genes); (4) Biogeochemical Dynamics (dynamic relationships among *in situ* geochemical, geological, hydrological, and microbial processes); and (5) Assessment (measuring and validating the biological and geochemical processes of bioremediation). University scientists continue to form the core of the NABIR science team that networks with the broader academic community as well as with scientists at the National Laboratories and at other agencies.

The NABIR Field Research Center (FRC) is located near the Y-12 area at the Oak Ridge Reservation and is the site of field-scale, hypothesis-driven research on the bioremediation of metals and radionuclides. Researchers are characterizing and modeling the subsurface water flow, contaminant transport and biogeochemical processes at the FRC. These experiments will be completed and

written up for peer-reviewed publication in FY 2003. In FY 2004, field experiments will continue. These combine both microbiological and chemical treatment of uranium and the common co-contaminant, nitrate.

The NABIR program will continue to take advantage of recently completed genome sequence of important metal and radionuclide-reducing microorganisms to study the regulation and expression of genes that are important to bioremediation. In FY 2004, researchers working on sequenced microorganisms such as *Geobacter sulfurreducens, Desulfovibrio vulgaris*, and *Shewanella onediensis* will use state-of-the-art nucleic acid based microarrays to identify environmental factors affecting genetic regulation of uranium reduction.

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

In FY 2004, the activities are reduced to enhance funding for Savannah River Ecology Laboratory.

- **General Plant Projects (GPP)** **4,791** **4,811** **4,811**

The General Plant Projects (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 in meeting the requirements for safe and reliable facilities operation. This subprogram 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. The effort will continue rehabilitation and upgrade of research facilities in the 300 area of the PNNL, including beginning the replacement of process water piping in a 40 year old building used for biological research, refurbishing 20-year old office and laboratory space, and reconfiguring space in several 40+ year old buildings to better accommodate current scientific research projects.

- **General Purpose Equipment (GPE)** **1,164** **1,169** **959**

The General Purpose Equipment (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.

Clean Up Research **44,915** **38,190** **39,470**

- **Clean Up Research** **790** **2,463** **2,448**

The modest program in clean up research will continue to be managed together with the EMSP program. The focus will continue on biophysical and chemical characterization of environmental contaminants in support of field and laboratory studies of contaminant transport and bioremediation.

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

	(dollars in thousands)		
	FY 2002	FY 2003	FY 2004

- **Environmental Management Science Program** **36,125** **29,886** **29,246**

  The goal of the Environmental Management Science Program (EMSP), transferred in FY 2003 from Environmental Management to the BER program, is to support basic research that improves the science base underpinning the clean up of DOE sites. Traditional clean up strategies may not work or be cost effective for many of the challenges that threaten the successful closure of DOE sites. The EMSP, through its support of basic research aims to develop and validate technical solutions to complex problems, provide innovative technical solutions where there are none, and lead to future risk reduction and cost and time savings. It is the intent or the expectation of the EMSP that the basic research projects funded are directed toward specific issues and uncertainties at the DOE sites. EMSP research will focus on contaminant fate and transport in the subsurface, nuclear waste chemistry and advanced treatment options, and novel characterization and sensor tools. In addition, studies on bioremediation of organic contaminants are conducted in EMSP, complementing the NABIR program, which focuses on metals and radionuclides.

  EMSP projects will continue to be funded through a competitive peer review process. The most scientifically meritorious research proposals and applications will be funded based on availability of funds and programmatic relevance to ensure a complete and balanced research portfolio that addresses DOE needs. Research will be funded at universities, national laboratories, and at private research institutes and industries. This research will be conducted in collaboration with the Office of Environmental Management.

  In FY 2004, the activities are reduced to enhance funding for the Savannah River Ecology Laboratory.

- **Savannah River Ecology Laboratory**..... **8,000** **5,841** **7,776**

  This activity supports, through a cooperative agreement with the University of Georgia, a long-term (40+ years) ecological research activity aimed at reducing the cost of clean up and remediation while ensuring biodiversity at the restored environment. Peer-reviewed research will be supported to assess the ecological risks of environmental contaminants and remediation activities. Characterizing and understanding the impacts of environmental contamination on intact, living ecosystems is a complex and long-term process since the research is dependent on natural cycles of growth, reproduction, and normal environmental variation. A sustained investment is required to understand the complex interactions of ecosystems with environmental contaminants.

