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 environmental 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, provides the science base in support of the Energy Policy Act of 1992, and works cooperatively with DOE's national security programs to develop tools to combat terrorism.

Strategic Objective

SC3: By 2010, develop the basis for biotechnology solutions for clean energy, carbon sequestration, environmental cleanup, and bioterrorism detection and defeat by characterizing the multiprotein complexes that carry out biology in cells and by determining how microbial communities work as a system; and determine the sensitivity of climate to different levels of greenhouse gases and aerosols in the atmosphere and the potential consequences of climate change associated with these levels by resolving or reducing key uncertainties in model predictions of both climate change that would result from each level and the associated consequences.

SC7: Provide major advanced scientific user facilities where scientific excellence is validated by external review; average operational downtime does not exceed 10% of schedule; construction and upgrades are within 10% of schedule and budget; and facility technology research and development programs meet their goals.

Progress toward accomplishing these Strategic Objectives will be measured by Program Strategic Performance Goals, Indicators and Annual Targets, as follows:

Program Strategic Performance Goals

SC3-1: Determine, compare, and analyze DNA sequences of microbes and other organisms that will underpin development of biotechnology solutions for clean energy, carbon sequestration, environmental cleanup, and bioterrorism detection and defeat. (Life Sciences, Environmental Remediation, and Medical Applications and Measurement Science subprograms)

Performance Indicator

Base pairs of DNA sequenced per year.

Performance Standards

As discussed in Corporate Context/Executive Summary.

Annual Performance Results and Targets

FY 2001 Results	FY 2002 Targets	FY 2003 Targets
By the end of FY 2001, the DOE Joint Genome Institute (JGI) completed the sequencing and submission to public databases of an additional 100 million finished and 250 million high quality draft base pairs of DNA, including both human and model organisms (e.g., the mouse) as part of the Human Genome Program. (SC2-1) [Exceeded goal]	By the end of FY 2002, the DOE Joint Genome Institute will complete the high quality DNA sequence of human chromosomes 16 and 19 and produce 6 billion base pairs of DNA sequence from model organisms (e.g., mouse, Fugu, and Ciona) to help understand the human sequence as part of the Human Genome Program. (SC3-1)	Complete the high quality DNA sequence of human chromosome 5. (SC3-1) Increase the DNA sequencing capacity of the DOE Joint Genome Institute (JGI), with no additional funding, to approximately 8 billion base pairs of DNA sequence per year, a 100% increase in the projected capacity over FY 2001. Establish at least 30 diverse collaborations for high throughput DNA sequencing with scientists outside the JGI important for Genomics and Genomes to Life research. (SC3-1)
Completed the genetic sequencing of three additional microbes that produce methane or hydrogen from carbonaceous sources and that could be used to sequester carbon as part of the Microbial Genomics and Carbon Sequestration programs. (SC2-1) [Exceeded goal]	Produce draft DNA sequence of more than 30 microbes that cover a range of functional relevance to DOE's life and environmental sciences and security missions - including carbon sequestration, environmental cleanup, bioremediation, and bioterrorism. (SC3-1)	Produce draft DNA sequences of more than 30 microbes vital to future U.S. energy security and independence, carbon sequestration, and environmental cleanup. (SC3-1)

SC3-2: Establish the scientific foundation for determining a safe level of greenhouse gases and aerosols in the atmosphere by resolving or reducing key uncertainties in predicting their effects on climate, and provide the foundation to predict, assess and mitigate potential adverse effects of energy production and use on the environment. (Climate Change Research subprogram)

Performance Indicator

Climate model resolution.

Performance Standards

As discussed in Corporate Context/Executive Summary.

Annual Performance Results and Targets

FY 2001 Results	FY 2002 Targets	FY 2003 Targets
Conducted five Intensive Operations Periods (IOPs) on schedule at the Atmospheric Radiation Measurement (ARM) Southern Plains site in Oklahoma. Obtained data from second station on the North Slope of Alaska, and made operational the third station in the Tropical Western Pacific on Christmas Island on schedule and within budget in accordance with program plan. (SC2-1) [Met goal]	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. (SC3-2)	Improve the precision of climate models by delivering a more realistic cloud submodel that reduces the uncertainty in calculations of the atmospheric energy budget by 10 percent and by increasing the spatial resolution of the atmospheric and ocean and sea ice submodels to 1.4 degrees (about 150 Kilometers) and approximately 0.7 degrees (about 75 Kilometers), respectively, for the fully coupled climate model. (SC3-2)

SC7-3: Manage all BER facility operations and construction to the highest standards of overall performance, using merit evaluation with independent peer review. (Life Sciences, Environmental Remediation subprograms).

Performance Indicator

Percent on time/on budget, percent unscheduled downtime.

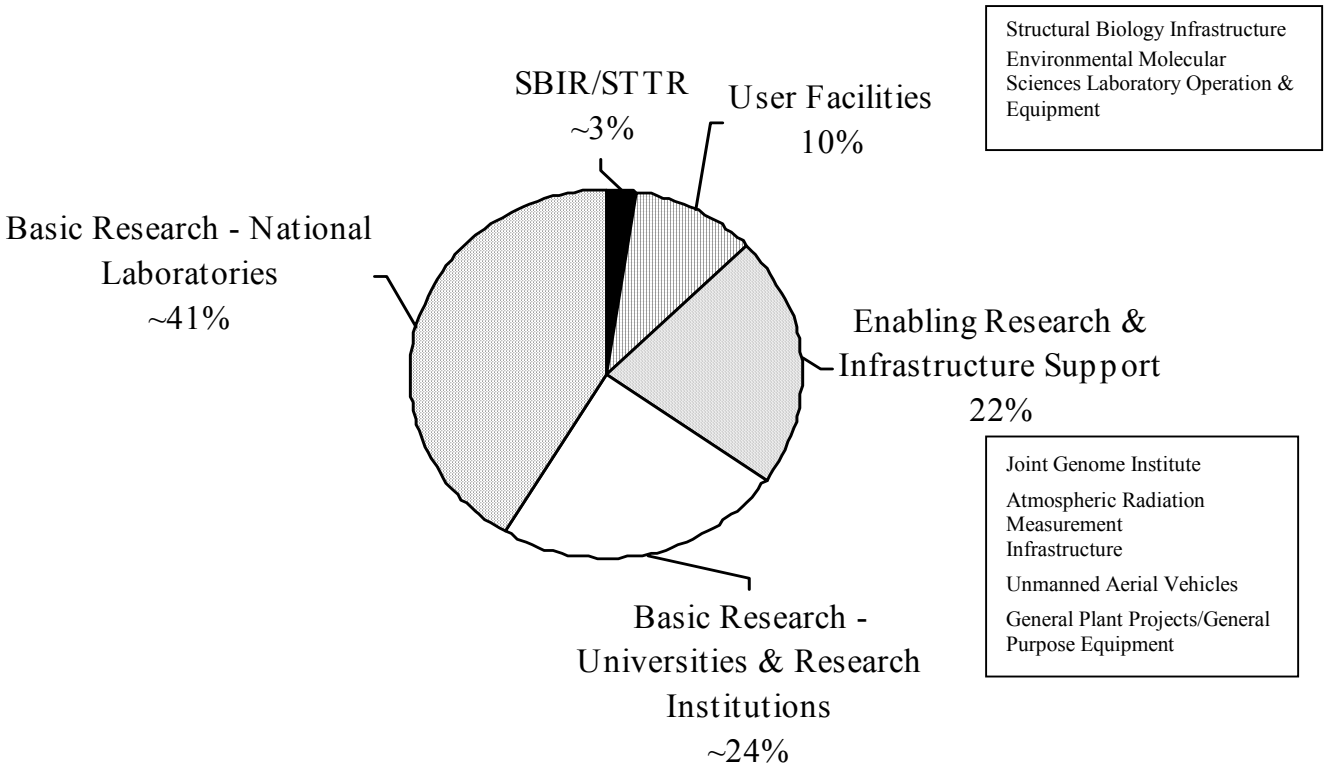
Performance Standards

As discussed in Corporate Context/Executive Summary.

Annual Performance Results and Targets

FY 2001 Results	FY 2002 Targets	FY 2003 Targets
Keep within 10 percent of cost and schedule milestones for upgrades and construction of scientific user facilities, initiate commissioning of the protein crystallography Structural Biology User Station at the Los Alamos National Laboratory and initiate construction of the Center for Comparative and Functional Genomics at Oak Ridge National Laboratory. [Met Goal]	Keep within 10 percent of cost and schedule milestones for upgrades and construction of scientific user facilities; begin acceptance testing of the new high performance computer at the Environmental Molecular Sciences Laboratory at the Pacific Northwest National Laboratory; continue construction of the Center for Comparative and Functional Genomics at Oak Ridge National Laboratory. (SC7-3)	Keep within 10 percent of cost and schedule milestones for upgrades and construction of scientific user facilities; begin operation of the new high performance computer at the Environmental Molecular Sciences Laboratory at the Pacific Northwest National Laboratory; complete construction of the Center for Comparative and Functional Genomics at Oak Ridge National Laboratory. (SC7-3)
Maintain and operate the BER scientific user facilities so the unscheduled downtime on average is less than 10 percent of the total scheduled operating time. [Met Goal]	Maintain and operate the BER scientific user facilities so the unscheduled downtime on average is less than 10 percent of the total scheduled operating time. (SC7-3)	Maintain and operate the BER scientific user facilities so the unscheduled downtime on average is less than 10 percent of the total scheduled operating time. (SC7-3)

To accomplish the BER Program strategic goals, the BER budget request for FY 2003 is $504,215,000, including support for basic research, scientific user facility operations, and enabling research and infrastructure support. In addition, the program includes funding for the Small Business Innovation Research (SBIR) and Small Business Technology Transfer program (STTR).



PROGRAM REVIEW, PEER REVIEW, AND USER FEEDBACK

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 and requested level of funding, 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. BER regularly compares its programs to the scientific priorities recommended by the Biological and Environmental Research Advisory Committee (BERAC), and by the standing committees created by the Office of Science and Technology Policy.

The BER program benefits from a diversity of program reviews. This is particularly the case for BER program elements that are components of international research endeavors, e.g., the International Human Genome Project and the U.S. Global Change Research Program. In addition to panel reviews used to evaluate and select individual projects and programmatic reviews by the chartered BERAC, BER evaluates its programs using interagency (and international) review bodies and 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 and the life sciences and aggressively pursues every opportunity to enhance the interface between the two scientific domains.

BER facility operations are also monitored by peer reviews and user feedback. BER manages these facilities in a manner that meets user requirements as indicated by achieving performance specifications while protecting the safety of the 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.

The reviews and user feedback are incorporated as BER 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 in close collaboration with the research community.

BER LEADERSHIP AND UNIQUE ROLES

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

- Manage research on microbes for energy, the environment, and national security 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 detector 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 Accomplishments and Program Shifts

SCIENCE ACCOMPLISHMENTS

Life Sciences

- *Human DNA Sequence Published* - Capping what may be one of the greatest scientific achievements of all time, the draft human DNA sequence was published in the February 15/16, 2001 issues of the journals *Nature* and *Science.* DOE initiated this monumental research project, sequenced human chromosomes 5, 16, and 19, and contributed many of the fundamental technologies and resources. Both the human DNA sequence and high throughput DNA sequencing capabilities, especially as applied to microbes, contribute to the identification of genetic factors that increase individual human susceptibility to radiation and other energy-related materials and to the use of microbes and microbial communities to solve challenges in carbon sequestration, clean energy, environmental cleanup, and national security.
- *Understanding Human Chromosome 19 by Studying the Mouse* - Interpreting the recently completed human DNA sequence and understanding the role each gene plays in human development, health and susceptibility is one of the next major challenge in biology. Identifying all the components of each human gene is made easier by comparing the human DNA sequence with the comparable

sequence in the mouse, sequences that have been remarkably conserved by evolution. The JGI has sequenced more than 42 Megabases (Mb) of the mouse genome that codes for genes related to those found on human chromosome 19. For a particular gene-rich region of human chromosome 19, called HSA 19, research to date has shown that direct counterparts of virtually all known genes in the HSA 19 region are found in the mouse. In particular, these initial comparisons identified both new genes and candidate regulatory regions that had not been found with "gene-finding" software.

- *Sequencing the Pufferfish to Understand the Human Genome* - Scientists searching the human genome for genes and their on/off switches will soon have a valuable new resource courtesy of the Japanese delicacy known as Fugu, or the pufferfish. Evolution has conserved many of the DNA sequences that code for genes or their regulatory sequences. Comparisons of genome sequences between species are, therefore, an effective and efficient means of finding new genes and gene regulatory (controlling) elements. The Fugu genome, is 8-fold more compact than the human genome, making it even more cost-effective for these comparisons than yeast, fly, worm, and mouse. In FY 2001, DOE's Joint Genome Institute, together with its international partners, determined more than 90-percent of the Fugu genome sequence and made it available in an accessible database.
- *DOE Investments in Structural Biology Make Big Payoffs* - Understanding the three dimensional structure of proteins is an important step in understanding how the information contained in genes is put into action. This knowledge has important applications in medicine, clean energy production, carbon sequestration, and environmental cleanup since proteins make biology "happen" whether in people or microbes. DOE investments in structural biology research, at user facilities at synchrotron light sources, and in the technologies for speeding the determination of protein structure have enabled the National Institute of General Medical Sciences at the National Institutes of Health to make a large investment (over $25,000,000 in FY 2001) in pilot projects for the NIH's new Protein Structure Initiative to develop high throughput methods for determining protein structure. Five of the seven initial pilot projects include partners from DOE Laboratories and nearly all are using DOE user facilities.
- *Approaching High Throughput Proteomics* - Pacific Northwest National Laboratory has developed a "next generation" instrument for quantitative high throughput proteomic studies of microorganisms that also holds promise for studies of higher organisms including mouse and human. Initial studies with the highly radiation resistant microorganism *Deinococcus radiodurans,* now being extended to *Shewanella oniedensis,* (both important in bioremediation and waste cleanup), gave precise, proteome-wide measurements of changes in protein abundances based on the use of atomic mass tags and a stable-isotope labeling method, thus, allowing effective comparison of the proteome of an organism under two different experimental conditions.
- *Record Breaking Year of Microbial DNA Sequencing* - In FY 2001 the DOE Joint Genome Institute (JGI) sequenced over 20 different microbial genomes. The high draft sequence quality enabled 95% of the genes in these organisms to be identified. This is the largest microbial data set produced in such a small period of time, making the JGI one of the largest producers of microbial genomic sequence. The microbes cover a range of functional relevance to DOE's life and environmental sciences mission - from carbon sequestration to environmental, bioremediation, and medical relevance. Each microbe had a scientific "champion" to ensure rapid and public dissemination and use of the data. This draft sequencing effort is part of an ongoing scientific test to determine the most effective way to generate and disseminate the largest amount of useful DNA sequence information to the scientific community in the shortest, most cost effective manner.

- *White Rot Fungus Sequenced* - In FY 2001, the JGI completed the draft DNA sequence of the 30 Mb White rot fungus, *Phanerochaete chrysosporium*. This is one of the first fungal genomes to be sequenced and is a landmark in the use of whole genome shotgun strategies and the testing of the JGI's genome assembler software. The white rot fungus genome is very important to current research in the areas of biomass conversion, carbon sequestration, and cellulose and lignin digestion as well as PCB detoxification.
- *Resolving A-Bomb Dosimetry After More than 50 Years* – BER, working with DOE's Office of Environment, Safety and Health; National Research Council; and RERF (Radiation Effects Research Foundation) is resolving A-bomb dosimetry after more than 50 years. This effort was conducted in response to a directive from Congress to the BER program. Standards for protecting people from exposure to ionizing radiation are based, in large part, on analyses of the survivors of the atomic bombs in Hiroshima and Nagasaki. However, these analyses have large uncertainties due to uncertainties in the estimated doses of radiation received by the survivors. New technologies for measuring irradiated materials and greatly increased computational capabilities are now leading to the development of a new dosimetry system for A-bomb survivors that will be completed in early 2002. This new A-bomb dosimetry will be used for the development of future radiation protection standards, important both for future uses of nuclear energy and for ongoing clean up of contaminated DOE sites.

Climate Change Research

- *Improvements in Measurements and Modeling of Atmospheric Radiation Improves Weather Forecasts* - Through improvements in measurement techniques and related climate model radiation codes, the ARM program has improved the agreement between measured and modeled instantaneous clear sky infrared fluxes from 20 Watts/m^2 to 5 Watts/m^2. The inclusion of the advanced radiation code into climate models has resulted in a 7 percent improvement in the usefulness of weather forecasts by extending the forecast period and reducing the computation time required to produce the forecasts.
- *Consistency Documented Between Observed Temperature Changes in the Atmosphere and Ocean and Model Simulated Temperature Changes* - The Parallel Climate Model (PCM), a collaborative climate modeling effort supported by BER at the National Center for Atmospheric Research and Los Alamos National Laboratory, with contributions from several other DOE National Laboratories and academic institutions, was applied to the problem of identifying whether a greenhouse-gas climate signal exists in the observational climate record. BER-supported researchers at Scripps Institution of Oceanography compared two ensembles of PCM simulations of the last 300 years. The first ensemble was a series of simulations that included observed increases in greenhouse gas and sulfate aerosol concentrations resulting from anthropogenic activities. The second ensemble was a series of "control runs" identical to the first series, except that the increases of greenhouse gas and sulfate aerosol concentrations were excluded. The results show that the simulated regional temperature changes in both the atmosphere and the ocean were statistically consistent with the observed data, the first time that a model has demonstrated the ability to realistically simulate both the atmosphere and the ocean. The analysis further revealed a statistically significant pattern of temperature differences between the forced simulations and the control run ensemble that can be attributed to human-induced climate change.
- *Understanding of Complex Pollution Phenomena Advanced* - Data from the Texas Air Quality Study (TexAQS 2000) has provided new information on the relative importance of emissions from

refineries and other sources of ozone and aerosols and the recirculation of polluted air from land and sea breezes in causing violations in ozone and particulate air quality standards in the Houston area. The research was an interagency effort supported by DOE, EPA, NOAA, NSF, TVA, NASA, the Texas Natural Resources Conservation Commission, and the Greater Houston Partnership. Information from this study is being provided to Texas authorities developing air quality improvement plans. Advances in the science are also being incorporated in predictive and assessment models that can then be applied to other urban areas.