  In FY 2004, new ecological research will develop the knowledge needed to understand how site environmental cleanup activities may impact biodiversity at the Savannah River Site and other DOE sites. This will continue a broad educational component at the site including opportunities for K-12, undergraduate, and graduate students, and post doctoral fellows.

(dollars in thousands)

	FY 2002	FY 2003	FY 2004
Facility Operations: William R. Wiley Environmental Molecular Sciences Laboratory (EMSL)	**37,614**	**37,948**	**37,138**
▪ **Operating Expenses**	**33,808**	**35,959**	**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 essential and will continue to allow the EMSL to operate as a user facility, and are used for maintenance of buildings and instruments, utilities, staff support for users, environment, safety and health compliance activities, and communications. With over 100 leading-edge instruments and computer systems, the EMSL annually supports approximately 1200 users. University scientists form the core of the EMSL science team that networks with the broader academic community as well as with scientists at other agencies. EMSL users have access to unique instrumentation for environmental research, including a new Linux-based supercomputer, a 900 MHz nuclear magnetic resonance (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.

The supercomputer will continue to support two dozen "grand challenge" computational projects at the molecular level and in areas ranging from molecular geochemistry and biogeochemistry, numerical modeling of reactive transport in the subsurface, chemical processing and catalysis, aerosol formation and chemical transformations, climate modeling and simulation, and structural biology.

The research activities using EMSL are carried out at National Laboratories, universities, and private institutions and selected through competitive and peer-reviewed processes.
BER will maintain and operate EMSL and the structural biology user facilities so that the unscheduled operating downtime will be less than 10%, on average, of total scheduled operating time.

In FY 2004, the activities are reduced to enhance funding for the Savannah River Ecology Laboratory.

▪ **Capital Equipment**	**3,806**	**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. Increased capital equipment funding ($2,994,000) in FY 2002 supported the upgrade of user capabilities through the acquisition of additional mass spectrometers and Nuclear Magnetic Resonance (NMR) spectrometers for structural biology research.

	(dollars in thousands)		
	FY 2002	FY 2003	FY 2004
SBIR/STTR	**0**	**2,692**	**2,845**
In FY 2002 $2,354,000 and $139,000 were transferred to the SBIR and STTR programs, respectively. FY 2003 and FY 2004 amounts are estimated requirements for continuation of these programs.			
Total, Environmental Remediation	**111,849**	**109,530**	**109,320**

Explanation of Funding Changes

	FY 2004 vs. FY 2003 ($000)
Bioremediation Research	
▪ GPE funding for motor vehicles at PNNL reduced	-210
▪ Funding for NABIR reduced to accommodate increase for Savannah River Ecology Laboratory	-623
Total, Bioremediation Research	-833
Clean Up Research	
▪ Funding for Savannah River Ecology Laboratory restored to FY 2002 level	+1,935
▪ Funding for Clean Up research reduced to accommodate increase for Savannah River Ecology Laboratory	-15
▪ Funding for EMSP reduced to accommodate increase for Savannah River Ecology Laboratory	-640
Total, Clean Up Research	+1,280
Facility Operations: William R. Wiley Environmental Molecular Sciences Laboratory (EMSL)	
▪ Funding for EMSL operations reduced to accommodate increase for Savannah River Ecology Laboratory	-810
SBIR/STTR	
▪ SBIR/STTR increases due to increased STTR allocation and increase in research for Environmental Remediation	+153
Total Funding Change, Environmental Bioremediation	-210

Medical Applications and Measurement Science

Mission Supporting Goals and Measures

The goal of the Medical Applications and Measurement Science subprogram is to deliver the scientific knowledge and discoveries that will lead to innovative diagnostic and treatment technologies for human health. The research builds on unique DOE capabilities in physics, chemistry, engineering, biology and computational science. Research will lead to new metabolic labels and imaging detectors for medical diagnosis; tailor-made radiopharmaceutical agents and beam delivery systems for treatment of inoperable cancers; and the ability to predict structure and behavior of cells and tissues to better engineer targeted drugs, biosensors, and medical implants. The basic research technologies growing out of this program offer applications for study, detection, diagnosis and early intervention of biochemical, bacterial, and viral health risks of biological, and/or gross environmental insults.

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 program seeks to develop 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. Using non-invasive technologies and highly specific radiopharmaceuticals, BER is ushering in a new era of brain mapping, and highly specific disease diagnostics. New tools will enable the real-time imaging of gene expression in a developing organism.

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 National Laboratories have highly sophisticated instrumentation (neutron and light sources, mass spectroscopy, high field magnets), lasers and supercomputers, to name a few, that directly impact research on human health. Research is directed to fundamental studies in biological and medical imaging (including construction of an artificial retina), biological and chemical sensors, laser medicine and informatics. This research is highly complementary to and coordinated with clinical research at the National Institutes of Health (NIH) and to basic research in the NIH intramural and extramural programs.

DOE supports cutting edge, high-risk, proof-of-concept research that develops research tools with broad applications in clinical medicine and in biological research. NIH supports cutting edge, disease-specific research that uses those tools, along with many others, to determine fundamental mechanisms of human disease for better diagnosis and treatment. For example, NIH supports clinical imaging research but not research to develop radiotracers or imaging instruments, whereas DOE is the only government agency that supports research to develop imaging instruments and the radiotracers needed to carry out imaging procedures.

The philosophical differences, roles, strengths, and advantages of the DOE versus NIH medical sciences research programs are clear:

- DOE medical sciences research is built on a base of chemistry, physics, engineering, computation, and biology. NIH medical sciences research is built on a complementary base of biology and medicine. DOE research leverages the unique combination of multidisciplinary competencies available at the DOE national laboratories.
- DOE develops research tools for medicine by supporting high-risk research often based on theoretical predictions of success rather than preliminary studies that demonstrate a promise of success. As in other fields of science, high risk research often leads to spectacular advances, e.g., the human genome project and genetics. NIH develops disease-specific applications for these research tools by supporting research that is generally based on substantive preliminary studies that actually demonstrate a promise of success.

Measurement Science research emphasizes new sensor instrumentation for cleanup efforts and new imaging instrumentation having broad application in the life and medical sciences.

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

The Medical Applications and Measurement Science subprogram provides fundamental knowledge building to long-term outcomes that underpin the Program Strategic Performance Goals and the Office of Science's Strategic Objectives. 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 BERAC will be in FY 2006. The following are recent scientific accomplishments that highlight program progress.

- *First technique to measure Alzheimer's disease onset.* DOE researchers at UCLA have developed an imaging technique that can detect early lesions in the brains of Alzheimer's disease before symptoms begin. The method utilizes a novel radiotracer and highly sensitive PET scanning. Early identification of Alzheimer's lesion offers the possibility of therapeutic intervention before severe brain injury and clinical debilitation occurs.
- *BNCT technology transferred to NIH for clinical trials*. DOE research at the Brookhaven National Laboratories, MIT and Harvard Medical School established the parameters of clinical safety of boron neutron capture therapy in humans. DOE has completed upgrade of the Medical Reactor at MIT; the facility now generates the most advanced neutron beam for clinical studies in the world. Using the fundamental technology developed by DOE, the National Cancer Institute has initiated a BNCT clinical trial in the treatment of brain cancer and melanoma at the MIT medical reactor.
- *Successful transfer of DOE Micro-Pet technology to industry.* DOE investigators at UCLA have successfully developed the Micro-Pet for repeated physiological imaging of small animals without sacrificing the animal. The Micro-Pet is a major advance in the study of animal models of human disease. The technology developed at UCLA has been transferred to Concorde Microsystems, Inc. of Knoxville, TN for marketing and public use.