- *Assessment of "Background" Sources of Ozone in Urban Areas* - Research using numerical chemistry and atmospheric transport models has improved our understanding of the processes that govern tropospheric ozone, other oxidants, and aerosols on urban, regional, and global scales. A major question is whether horizontal transport by winds over regional distances, up to about 1000 kilometers, can substantially influence concentrations of these pollutants in U.S. metropolitan areas. Evaluation of data from recent field studies showed that ozone produced in southern California might be carried to the Phoenix area, thus altering the effectiveness of potential localized controls on energy-related emissions that contribute to oxidant formation where the current urban background concentration is about 40 parts per billion by volume (ppbv). Surface ozone concentrations can be elevated over this background by 5 to 25 ppbv, usually in episodic events by this regional scale transport. In addition, transport of ozone from the stratosphere can increase surface ozone by 10 ppbv or more near the surface.
- *AmeriFlux Network Increased to 40 Sites for Measuring N. American Terrestrial Carbon Sink* - The AmeriFlux network where net carbon dioxide (CO_2) exchange between the atmosphere and ecosystems across North America is measured, increased to 40 locations. The systematic net carbon dioxide exchange measurement offers one approach for estimating how much excess carbon dioxide from fossil fuel combustion is sequestered by terrestrial ecosystems. Over the past 3 years, annual net production or carbon gain of the instrumented forest sites ranged from 2 to 4 metric tons per hectare. For example, the carbon gain by deciduous forest ecosystems averages 6 grams of carbon per square meter per day. Net production generally increased with growing season length, which means that early onset of the growing season, or longer growing seasons associated with future climate changes can theoretically lead to more carbon sequestration. Related scientific research also determined that cloudiness leads to more efficient photosynthetic use of light by the plants to fix carbon. Web-based AmeriFlux data are disseminated to the scientific community by the Carbon Dioxide Information and Analysis Center where, in 2000, over 30,000 inquiries from 24 countries were recorded on the web site. In addition, the network is providing both high quality, real-time micrometeorological data for modeling ecosystem processes, and ground-truth plant productivity data for a NASA satellite platform designed to provide estimates of global ecosystem productivity.
- *Novel Ecological Results Obtained from Elevated-Carbon Dioxide Field Experiments* - Recent BER-sponsored Free-Air Carbon Dioxide Enrichment (FACE) field experiments that address DOE's mission to ensure that energy systems are environmentally sustainable have led to discoveries about ecosystem responses to future increases in atmospheric carbon dioxide levels resulting from fossil fuel combustion. In the southwestern U.S., a 50% increase in atmospheric carbon dioxide stimulated growth and seed production of an invasive annual grass species to a greater extent than native annual plants. This indicates that rising atmospheric carbon dioxide may favor exotic annual grasses, which might accelerate the fire cycle and reduce biodiversity in arid ecosystems. In a northern-U.S. FACE experiment, more diverse plant communities were found to respond more favorably to elevated carbon dioxide than less diverse communities, suggesting that biodiversity

losses could significantly affect how terrestrial ecosystems will respond to increasing atmospheric carbon dioxide. In a southeastern loblolly pine plantation in which 16 year old loblolly pines were exposed to elevated carbon dioxide, growth and carbon sequestration by this forest ecosystem were enhanced most when the poorest quality sites received both carbon dioxide and nutrient (nitrogen) amendments. The trees exposed to elevated carbon dioxide alone (55% above ambient) reached reproductive maturity at least two years sooner than trees exposed to the ambient carbon dioxide concentration. Elevated carbon dioxide also resulted in a disproportionate allocation of carbon to cones and seeds compared to tree stems (wood). The responses have implications for management of future forests regarding rotation intervals and selection of species grown for commercial purposes.

- *Fate of Injected Carbon Dioxide in the Deep Ocean Modeled* - LLNL researchers at the DOE Ocean Carbon Sequestration Consortium published a numerical simulation of the distribution of the relative carbon dioxide concentrations in the ocean resulting from a continuous 20-year injection of carbon dioxide at 1700 meters depth near Cape Hatteras, North Carolina. This simulated scenario showed that the injected carbon dioxide was transported under the Gulf Stream and remained isolated from the atmosphere for periods of decades or longer following the injection.
- *48 Students Enrolled in the Global Change Education Program for Undergraduate and Graduate Students* - Twenty-four outstanding undergraduate students were selected for participation in the 2001 DOE Summer Undergraduate Research Experience (SURE) and 24 exceptional graduate students were selected for DOE Graduate Research Environmental Fellowships (GREF), which provide support for their graduate research on climate change.

Environmental Remediation

- *Radiation Resistant Microbe Enzymatically Reduces Common Contaminants at DOE Sites* - The radiation resistant "superbug" *Deinococcus radiodurans* was shown by PNNL researchers to change chemical species of contaminants common to DOE sites (e.g., Uranium, Technetium, and Chromium) that are relatively soluble and mobile in water to unsoluble and relatively immobile species. Under conditions where ionizing radiation is high, such as sediments and soils beneath leaking waste storage tanks at some DOE sites, *Deinococcus radiodurans* may provide a means for limiting the migration of multivalent radionuclides and heavy metals. Moreover, *Deinococcus* has now been reported to be endemic to the populations of soil microorganisms beneath radioactive waste storage tanks at the Hanford reservation, making this microbe especially promising for *in situ* bioremediation approaches.
- *Portable Immunoassay Instrument Developed for Quantitative Measurement of Uranium in the Field* - A field portable immunoassay has been developed to measure uranium, a common legacy waste contaminant at DOE sites. Researchers at Tulane University developed an immunosensor that can be used for speciation and quantification of uranium in groundwater. A prototype hand held instrument has been developed in collaboration with Sapidyne Instruments. This technology makes it possible to rapidly obtain information on levels of uranium contamination and the effectiveness of remediation approaches for reducing or stabilizing uranium contamination at DOE sites.

Medical Applications and Measurement Science

- *PET/Radiotracer Studies Help Anti-addiction Drug Development* - The Brookhaven National Laboratory (BNL) uses positron emission tomography (PET) and radiotracer techniques to study the brain mechanisms underlying addiction. PET and carbon-11 studies with Vigabatrin also known as GVG, a drug used to treat epilepsy outside the U.S., have shown that GVG may prove to be an effective pharmaceutical treatment for cocaine addiction. In subsequent studies, Brookhaven scientists and collaborators found that the drug effectively blocked test animals' craving for nicotine, heroin, alcohol, and methamphetamine.
- *Tracking the Brain Dopamine Pathology Related to Obesity* - PET and carbon -11 radiotracer drug studies at BNL, recently published in *Lancet* 357, 354-357, 2001, provide evidence of brain dopamine pathology in obesity. The studies have shown that the brains of obese people have abnormalities in the chemical dopamine that regulates pleasure centers in the brain.
- *New Radiotracers to Study Stroke* - Lawrence Berkley National Laboratory scientists have developed a new radiotracer probe to study the brain biochemistry relevant to stroke. The tritiated compound, known as drug candidate CNS5161, will be used first as a research tool in animal models of stroke, trauma, drug addiction, and memory consolidation. The carbon-11 labeled form of this compound will be developed to assess acute brain biochemical receptor activation in human stroke and head trauma as well as for monitoring the more chronic changes in neurodegenerative disorders.
- *Helping the Blind See* - A collaborative research project at The Johns Hopkins Wilmar Eye Institute and at Oak Ridge National Laboratory (ORNL) in Tennessee is developing a retinal prosthetic device (an artificial retina) that will allow patients who have retinitis pigmentosa or age-related macular degeneration to see again. Significant progress has been made on the development of a micro-imaging sensor that is small enough that it can be safely implanted into the eye. Preliminary results predict that patients with retinitis pigmentosa or age-related macular degeneration will have vision restored to a level equivalent to reading large print.
- *New Biological Microscope Wins Discover Award* - A new microscope, that pairs optical confocal microscopy with magnetic resonance microscopy, has been developed by scientists at the Environmental Molecular Sciences Laboratory (EMSL). This new microscope, which combines the unique features of both technologies, will allow researchers to visualize in living cells, important morphological changes that occur when normal healthy cells transform into tumor cells.
- *Polymer Formulations for Cartilage Repair* - Pacific Northwest National Laboratory (PNNL) researchers have demonstrated that temperature sensitive polymers can support cartilage-forming cell growth outside the body and also provide a temporary synthetic “scaffold” to support growth of the newly grown cartilage cells once they are injected back into the joint.
- *Mini-Camera for Fewer Biopsies in Breast Cancer Diagnosis* - Researchers at Hampton University and the Thomas Jefferson National Accelerator Facility developed a gamma mini-camera that uses a specially modified personal computer for data acquisition and analysis. The smaller camera coupled to a superior imaging and high-performance processing system provides better resolution of the breast and is expected to result in fewer biopsies.
- *New Method for Cancer Risk Assessment* - Scientists at Ames Laboratory have developed a chip-based, direct-readout methodology for detecting and quantifying DNA adducts, chemical compounds in which a carcinogen is attached to the DNA. These chemical compounds can be present long before cancer develops and are critical in understanding early events in carcinogenesis.