- *Helping the blind to see.* A collaborative project between USC Doheny Eye Institute, Oak Ridge National Laboratory, Sandia National Laboratory, Argonne National Laboratory, Lawrence Livermore National Laboratory, and Los Alamos National Laboratory is aimed at developing an artificial retina to restore the sight of patients with retinitis pigmentosa and age-related macular degeneration. A milestone was reached in which a prototype design of a high-density sensor was successfully inserted into a canine and tested successfully. Future programmatic goals include improvement in the prototype design of the retinal device and eventually implantation into the eye of a blind person.
- *New, ultra-sensitive detection of prostate cancer protein in the blood*. DOE scientists at ORNL and UC-Berkeley have developed a cancer detecting microchip that works as a sensitive assay for prostate cancer. The device utilizes a micro machine cantilever to detect prostate specific antigen and is twenty times more sensitive than currently used assays. This technology, which has been pioneered at ORNL, can be adapted to measure other clinically important molecules at high levels of sensitivity.
- *DOE technology for stroke treatment transferred to NIH.* DOE researchers at Lawrence Livermore National Laboratory have successfully completed the material design of a mechanical shape memory polymer device that can be introduced into the vessels in the brain and successfully remove a blood clot causing a stroke. This technology has the potential of significantly reducing deaths from one of the major disease killers in the United States. The DOE has successfully transferred this technology to the NIH, which will fund initial clinical evaluation of the device.
- *A Multitracer Technique for Diagnosing the Root Cause of Obesity.* Brookhaven National Laboratory (BNL) scientists have developed a multi-radiotracer (carbon-11-raclopride, fluorine-18-FDG and carbon-11 cocaine combined) PET imaging approach which shows that obese individuals have an understimulated brain dopamine system similar to drug abusers. Dopamine is a brain chemical that is important in reward and well-being. This disruption of dopamine function may account for pathological overeating, which has parallels in the drug abuser who cannot stop taking the drug even when this behavior is detrimental. This suggests that improving dopamine function may be a useful treatment strategy for obesity, a major public health problem affecting more than 25% of the United States population.
- *New Toluene Radiotracer Developed to Study Inhalant Abuse*. BNL scientists have successfully labeled the volatile chemical toluene with carbon-11 for PET imaging. Using carbon-11 toluene for PET imaging, Brookhaven scientists have shown for the first time that toluene, the most common solvent of abuse, rapidly enters the brain and localizes on the same areas of the brain that are affected by cocaine and other drugs of abuse. This new approach and the new knowledge that it is generating are an important step in understanding and eventually treating addiction to inhalants. The abuse of inhalants ("huffing") by children is a growing problem worldwide.
- *PET Imaging Study Provides New Knowledge For Improved Targeting of Attention Deficit Hyperactivity Disorder.* For more than 40 years, attention deficit hyperactivity disorder (ADHD) has been treated with Ritalin, a stimulant. Yet there have been no studies showing how Ritalin affects the human brain. Using PET imaging with radiotracers (carbon-11 raclopride, and carbon-11 cocaine) Brookhaven researchers have shown for the first time in the human brain that Ritalin elevates

dopamine, a signaling chemical that is important in regulating attention. This new knowledge will form the groundwork for designing better drugs to treat ADHD.

Subprogram Goals

Develop innovative radiopharmaceuticals for diagnosis and treatment of human disease and develop novel imaging instrumentation and technologies to precisely visualize and measure biological functions, including gene expression, and more accurately detect human disease.

Performance Indicator

Number of novel imaging devices delivered.