- *New Radiopharmaceuticals for Cancer Therapy* - Investigators at Duke University have developed iodine-131 and astatine-211 labeled antitenascin-antibody proteins for treatment of brain tumors such as gliomas. The antibody proteins carrying the therapeutic doses of radiation can selectively seek tenascin molecules located on glioma cancer cells, bind and deliver the radiation for effective cancer cell killing.

FACILITY ACCOMPLISHMENTS

Life Sciences

- *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.

Environmental Remediation

- *Unique High Throughput Approach Using Mass Spectrometry for Proteome Characterization* - New mass spectrometry techniques developed by EMSL scientists are the basis for measuring changes in protein expression within a single experiment. This new approach can be used to monitor thousands to tens of thousands of proteins per day. The global perspective afforded by this new proteome measurement capability is diagnostic of changes within entire sets of cellular pathways and networks, thereby helps to identify those pathways key to a cell's state of development or response to a changing environment. The high throughput approach has been used to characterize the proteome of *Deinococcus radiodurans*, a microorganism with potential for bioremediating contaminated soils and groundwater. This approach confirmed almost half of the proteins predicted by genome annotation. Key to this successful project was the development of the ion funnel, a device that prevents ions in a sample from becoming lost by charge-charge repulsion of the ion beam as it is transferred into a mass spectrometer; greatly improved high pressure capillary liquid chromatographic separations; new methods for extending the dynamic range of measurements; and data processing methods that provide greater mass measurement accuracies for improved protein identification.

- *Computational and Experimental Chemistry Used to Determine New Estimate of Heat of Formation of OH Radical* - A team of scientists from EMSL and Argonne National Laboratory combined results from computational and experimental chemistry studies to determine a new value for the heat of formation of the hydroxyl radical (OH). This important result required use of the massively parallel supercomputer in EMSL and will have significant impact on models of combustion and atmospheric chemistry. The same approach has been used for many small, highly reactive species including those involved in fluorocarbon production and processing and the decomposition products of ammonia. Reliable prediction of the energetics of molecular systems is made possible by the revolution in computer hardware, software and computational methods and their application in computational chemistry.

PROGRAM SHIFTS

For FY 2003, BER will focus on:

- Further developing the research infrastructure needed for Genomes to Life research. The development of virtual, distributed research centers, begun in FY 2002, will expand to include research capabilities needed for analyses of the functional capabilities of microbial populations comprised of multiple microbial species, enabling the development of strategies to use complex microbial communities to address DOE needs in clean energy production, carbon sequestration, and environmental cleanup.
- With the completion of the high quality DNA sequence of human chromosomes 5, 16, and 19, DNA sequencing capabilities at the Joint Genome Institute will increasingly emphasize the needs of research on microbes for energy, the environment, and national security and, through interagency partnerships, selected sequencing needs of other agencies including the National Science Foundation and the U.S. Department of Agriculture.
- In FY 2003 the Administration will launch a new Climate Change Research Initiative (CCRI). The CCRI will focus on research areas where substantial progress in both understanding and prediction are likely over the next five years, including climate variation and change, carbon cycle, water cycle, atmospheric composition, and regional impacts. BER will participate in one of the specific areas: understanding the North American Carbon Cycle.
- 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 are transferred from the Office of Environmental Management (EM) to the Office of Science. BER will manage these research activities according to Office of Science principles, but with extensive input from EM.
- In FY 2003, funding for the followup of all patients treated in the human clinical trials of boron neutron capture therapy (BNCT) at Brookhaven National Laboratory and the Massachusetts Institute of Technology will be completed with the transfer of clinical technology to the National Cancer Institute of the National Institutes of Health. The basic drug development research program for BNCT will evolve into a new program of innovative approaches to cell-targeted ablation therapy for cancer with in-vivo radiation techniques. The emphasis of this program will be on the

therapeutic use of ionizing radiation that may be achieved with radionuclide therapy and novel methods of tumor targeting.

Genomes to Life Research

The FY 2003 budget includes funds for the continued expansion of the research on microbes to address DOE's energy, environment, and national security mission needs. Initiated in FY 2002, 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 functional diversity found in populations of microbes isolated from DOE-relevant sites. In FY 2003, new research will be initiated that focuses on further developing the research tools needed to study microbial communities that may have applications to clean energy, environmental cleanup, and carbon sequestration.

Climate Change Research Initiative

In FY 2003, the Administration will institute a new Climate Change Research Initiative (CCRI). The CCRI is intended to focus research on areas where substantial progress in understanding and prediction are likely over the next five years, including climate variation and change, carbon cycle, water cycle, atmospheric composition, and regional impacts. The set of cross agency programs will have strong focus on outcomes and deliverables. DOE, in conjunction with other USGCRP agencies, will begin a focused research program in specific research areas. The deliverables will be targeted at information useful to policy-makers (e.g., provide quantitative estimates of the carbon balance in regions across the U.S.). DOE will participate in one of the specific research areas: understanding the North American Carbon Cycle (with NOAA, NSF, and USDA).

Scientific Facilities Utilization

The Biological and Environmental Research request includes $52,088,000 to maintain support of the Department's major scientific user facilities. Facilities include structural biology research beam lines at the synchrotron light 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.

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 the 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 2002. BER will continue its support for graduate students and post-doctoral investigators in FY 2003. The number of graduate students and post-doctoral investigators will remain approximately at the FY 2002 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 postdoctoral 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 not included here. A total of 500 graduate students and post-doctoral investigators conducted their research at the EMSL in FY 2001.

BER will continue its commitment to and dependence on research scientists at the Nation's universities. Approximately 40 percent of BER basic research funding directly 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.

Funding Profile

(dollars in thousands)

	FY 2001 Comparable Appropriation	FY 2002 Original Appropriation	FY 2002 Adjustments	FY 2002 Comparable Current Appropriation	FY 2003 Request
Biological and Environmental Research					
Life Sciences	188,469	193,385	-812	192,573	210,878
Climate Change Research	125,678	129,469	-547	128,922	137,959
Environmental Remediation ..	104,235	69,637	+44,764	114,401	109,530
Medical Applications and Measurement Science.....	93,187	123,509	-510	122,999	45,848
Subtotal, Biological and Environmental Research.....	511,569	516,000	+42,895	558,895	504,215
Construction	2,495	11,405	--	11,405	0
Subtotal, Biological and Environmental Research.....	514,064	527,405	+42,895	570,300	504,215
General Reduction.....	--	-2,155	2,155	0	--
Total, Biological and Environmental Research.....	514,064[a b c]	525,250	45,050	570,300 [c]	504,215

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 $11,088,000 which was transferred to the SBIR program and $665,000 which was transferred to the STTR program.

[b] Excludes $650,000 which was transferred to the Science Safeguards and Security program in an FY 2001 reprogramming.

[c] Includes $43,947,000 in FY 2001 and $45,050,000 in FY 2002 for Environmental Management Science Program and Savannah River Ecology Laboratory being transferred from Environmental Management.