Annual Performance Results and Targets

FY 2002 Results	FY 2003 Targets	FY 2004 Targets
(Novel cell-directed cancer therapies)	(Novel cell-directed cancer therapies)	(Novel cell-directed cancer therapies)
BNCT program at MIT/Harvard was successfully transferred to the National Cancer Institute for conduct of clinical trials. [Goal Met]	Number of tumor therapeutic agents that perform sufficiently well in pre-clinical evaluations to deserve consideration for clinical trials by NIH and/or private industry.	Number of tumor therapeutic agents that perform sufficiently well in pre-clinical evaluations over five years to deserve consideration for clinical trials by NIH and/or private industry and success in developing a high flux epithermal beam suitable for clinical use at the MIT reactor.
(Radiopharmaceutical design/synthesis)	(Radiopharmaceutical design/synthesis)	(Radiopharmaceutical design/synthesis)
A novel radiotracer was developed that can be used to detect early lesions in Alzheimers Disease. [Goal Met] A multi-radiotracer detection system was developed to detect biochemical abnormalities in brains of patients with obesity. [Goal Met] A toluene radiotracer was developed to study inhalant abuse. [Goal Met]	Develop unique radiopharmaceutical tracers that will enable PET medical imaging to more precisely diagnose neuro-psychiatric illnesses (Alzheimer's Disease, Parkinson's Disease, multiple sclerosis, and others) and cancer in humans. This research is closely coordinated with the NIH Institutes of Drug Abuse, of Mental Health, and of Neurological Disorders and Stroke. Develop innovative methods and instrumentation to image gene expression in real time in cells, tissues and whole organisms.	Through radiopharmaceutical and molecular nuclear medicine research, three positron emission tomography (PET) radiotracers with precise cellular, subcellular, and molecular targeting capability will be developed as potential imaging agents for nuclear medicine research and clinical use to study brain disorders due to substance abuse and mental illnesses (such as Alzheimer's and Parkinson's diseases), cancer diagnosis and treatment, heart-function-related ailments, therapeutic gene expression in the whole animals, and for monitoring progress to therapy.

FY 2002 Results	FY 2003 Targets	FY 2004 Targets
(Imaging Sciences) Micro-PET technology was transferred to industrial partners for commercialization. [Goal Met] A prototype artificial retina device was successfully inserted into the eye of a blind person. [Goal Met] A PET imaging system was used to pinpoint abnormalities in the brains of patients with attention deficit disorder. [Goal Met] An ultra sensitive cantilever detection system, even more sensitive than currently used technology, was developed as a potential new clinical tool to detect prostate specific antigen (PSA). [Goal Met]	(Imaging Sciences) Enhance micro-PET and micro-CT scanners so that these unique and powerful tools can be used to enhance basic biomedical research in medical centers, leading to improved human health care. In close partnership with NIH, develop novel technology and instrumentation for imaging single molecules, genes, cells, organs, and whole organisms in real time under natural physiological conditions with a high degree of precision, including MRI, PET, and SPECT. Technology and detector systems will be developed to capitalize on recent findings of the human genome project that will enable imaging of gene expression in real time that will have a critical impact on biomedical research and medical diagnosis.	(Imaging Sciences) Complete the design, computational modeling and construction of a prototype high-density micro array device (artificial retina) and have implanted the test device into the canine eye. The device will receive light signals from an external camera and convert the photons to electrical signals to be transmitted to the brain. The biological compatibility and ability of the device to transmit signals to the canine brain will be measured. Complete the development of a radiotracer imaging system that approaches the fundamental limit of spatial resolution and detector sensitivity to be applied to the diagnosis of small cancers. Complete the prototype design of MRI and PET instruments capable of performing functional images on moving animals including the design of novel dipole magnets, fiber-optic arrays, miniature positron detectors, and the construction of algorithms to detect and correct for motion during image acquisition. Develop an array of biological sensors employing laser cantilever technology, protein-receptor detection systems that rely on fluorescent resonant energy transfer, and microspectroscopy platform systems.

Funding Schedule

(dollars in thousands)

	FY 2002	FY 2003	FY 2004	$ Change	% Change
Medical Applications	116,085	38,701	38,642	-59	-0.2%
Measurement Science	2,555	5,961	5,952	-9	-0.2%
SBIR/STTR	0	1,186	1,254	+68	+5.7%
Total, Medical Applications and Measurement Science	118,640	45,848	45,848	0	--

Detailed Program Justification

(dollars in thousands)

	FY 2002	FY 2003	FY 2004
Medical Applications	**116,085**	**38,701**	**38,642**
▪ **Novel cell-directed cancer therapies**	**9,699**	**4,870**	**4,862**

In FY 2004, BER continues to support fundamental research on the therapeutic use of ionizing radiation that may be achieved with radionuclide therapy and novel methods of tumor targeting. Recent therapeutic successes employing antibodies or ligands linked to radionuclides has grown out of fundamental combinatorial radiochemistry supported by BER. The specific goals include the development of novel therapeutic agents and delivery techniques to target and treat cancer at the cellular level. Research will address such complex challenges as chemical ligand synthesis, tumor-targeting, and dosimetry.

Overall program objectives include: (1) techniques to ensure highly selective tumor-targeting by the proposed therapeutic agents; (2) efficient screening techniques for selecting candidate therapeutic agents for in-vivo testing; (3) research suggesting a reasonable likelihood of success for in-vivo targeting of primary tumors and their metastases in pre-clinical animal trials; (4) reliable approaches for dosimetry calculations to normal tissues and to tumor sites based on 3-dimensional modeling; (5) measurement techniques for accurately assessing the success of tumor-targeting in vivo; and (6) measurement techniques for assessing therapy effects in vivo at the molecular, cellular and metabolic levels.

The BER supported Boron Neutron Capture Therapy clinical safety studies at the Brookhaven National laboratories and at MIT/Beth Israel Hospital were completed in FY 2002. BER funding of the MIT medical reactor continues with the aim of developing the optimum neutron beam delivery for animal studies and to support NIH research trials of BNCT cancer treatment in humans.

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

▪ **Radiopharmaceutical Design and Synthesis**	**23,570**	**24,445**	**24,407**

In FY 2004, BER will continue to support research on radiopharmaceutical design and synthesis using concepts from genomics as well as computational biology and structural biology. BER will continue research into radiolabeling of monoclonal antibodies for cancer diagnosis and new radiotracers for the study of brain and heart function. Molecules directing or affected by homeostatic controls always interact with each other and, thus, are targets for specific molecular substrates. The substrate molecules can be tailored to fulfill a specific need and labeled with appropriate radioisotopes to become measurable in real time in the body on their way to, and during interaction with their targets, allowing the analysis of molecular functions in the homeostatic control in health and disease. The function of radiopharmaceuticals at various sites in the body is imaged by nuclear medical instruments, such as, gamma ray cameras and positron emission tomographs (PET). This type of imaging refines diagnostic differentiation between health and disease at the molecular/metabolic levels leading to more effective therapy. If labeled with high energy-emitting

radioisotopes, the substrate molecules, carrying the radiation dose may be powerful tools for targeted molecular therapy especially of cancer. The program will continue to support development of new radiotracer and radiopharmaceutical molecules for PET imaging applications (e.g., normal and abnormal brain biochemistries in response to normal and abnormal brain functions in health and disease).

BER will also develop nuclear medicine driven technologies to image mRNA transcripts in real time in tissue culture and whole animals. Currently the expression of endogenous genes in animals (including humans) cannot be imaged, at least not directly. However, given the astounding pace of biotechnology development, such imaging is an attainable goal. This research includes an emphasis on nucleic acid biochemistry, radioactive ligand synthesis and macromolecular interactions. It addresses the functional consequences of gene expression by targeting and perturbing the activity of a particular gene in living cells or animals. It also develops new biological applications using optical and radionuclide imaging devices for imaging specific gene expression in real time in both animals and humans. Methods such as combinatorial chemistry techniques will be used to develop antisense radiopharmaceuticals that hybridize DNA probes to RNA transcripts in highly specific ways to block their activity or function. Molecular signal amplification methods that work in vivo at the mRNA level will be developed. Drug-targeting technology will be developed to such an extent that the various biological barriers can be safely surmounted in vivo. The research will evaluate the clinical potential of real-time imaging of genes at work in cells, tissues, and whole organisms, including humans. This information will have applications ranging from understanding the development of a disease to the efficacy of treatments for the disease. This new technology will strongly impact developmental biology, genome research, and medical sciences.