Funding By Site

(dollars in thousands)

	FY 2001	FY 2002	FY 2003	$ Change	% Change
Albuquerque Operations Office					
Los Alamos National Laboratory	22,447	19,848	18,681	-1,167	-5.9%
Sandia National Laboratories	3,474	3,391	2,737	-654	-19.3%
Albuquerque Operations Office	1,597	900	850	-50	-5.6%
Total, Albuquerque Operations Office	27,518	24,139	22,268	-1,871	-7.8%
Chicago Operations Office					
Ames Laboratory	1,066	690	512	-178	-25.8%
Argonne National Laboratory – East	27,521	23,067	22,595	-472	-2.0%
Brookhaven National Laboratory	23,549	18,862	15,993	-2,869	-15.2%
Chicago Operations Office	92,092	47,702	46,146	-1,556	-3.3%
Total, Chicago Operations Office	144,228	90,321	85,246	-5,075	-5.6%
Idaho Operations Office					
Idaho National Engineering & Environmental Laboratory	1,440	1,056	400	-656	-62.1%
Idaho Operations Office	37,029	37,050	29,886	-7,164	-19.3%
Total, Idaho Operations Office	38,469	38,106	30,286	-7,820	-20.5%
Oakland Operations Office					
Lawrence Berkeley National Laboratory	61,970	50,133	44,821	-5,312	-10.6%
Lawrence Livermore National Laboratory	33,450	32,715	36,899	+4,184	+12.8%
Stanford Linear Accelerator Center	3,656	4,170	5,550	+1,380	+33.1%
Oakland Operations Office	70,815	46,043	38,386	-7,657	-16.6%
Total, Oakland Operations Office	169,891	133,061	125,656	-7,405	-5.6%
Oak Ridge Operations Office					
Oak Ridge Inst. For Science & Education	5,179	4,893	4,761	-132	-2.7%
Oak Ridge National Laboratory	45,798	45,134	33,085	-12,049	-26.7%
Oak Ridge Operations Office	380	352	352	0	--
Thomas Jefferson National Accelerator Facility	620	400	500	+100	+25.0%
Total, Oak Ridge Operations Office	51,977	50,779	38,698	-12,081	-23.8%

(dollars in thousands)

	FY 2001	FY 2002	FY 2003	$ Change	% Change
Richland Operations Office					
Pacific Northwest National Laboratory	72,618	73,383	73,052	-331	-0.5%
Savannah River Operations Office	7,880	8,000	5,841	-2,159	-27.0%
Washington Headquarters	1,483	152,511	123,168	-29,343	-19.2%
Total, Biological and Environmental Research.....	514,064[a b c]	570,300 [c]	504,215	-66,085	-11.6%

[a] Excludes $11,088,000 which was transferred to the SBIR program and $665,000 which was transferred to the STTR program.

[b] Excludes $650,000 which was transferred to the Science Safeguards and Security program in an FY 2001 reprogramming.

[c] Includes $43,947,000 in FY 2001 and $45,050,000 in FY 2002 for Environmental Management Science Program and Savannah River Ecology Laboratory being transferred from Environmental Management.

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, 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 structural 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.

Global change activities 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 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 approaches to remediate 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 biological research community.

PNNL provides the lead scientist for the Environmental Meteorology Program, the G-1 research aircraft, and expertise in 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.

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 Stanford Synchrotron Radiation Laboratory 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 nearly 340 institutions, including colleges/universities, private industry, and other federal and private research institutions located in 43 states. Also included are funds for research awaiting distribution pending completion of peer review procedures.

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 in all aspects of the program. 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 programs. Academic investigators are 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 Objectives

The goal of the Life Sciences subprogram is to deliver knowledge in structural biology, genomics, and the health effects of low dose radiation. Human, animal, and microbial DNA sequencing will be used to understand the genetic and environmental basis of normal and abnormal function. Scientific tools will be developed to understand gene function and protein structure needed for biotechnology solutions for clean energy, carbon sequestration, environmental cleanup, and bioterrorism detection and defeat. Low dose radiation research will provide knowledge for rigorous, cost-effective standards to protect the health of cleanup workers and the public and for science-based decisions on DOE site cleanup operations.

BER's Life Sciences research is focused on developing, making available, and using unique DOE resources and facilities to understand and mitigate potential health effects of energy development, energy use, and waste cleanup, and develop novel biotechnology solutions for energy, environmental, and national security applications. BER supports research in five areas: structural and computational biology, low dose radiation, microbial biology, human genome, and biological research.

- BER develops and supports user facilities for the Nation's structural biologists; combines computer science, structural biology, and genome research for analyses and predictions of gene function from the individual gene to the genomic level; and develops new technologies and methodologies to understand the dynamic processes of protein-protein interactions that are unique to living organisms.
- BER supports research on low dose and low dose-rate radiation and addresses both the scientific issues and results with scientists, regulators, and the public to provide a better scientific basis for achieving acceptable levels of human health protection from low levels of ionizing radiation.
- BER takes advantage of the remarkable diversity of microbes found in the environment and our ability to identify and to understand how biological functions follow from the DNA sequence to the behavior of an entire organism. This information can help in the development of unique solutions in energy production, waste cleanup, and carbon management.
- BER is an integral part of the International Human Genome Project that has made publicly available a highly accurate sequence of the human DNA sequence. The BER Human Genome program also develops resources, tools, and technologies needed to analyze and interpret DNA sequence data from entire organisms, determines the function of the genes identified from DNA sequencing, and studies the ethical, legal, and social implications (ELSI) of information and data resulting from the genome project.
- Finally, BER's research program is developing the capability to predict how single cells and multi-cellular organisms respond to biological and environmental cues and to use this predictive capability to address DOE needs in energy, the environment, and for national security. This challenge starts with the remarkable progress being made in all other parts of the Life Sciences subprogram, from DNA sequencing to structural biology, and requires the development of new technologies, analytical methods, and modeling capabilities.

The Life Sciences subprogram's support of microbial genome research also contributes to the BER clean energy and carbon sequestration research programs. Knowing the genomic sequence of microbes that are involved in carbon sequestration or that produce methane and hydrogen, is enabling the identification of the key genetic and protein components of the organisms that regulate these processes. Understanding more fully how the enzymes and organisms operate will enable scientists to evaluate their potential use to remove excess carbon dioxide from the atmosphere or to produce methane or hydrogen from either fossil fuels or other carbonaceous sources, including biomass or even some waste products. Recently discovered extremophile organisms could be used to engineer biological entities that could ingest a feedstock like methane, produce hydrogen, and sequester the carbon dioxide by-product.

Funding Schedule

(dollars in thousands)

	FY 2001	FY 2002	FY 2003	$ Change	% Change
Structural Biology	35,975	27,927	27,847	-80	-0.3%
Molecular and Cellular Biology	49,387	58,272	73,264	+14,992	+25.7%
Human Genome	85,491	87,858	90,185	+2,327	+2.6%
Health Effects	17,616	13,640	14,251	+611	+4.5%
SBIR/STTR	0	4,876	5,331	+455	+9.3%
Total, Life Sciences	188,469	192,573	210,878	+18,305	+9.5%

Detailed Program Justification

(dollars in thousands)

	FY 2001	FY 2002	FY 2003
Structural Biology	**35,975**	**27,927**	**27,847**
▪ **Basic Research**	**12,012**	**12,627**	**12,547**

BER will continue to invest in structural biology research. In biology, most proteins do not act independently in living systems. In carrying out their functions within cells, proteins form complexes with other proteins (molecular machines) and interact with a variety of structural and regulatory molecules on which proteins carry out their functions. The role of structure in determining protein interactions with diverse molecules in a cell is still poorly understood. Understanding how molecular machines carry out their biological functions requires that we observe dynamic changes in protein structure and study protein modifications, translocation, 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 translocations.

DOE investment in structural biology research is having a large impact on basic research investments being made by other agencies. DOE investments in structural biology user facilities at synchrotron light sources and at the Environmental Molecular Sciences Laboratory (EMSL) and in development of key technologies for speeding the determination of protein structure have enabled the National Institute of General Medical Sciences at the National Institutes of Health (NIH) to make a large investment (over $25,000,000 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 seven initial pilot projects, funded by NIH, include partners from DOE Laboratories and nearly all are centered around DOE user facilities.

Performance will be measured by the development of experimental and 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.

- **Infrastructure Development** **23,963** **15,300** **15,300**

BER supports and develops beamlines and instrumentation for the Nation's structural biologists. It coordinates with the NIH and the NSF development and operation of experimental stations at DOE synchrotrons (Advanced Photon Source, Advanced Light Source, Stanford Synchrotron Radiation Laboratory and National Synchrotron Light Source) and neutron beam sources (the Los Alamos Neutron Science Center (LANSCE) and High Flux Isotope Reactor at ORNL). BER also supports access to mass spectrometry and nuclear magnetic resonance spectrometry user facilities at the EMSL that are used for both proteomic and structural biology research. University scientists are the principal users of these facilities.

Performance will be measured by having more than 2,500 highly satisfied users of the structural biology instruments at the DOE national user facilities.

By the end of FY 2003, BER's new (funded in FY 2001) DNA Repair Protein Complex Beamline at the Advanced Light Source at Lawrence Berkeley National Laboratory will be operational and available for users. This beamline will have novel features that include the ability to conduct both high-resolution (2 Angstrom) and low-resolution (2000 Angstrom) studies on important biomolecules using the same beamline. It will meet a rapidly growing need in the structural biology user community to provide unique information on functionally important conformational changes of multiprotein complexes and on factors that regulate the assembly of those complexes.

(dollars in thousands)

FY 2001	FY 2002	FY 2003

BER also operates the neutron protein crystallography station at the Los Alamos Neutron Science Center (LANSCE) and will complete a new station for small angle neutron scattering at the High Flux Isotope Reactor (HFIR) at ORNL.