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

- **Imaging Sciences Instrumentation and Research** **13,994** **9,386** **9,373**

In FY 2004, BER will emphasize support in fundamental research to facilitate the development of imaging systems relevant to solving critical problems related to the Nation's health. This program capitalizes on the unique resources at the National Laboratories in the fields of computational modeling, detector development, multimodal spectroscopy, high-field magnet development and microelectronics. Imaging instrumentation and technology being developed includes: **(**1) the development of a high-density microelectronic array (the artificial retina) that can be packaged into a tiny device to be implanted in to the back of the eye. The device will be used for the treatment of the major causes of blindness in the United States, retinitis pigmentosa and age-related macular degeneration; 2) PET and MRI instruments that will be used to study brain function in the awake individual. These imaging devices will obviate the necessity of anesthetizing animals (inducing coma) to acquire brain images and may also have great potential for use with infants; 3) a range of image detector systems that will be more sensitive and cost effective than current instrumentation used in the diagnosis of human disease; and 4) novel biosensor devices that can detect specific molecules or biological processes important in human biology and disease and convert this

information into a measurable signal. These devices can be adapted to rapidly diagnose microorganisms in the field.

BER's imaging technology program works closely with other Federal Agencies, especially the National Institutes of Health, to help coordinate and focus the research efforts at the National Laboratories. Federal Agency partners include National Institutes of Health Biomedical Engineering Consortium (BECON) and the National Institute of Bioengineering and Bioimaging (NBIB).

The research activities in this subprogram are principally carried out at National Laboratories.

- **Congressional Direction** **68,822** **0** **0**

Congressional direction in FY 2002 for Positron Emission Tomography Center at the University of South Alabama; Gulf Coast Cancer Center and Research Institute; Center for Nuclear Magnetic Resonance Imaging at the University of Alabama Birmingham; University of South Alabama research, in cooperation with industry and the Cooperative Research Network of the National Rural Electric Cooperative Association, on a fuel cell powered home using the Smart Energy Management Control System; Library and Regional Resource Learning Center at Spring Hill College; South Alabama Medical Education Outreach Program; University of Florida Genetics Institute; Linear Accelerator for the Baystate Medical Center; Cancer Institute at New Jersey; Institute for Molecular Biosciences at the University of Arizona; Stanley Scott Cancer Center at Louisiana State University; Infotonics Center of Excellence in Rochester New York; Joint Collaboration on Advanced Nanotechnology and Sensors with the University of New Orleans, Louisiana State University, and Louisiana Tech; Breast Cancer Program at the North Shore-Long Island Jewish Health System; Functional Magnetic Resonance Imaging Machine at the University of Texas at Dallas and the University of Texas Southwestern Medical Center's Center for Brain, Cognition, and Behavior; Integrated Environmental Research and Services Program at Alabama A&M University; Energy Efficiency Initiative at the Carolinas Health Care System; Multidisciplinary Research Facility at the College of Engineering, University of Notre Dame; Linear Accelerator for the Burbank Regional Cancer Center in Fitchburg, Massachusetts; Hampshire College's National Center for Science Education; Audubon Biomedical Science and Technology Park at Columbia University; McFadden Science Center at Texas Wesleyan University; Emergency Power Supply System at Cedars-Sinai Medical Center; Rush-Presbyterian-St. Luke's Medical Center; Nanoscience Facility at Purdue University; Julie and Ben Rogers Cancer Institute; School of Public Health at the University of South Carolina; Continued Development of the Life Science Building at Brown University; Environmental Modeling at the University of North Carolina at Chapel Hill; Renovation of the Science, Technology, and Engineering Research Complex at Jackson State University; PowerGrid Simulator at Drexel University and the New Jersey Institute of Technology; Positron Emission Tomography Facility at West Virginia University; Linear Accelerator for the University Medical Center of Southern Nevada; Research Foundation of the University of Nevada-Las Vegas; University of Nevada-Las Vegas for Continued Study of the Biological Effects of Exposure to Low-level Radioactivity; Biomolecular Nuclear Magnetic Resonance Instrument at the Medical University of South Carolina; Oncology Center of the Medical University of South Carolina; National Center of Excellence in Photonics and

(dollars in thousands)