Performance will be measured by having ten external user groups use the LANSCE protein crystallography station and by beginning the commissioning of the Biological Small Angle Neutron Scattering Station at the Oak Ridge National Laboratory High Flux Isotope Reactor by the end of FY 2003.

BER also supports, with NSF and NIH, the Protein Data Bank for three-dimensional protein structures, a resource of growing importance that serves the NIH's high throughput structural genomics initiative as well as the Nation's life sciences research programs.

Unique facilities being developed at BER's Environmental Molecular Sciences Laboratory (EMSL) are now being made available to the structural biology user community.

Performance will be measured by the number of users resulting from the use of advanced mass spectrometry and nuclear magnetic resonance instrumentation at the Environmental Molecular Sciences Laboratory (EMSL) for structural biology and proteomics research.

Molecular and Cellular Biology	**49,387**	**58,272**	**73,264**
▪ **Microbial Genomics**	**13,345**	**10,868**	**10,928**

- *Microbial genomics research addresses DOE mission needs* – The program continues to sequence microbes that will be used to impact several DOE missions including: microbes for energy production (methane or hydrogen producing microbes), as alternative fuel sources (methane production or energy from biomass), for carbon sequestration, for helping to clean up the environment, and that are related to potential biothreat agents. 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 keys 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.
- *Scientific needs of the DOE microbial genome program* – Now that the DNA sequence of more than 50 microbes with potential uses in energy, waste cleanup, and carbon sequestration have been determined, the program is beginning to further interpret and use that DNA sequence information. In FY 2003, the microbial genome program will continue to focus on 5 scientific challenges:
  - *Functional analysis* - It is presently difficult to predict biological function of novel genes from genomic sequence data. The program is developing better experimental and computational methods to identify these novel genes and predict the functions of the proteins they encode.

(dollars in thousands)

FY 2001	FY 2002	FY 2003

- *Bioinformatics* – More than a third of the nearly 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.
- *Microbial Genomic Plasticity* – Current microbial DNA sequence data strongly suggests 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 sequence data and for designing novel strategies for using microbes to address DOE mission needs.
- *Novel Approaches to Microbial Genomic Sequencing* - 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.
- *Consortia and Hard-to-Culture Microbes* – Most microbes in the environment neither live in isolation from other microbes or can be readily grown in the laboratory. Research is focused on the organization, membership, or functioning of consortia of microbes, especially those involved in environmental processes of interest to DOE or that use potential biothreat agents, and on the development of technologies that enable genomic analyses of these consortia without the need for isolating individual microbes.

Performance will be measured by drafting genomic sequence of more than 30 microorganisms of high DOE relevance and scientific research; improving the computational tools for predicting gene function; and by the development of methods for sequencing unculturable microbes and microbial consortia.

- **Carbon Sequestration Research** **7,127 7,107 7,138**

Microbes play a substantial role in the global cycling of carbon through the environment. The main emphasis of the program in FY 2003 is to leverage this new genomic DNA sequence information to characterize key biochemical pathways or genetic regulatory networks in these microbes. Analysis of biochemical pathways has previously focused on single genes or small numbers of genes at one time. Research in this program will focus, as described above, on the development and use of new, high-throughput technologies to determine the function of new genes discovered from microbial DNA sequencing. 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.

(dollars in thousands)

FY 2001	FY 2002	FY 2003

Performance will be measured by the completion of a draft 3x DNA sequence of a member of the genus *Populus* (trees like poplar, aspen, etc.). These rapidly growing trees not only offer an opportunity for carbon sequestration, but also for bioremediation and energy from biomass. In addition, *Thalassiosira*, a diatom important in oceanic sequestration will also be draft sequenced.

- **Genomes to Life** **9,361 21,514 36,675**

Research on microbes that address DOE energy, environmental, and national security needs continues to expand in FY 2003 as a research program on the leading edge of biology. The research will offer new biotechnology solutions to challenges related to DOE's missions in, for example, new clean energy sources, climate stabilization through carbon sequestration, toxic waste cleanup, and biothreat reduction.

Microbes and plants are responsible for the initial production of essentially all carbon-based energy that we use, whether from oil, coal or biomass, and for the subsequent removal of the energy-related carbon from the atmosphere. Microbes and microbial communities also make up about 60% of the biomass on Earth and have the potential to make a substantial impact on energy production, sequestration of carbon from the atmosphere, and the cleanup of hazardous waste. A deeper, genetically based understanding of these organisms, culminating in computational models of their function that can be used to predict and even modify their functions or efficiencies, promises a revolution in energy production, use, and environmental impact. This research program is part of an interagency program to understand life's basic processes to meet National goals in many areas including health, agriculture, and energy.

The availability of complete genome sequences for all manner of life on Earth has opened a new era and new opportunities in biology. Research on the biological processes involved in the carbon cycle will lead to new biological strategies for storing and monitoring carbon. Understanding metabolic pathways and their regulatory networks will allow us to more effectively use or create designer microbes or plants that produce and convert biomass for fuel, power, and products. Harnessing metabolic or regulatory pathways in hydrogen-producing microbes could provide an alternative and ultimately clean energy source. This new understanding will also enable development of better detection and prevention strategies for potential biothreat agents.

We are just beginning to appreciate the potential applications of microorganisms. For all intents and purposes, ours is a microbial world filled with microscopic creatures that we take for granted and almost never even know are there. Microorganisms are Earth's recyclers, participating in the recycling of most biological materials on Earth. In the process they produce and, together with plants, take up greenhouse gases. Microbes in particular have evolved on Earth for some 3.8 billion years and, as suggested by their diversity and range of adaptation, have long ago solved many problems for which DOE is seeking solutions. It has been estimated that more than 99% of Earth's genetic and metabolic diversity, and, importantly, Earth's useable potential, reside in the microbial universe of bacteria, fungi, archaea, and minute protozoa and micro algae that collectively comprise the planktonic communities in the oceans and the majority of life in soil.

(dollars in thousands)

FY 2001	FY 2002	FY 2003

Underlying all potential applications of biotechnology to clean energy, mitigation of greenhouse gas effects on climate change, and environmental cleanup is the need for a solid understanding of the biochemistry and genetics of plants and microorganisms. We are only now beginning to appreciate the complexity of metabolic and regulatory signaling pathways in the simplest of bacteria that might be harnessed for clean energy and carbon management. Two simple examples: If, in the long-term, we are to enhance the productivity of forests, biomass crops and agricultural systems, it is imperative to understand why, for example, Rubisco--a mediator of photosynthesis and the single most abundant enzyme complex on Earth--is seemingly so energetically inefficient. This research program may show us that Rubisco can be engineered to carry out carbon fixation more efficiently, if its genetic regulatory circuits can be "rewired" or, perhaps, that there are more efficient forms of this enzyme still waiting to be discovered and used. Similarly, it may help to develop a more efficient hydrogen-based energy economy through an understanding of how oxygen poisons a key group of enzymes, hydrogenases, capable of producing hydrogen in the absence of air. This program will help us answer these types of questions.

The capture and sequestration of huge, gigaton volumes of carbon dioxide (CO_2) on a global scale from power generation and heavy industry is central to the success of any future strategy to control atmospheric greenhouse gases. This research program contributes to this challenge through its systems approach to understand biological systems at both the molecular and environmental (microbial community) levels that can point to possible applications of this new knowledge. With an appropriate geologic energy source, subsurface microbial communities under thermodynamically favorable conditions might be manipulated to convert sequestered CO_2 into biomass, and ultimately extractable methane. This program will also seek to understand the need to understand microbiological and biogeochemical mechanisms important to long-term geologic storage and leakage of stored CO_2.

Bioprocesses are often more energy efficient than current industrial processes. A key challenge, therefore, is to take advantage of and apply nature's efficiency to large-scale processing, a result that would help transform the energy economy. Bioconversion uses microorganisms such as bacteria and fungi or cell-free enzyme systems to capture energy or to transform organic or inorganic materials to useful products including fuel, food, fiber, and commodity and special chemicals. Heading the list of possibilities is the direct biological production of hydrogen and, perhaps in a simultaneous process, reducing the carbon density of coal, oil, and gas. Bioconversion also promises innovative approaches to clean energy and for mitigating greenhouse gas emissions by directly capturing emissions from industry and power generation. This program will provide the necessary knowledge base and the biotechnology tools to explore these possibilities.

Proteins rarely work alone. They assemble in larger multi-protein complexes often referred to as molecular machines. Understanding these molecular machines is a major goal of the research. Similarly, microbes of potential importance for DOE's energy and cleanup missions rarely work alone in nature. Microbes are often found as part of complex, and poorly understood consortia of many different types of microbes.

(dollars in thousands)

FY 2001	FY 2002	FY 2003

The research will:

- Identify life's molecular machines, the multiprotein complexes that carry out the functions of living systems. Emphasis will focus on molecular machines from organisms of potential importance to DOE missions (e.g., energy production, environmental remediation, and carbon sequestration, and biothreat reduction).
- Characterize the gene regulatory networks and processes that control the molecular machines of interest.
- Characterize the functional repertoire of complex microbial communities in their natural environments and use the integrated genomics, biochemical, structural, and physiological information to address DOE missions in energy, waste cleanup, and biothreat reduction.
- Develop computational capabilities needed to model the complexity of biological systems.

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.

Computation and modeling of biological processes and systems is key to the success of this effort given the complexity of biological systems. Greatly improved computational strategies, tools and resources are needed and will be developed in partnership with the Advanced Scientific Computing Research program. One goal is to bring terascale computing into Genomes to Life as a model for all biologists.

The broad goals of this research are shared with other agencies, such as the National Institutes of Health and the National Science Foundation, 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 will focus on high throughput genomic-scale activities (e.g., DNA sequencing, complex computational analysis, and genomic protein-expression experimentation and analysis) that are out of reach of individual investigators or even small teams.

The increase in funding will accelerate development of the research infrastructure needed to conduct the complex, multidisciplinary research. Funds will be used to develop peer-reviewed, virtual, distributed research centers comprised of teams of National Laboratory, university, and private sector scientists who, together will develop, use, and distribute research resources for the program.

Performance will be measured by:

- The funding of new, large multidisciplinary research teams comprised of scientists from National Laboratories and universities and by the successful partnering with research programs in other federal agencies.
- In conjunction with ASCR, develop new computational tools for the analysis and simulation of biological processes.

(dollars in thousands)

FY 2001	FY 2002	FY 2003

- 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.

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

BER will continue to fund the Human Frontiers Science program, an international program of collaborative research to understand brain function and biological function at the molecular level supported by the U.S. government through the DOE, the National Institutes of Health, the National Science Foundation, and the National Aeronautics and Space Administration. This program continues to get high marks from the international scientific community about the quality of the science it supports, the multidisciplinary and collaborative nature of the research and its productivity. In FY 2002, DOE expects to explore the possibility of other agencies with stronger interests in brain function continuing the program allowing DOE to refocus its efforts on more mission relevant science. FY 2003 funding will complete DOE activities.

- **Low Dose Radiation Research** **18,362** **17,783** **17,523**

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.

In FY 2003, BER will continue to emphasize the use of new tools such as microbeam irradiators developed in the program in prior years, the characterization of individual susceptibility to radiation, and the forging of 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.
- *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.

- *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.
- *Endogenous versus low dose radiation induced damage* - A key element of 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.
- *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.

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.

Performance will be measured: By the end of FY 2003, results from the Low Dose Radiation Research program will be incorporated into the National Academy of Sciences Biological Effects of Ionizing Radiation (BEIR) VII report that will serve as a basis for future policy decisions on low dose radiation.

(dollars in thousands)

FY 2001	FY 2002	FY 2003

- **Congressional Direction** **192** **0** **0**

  Congressional direction in FY 2001 for a Study of Avian Populations at the Nevada Test Site.

Human Genome **85,491** **87,858** **90,185**

- **Joint Genome Institute** **61,822** **57,200** **57,200**

  With the completion of the high quality DNA sequences of human chromosomes 16 and 19 in FY 2002 (DOE's share of the effort to sequence the human genome), the Joint Genome Institute (JGI) will continue to use its sequencing capacity to address the challenges of understanding the human genome, to address DOE mission needs and as a resource for our Nation's scientists. Past investments in DNA sequencing technology have continued to push costs down and throughput up making high-throughput DNA sequencing an even better scientific investment and a more effective research tool than ever for gene identification, finding gene regulatory elements, elucidating gene function, understanding evolutionary processes, developing the tools needed to predict cellular response to environmental stress, and performing the genetic manipulations needed to improve or alter gene function. In FY 2003 the JGI will focus on four main scientific areas:

  - Microbial and Fungal Genomics
  - Human Susceptibility
  - Understanding the Regulatory Functions of DNA
  - JGI as a National Resource

  MICROBIAL AND FUNGAL GENOMICS – The JGI anticipates using 20% of its production DNA sequencing throughput on microbial and fungal genomics as well as a similar level of effort on functional genomics. The JGI will continue its efforts to understand the genomes and proteomes of microbial and fungal genomes important to DOE for:

  - Carbon Sequestration - organisms that remove carbon from the environment
  - Energy Sources - organisms that display novel photosynthetic or energy producing characteristics
  - Bioremediation – organisms that act to clean up the environment
  - Environmental Analysis - understanding how communities of microbes relevant to DOE missions interact to alter and detoxify their environment.
  - Bioterrorism – organisms that could be used as or closely related to biothreat agents.

  HUMAN SUSCEPTIBILITY - With the completion of the human DNA sequence we are now poised to understand how genes and the environment interact. This is especially important for understanding the role our genetic makeup plays in defining how we as individuals respond to

environmental stress in its many forms. This ties into many DOE programs, including the Low Dose Radiation Research program. The JGI will systematically analyze the human genome to first identify and then determine DNA sequence variation in the estimated ~5,000 human susceptibility genes. This will require an estimated 30% of the JGI production DNA sequencing capacity and the majority of its functional genomics resources. This information will be key to the Low Dose Radiation Research program with its complementary goal of understanding and characterizing genetic factors that contribute to individual sensitivity to energy-related insults.

UNDERSTANDING THE REGULATORY FUNCTIONS OF DNA - As a continuation of its responsibility to help understand the functioning of the human genome and as a key part of research on microbes for DOE energy and environmental needs, the JGI will focus on understanding the regulatory functions of DNA, such as gene regulation, characterization of DNA binding proteins and the full elucidation of gene promoters, enhancers and other regulatory mechanisms. Approximately 30% of the JGI's production DNA sequencing capacity will be required to meet this goal in addition to a proportion of its functional genomics resources. Model genomes currently under consideration for DNA sequencing and functional analysis to meet this goal include the *Ciona intestinalis*, chicken, and *Xenopus tropicalis*.

JGI AS A NATIONAL RESOURCE - A proportion, 20%, of the JGI's production DNA sequencing facility will be dedicated to the sequencing of a number of genomes or regions of interest as defined by the broader scientific community. This has proved to be a very productive and successful venture as demonstrated by previous "microbe months" in which large numbers of microbes were sequenced for JGI's scientific collaborators in a focused effort. The JGI will continue to seek guidance from its scientific advisors and to ensure that its efforts are of maximal benefit to DOE programs. Included in the JGI's DNA sequencing as a national resource is the completion of selected microbial and fungal genomes and a variety of projects in collaboration with and through grants from other agencies, such as the USDA.

Performance will be measured by (1) producing, with no increased funding, a total of approximately 8 billion base pairs of DNA sequence in FY 2003, a 100% increase in the number projected for FY 2001, and (2) establishing at least 30 diverse collaborations for high throughput DNA sequencing with scientists outside the JGI and with programs at other federal agencies.

- **Tools for DNA Sequencing and Sequence Analysis**..... **21,242** **28,179** **30,280**

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. Unimaginable amounts of DNA sequencing, at dramatically increased speed and reduced cost, will be required in the future for medical and commercial purposes and to understand the information in the DNA sequence that has already been determined. BER continues to support research to further improve the reagents used in DNA sequencing and analysis; to decrease the costs of sequencing; to increase the speed of DNA sequencing; and new computational tools for genome-wide data analysis. Novel sequencing strategies such as microchannel capillary electrophoresis offer great promise for the every day sequencing needs of the future.

(dollars in thousands)

FY 2001	FY 2002	FY 2003

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 2003, BER will continue to increase efforts to develop high-throughput approaches for analyzing gene regulation and function.

- **Ethical, Legal, and Societal Issues (ELSI)** **2,427** **2,479** **2,705**

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 issues associated with the genome program. DOE's ELSI research program represents 3 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 multi-genic characteristics and conditions.

A table follows displaying both DOE and NIH genome funding.

U.S. Human Genome Project Funding

(dollars in millions)

	Prior Years	FY 2001	FY 2002	FY 2003
DOE Total Funding (FY 87-00).....	779.0	85.5	87.9	90.2
NIH Funding (FY 88-00).....	1,859.2	382.4	426.7[a]	TBD
Total U.S. Funding.....	2,638.2	467.9	514.6	TBD

(dollars in thousands)

	FY 2001	FY 2002	FY 2003
Health Effects.....	**17,616**	**13,640**	**14,251**
▪ **Functional Genomics Research**.....	**14,417**	**13,640**	**14,251**

Scientific needs for functional genomics research - Functional genomics research capitalizes on our understanding and the manipulability of the genomes of model organisms, including Fugu (puffer fish), Ciona (sea squirt), and mouse, to speed understanding of human genome organization, regulation, and function. This research is a key link between human genomic sequencing, which provides a complete parts list for the human genome, and the development of information (a high-

[a] Estimate from NIH.