	FY 2002	FY 2003	FY 2004

Microsystems in New York; Institute of Comparative Genomics at the American Museum of Natural History; Inland Northwest Natural Resources Center at Gonzaga University; Hall of Paleontology at the Field Museum; Center for Catalysis at Iowa State University; Human Genome Project at the University of Southern California; Biomedical Research at Creighton University; Child Health Institute of New Brunswick, New Jersey; Oregon Renewable Energy Center; Superconductor Research at Boston College; Natural Renewable Energy Laboratory in Hawaii; Rochester Institute of Technology Microelectronics Technology Program; Operations and Capital Investment at the Mental Illness and Neuroscience Discovery Institute; and University of Missouri-Columbia to Expand the Federal Investment in the University's Nuclear Medicine and Cancer Research Capital Program.

Measurement Science	**2,555**	**5,961**	**5,952**

In FY 2004, BER will continue research on new sensor instrumentation for characterizing the chemical composition of contaminated subsurface environments in support of the Department's environmental cleanup efforts of highly radioactive chemical wastes.

The research will include the development of new environmental sensors that are better, faster, and more economical than existing laboratory techniques. New field-based sensors that take advantage of novel biotechnologies will be ready for deployment. The new sensors will include antibody and nucleic acid approaches that have precedence in other applications but will be new to bioremediation at DOE legacy sites.

Research into new imaging instrumentation for life sciences and biomedical sensor applications will be continued. Capital equipment funds will be used for research to develop new instrumentation having broad application in the life and medical sciences. BER will continue research on medical applications of laser technology at the National Laboratories and at universities.

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

SBIR/STTR	**0**	**1,186**	**1,254**

In FY 2002 $3,008,000 and $193,000 were transferred to the SBIR and STTR programs, respectively. FY 2003 and FY 2004 amounts are estimated requirements for the continuation of these programs..

Total, Medical Applications and Measurement Science	**118,640**	**45,848**	**45,848**

Explanation of Funding Changes

	FY 2004 vs. FY 2003 ($000)
Medical Applications & Measurement Science	
▪ Activities will continue at near FY 2003 levels. Decrease is due to the increase in STTR allocation.	-68
SBIR/STTR	
▪ SBIR/STTR increases due to STTR allocation increase	+68
Total Funding Change, Medical Applications and Measurement Science	0

Construction

Mission Supporting Goals and Measures

Construction is needed to support the research under the Biological and Environmental Research Program (BER) program. Cutting-edge basic research requires that state-of-the-art facilities be built or existing facilities modified to meet unique BER requirements.

Funding Schedule

(dollars in thousands)

	FY 2002	FY 2003	FY 2004	$ Change	% Change
Construction	11,405	0	0	0	0.0%

Detailed Program Justification

(dollars in thousands)

	FY 2002	FY 2003	FY 2004
Construction	**11,405**	**0**	**0**

- The Laboratory for Comparative and Functional Genomics at Oak Ridge National Laboratory will provide a modern research facility to help understand the function of newly discovered human genes, to support DOE research programs and to house the genetic mutant mouse lines created during the past 50 years. This new facility will replace a 50-year old animal facility with rapidly escalating maintenance costs still in use at Oak Ridge.

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

Explanation of Funding Changes

	FY 2004 vs. FY 2003 ($000)
Construction	
▪ Funding for the construction of the Laboratory for Comparative and Functional Genomics is completed in FY 2002.	0

Capital Operating Expenses & Construction Summary

Capital Operating Expenses

(dollars in thousands)

	FY 2002	FY 2003	FY 2004	$ Change	% Change
General Plant Projects	4,991	4,811	4,811	0	--
Capital Equipment	37,263	17,047	19,625	+2,578	+15.1%
Total Capital Operating Expenses	42,254	21,858	24,436	+2,578	+11.8%

Construction Projects

(dollars in thousands)

	Total Estimated Cost (TEC)	Prior Year Approp-riations	FY 2002	FY 2003	FY 2004	Unapprop-riated Balance
01-E-300, Laboratory for Comparative and Functional Genomics, ORNL	13,900	2,495	11,405	0	0	0
Total, Construction		2,495	11,405	0	0	0