(dollars in thousands)

FY 2001	FY 2002	FY 2003

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. It is an integral part of our functional genomics research effort. 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 strategies for using model organisms such as the mouse, Fugu, and *Ciona* to understand the function of human genes continues in FY 2003.

▪ **Technology Development Research**	**3,199**	**0**	**0**

Technology development research is absorbed within the individual Life Sciences subprogram elements.

SBIR/STTR increased with Life Sciences program increase	**0**	**4,876**	**5,331**

In FY 2001 $4,329,000 and $260,000 were transferred to the SBIR and STTR programs, respectively. FY 2002 and FY 2003 amounts are estimated requirements for the continuation of these programs.

Total, Life Sciences	**188,469**	**192,573**	**210,878**

Explanation of Funding Changes from FY 2002 to FY 2003

	FY 2003 vs. FY 2002 ($000)
Structural Biology	
▪ Maintain structural biology research at near FY 2002 levels	-80
Molecular and Cellular Biology	
▪ Increase for Genomes to Life research on microbes that work to address DOE needs focused on understanding cellular processes and multicellular systems to a level where predictive simulation models can be developed to guide the use or development of microbial systems to solve DOE mission needs for energy use and production, waste cleanup, carbon sequestration, and biothreat reduction; and maintain microbial genomics and carbon sequestration research at near FY 2002 levels	+15,252
▪ Maintains Low Dose Radiation Research at near FY 2002 levels.	-260
Total, Molecular and Cellular Biology	+14,992

	FY 2003 vs. FY 2002 ($000)
Human Genome	
▪ High throughput sequencing to characterize the function and regulation of genes on human chromosomes 5, 16, 19 (the chromosomes worked on by DOE) and to use high throughput sequencing as a basic research tool in biology	+2,101
▪ Ethical, Legal, and Societal Issues program maintains funding at approximately 3% of total human genome funding	+226
Total, Human Genome	+2,327
Health Effects	
▪ Increase for research that develops strategies and tools to understand human gene function using model organisms.	+611
SBIR/STTR	
Increase in SBIR/STTR due to increase in research funding for the Life Sciences program.	+455
Total Funding Change, Life Sciences	+18,305

Climate Change Research

Mission Supporting Goals and Objectives

The goal of the Climate Change Research subprogram (previously the Environmental Processes subprogram) is to deliver relevant scientific knowledge that will enable scientifically-based predictions and assessments of the potential effects of greenhouse gas and aerosols 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). The National Institute for Global Environmental Change (NIGEC) is integrated throughout the subprogram (FY 2003 Request is $8,763,000).

A major emphasis of the Climate Change Research subprogram is on understanding the radiation balance from the surface of the Earth to the top of the atmosphere and how changes in this balance due to increases in the concentration of greenhouse gases in the atmosphere may alter 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 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 research 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.

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 global change data and make it available for use by the broader global change research community.

Funding Schedule

(dollars in thousands)

	FY 2001	FY 2002	FY 2003	$ Change	% Change
Climate and Hydrology	71,205	70,490	74,669	+4,179	+5.9%
Atmospheric Chemistry and Carbon Cycle	35,193	34,666	37,764	+3,098	+8.9%
Ecological Processes	11,352	12,383	13,888	+1,505	+12.2%
Human Interaction	7,928	8,054	8,084	+30	+0.4%
SBIR/STTR	0	3,329	3,554	+225	+6.8%
Total, Climate Change Research	125,678	128,922	137,959	+9,037	+7.0%

Detailed Program Justification

	(dollars in thousands)		
	FY 2001	FY 2002	FY 2003
Climate and Hydrology	**71,205**	**70,490**	**74,669**
▪ **Climate Modeling**	**27,301**	**27,064**	**27,181**

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 be provided to acquire 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 processes.

Performance will be measured: By the end of FY 2003, the program will increase the realism of the parallel coupled climate model by increasing the spatial resolution of the atmospheric model to 1.4 degrees and the ocean and sea ice model to approximately 0.7 degrees, which will be a higher resolution than any fully coupled climate model currently available to assess climate change. The capacity to produce multiple, long-term climate change scenarios for climate change research and assessment purposes will be enhanced by improvements in computing software and the development of improved algorithms needed to effectively exploit the new computing technology.

In FY 2003, 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 increase the emphasis on 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.

NIGEC will continue the support of research to evaluate the reliability of using isotopic signatures of trace gases in ice cores for interpreting climate variation and change in the past and the relationship between greenhouse gas concentrations and climate change (FY 2003 Request is $2,191,000).

- **Atmospheric Radiation Measurement (ARM) Research** **13,812 13,310 13,310**

The principal goal of the ARM scientific enterprise is to develop 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.

Performance will be measured: By the end of FY 2003, the program will deliver a more realistic representation of clouds for incorporation in atmospheric general circulation models. The improved representation of clouds will result in a 10% reduction in the uncertainty in calculations of the atmospheric energy budget and improve the accuracy and precision of climate models used to simulate and predict the effects on climate of atmospheric increases in energy-related greenhouse gases and aerosols.

- **Atmospheric Radiation Measurement (ARM) Infrastructure**.. **27,371 27,371 31,441**

The Atmospheric Radiation Measurement (ARM) infrastructure program develops, supports, and maintains 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, pygeometers, 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.

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 (IOP). 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 increased funding will provide new instrumentation at the three ARM sites to measure the major components of the water cycle (including atmospheric water vapor, precipitation, evaporation, transpiration, soil water, and water runoff from land surfaces) and to measure energy-related aerosols and their radiative properties. The water cycle measurements will improve the climate models' parameterization of the coupling of radiation, cloud processes, and the land surface processes to reduce the current high uncertainty in predictions of precipitation patterns. The new knowledge gained from the water cycle study and aerosol measurements is important for climate studies. Additional staff and equipment will be provided to the ORNL ARM Data Archive to quality assure and distribute the data. The investment will increase the ARM users from about 680 to 800.

Performance will be measured by achieving a downtime of less than five percent for the principal ARM instruments and by the successful conduct of five IOPs across the three ARM sites.

- **Atmospheric Radiation Measurement (ARM)/Unmanned Aerial Vehicles (UAV)**..... **2,721** **2,745** **2,737**

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 budget.

Atmospheric Chemistry and Carbon Cycle..... **35,193** **34,666** **37,764**

- **Atmospheric Science** **14,582** **12,510** **12,571**

The Atmospheric Science projects 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 2003 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 global 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 2003 the Atmospheric Sciences subprogram will, in general, focus on the evaluation of preliminary findings from field measurement campaigns in both atmospheric chemistry and environmental meteorology.

Performance will be measured by the extent, over five years, to which scientific results are incorporated into models to predict and assess air quality and radiative forcing of other energy-related greenhouse gases (such as ozone) and aerosols.

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 2003 Request is $2,191,000).

- **Terrestrial Carbon Processes and Ocean Sciences**..... **10,557** **13,635** **13,716**

BER will continue supporting the AmeriFlux program, which is a network of approximately 25 research sites where 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 several AmeriFlux sites.

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

Performance will be measured: By the end of FY 2003, the program will deliver quantitative estimates of net annual carbon sequestration in terrestrial ecosystems at five of the AmeriFlux network sites. The program will also deliver regional-scale estimates of the terrestrial carbon budget for three regions in North America such as the deciduous forest region of the eastern U.S.

(dollars in thousands)

FY 2001	FY 2002	FY 2003

The 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).

- **Climate Change Research Initiative** **0** **0** **2,920**

In FY 2003, the Administration will institute a new Climate Change Research Initiative (CCRI). The set of cross agency programs with a strong focus on outcomes and deliverables. The CCRI will focus on specific areas of research, including climate variation and change, carbon cycle, water cycle, atmospheric composition, and regional impacts. DOE, in conjunction with other USGCRP agencies, e.g., NASA, NOAA, NSF, etc., will contribute to one specific research area. The deliverables will be targeted at information useful to policy-makers, such as more reliable predictions of what the future climate would be under different greenhouse forcing scenarios and how much climate and land use changes will affect natural sources and sinks of carbon. DOE will participate in one of the specific research areas: understanding the North American Carbon Cycle (with NOAA, NSF, and USDA), which is identified as a priority need in the interagency Carbon Cycle Science Plan.

BER activities on the carbon cycle explore the movement of carbon on a global scale starting from natural and anthropogenic emissions to ultimate sinks in the terrestrial biosphere and the oceans. The AmeriFlux sites are essential to quantifying the net exchange of carbon between the atmosphere and major terrestrial ecosystems in North America and hence are essential to documenting the magnitude and variation in the North American carbon sink and how it is affected by interannual changes in climate. Experimental and modeling efforts primarily address the net exchange of carbon between major types of terrestrial ecosystems and the atmosphere.

BER will expand the facilities in the successful AmeriFlux program by including intensive measurements of additional parameters (e.g., above and belowground carbon stocks in roots, soil organic matter, aboveground tree trunks, stems leaves, litter, etc., and mortality of vegetation) and processes (e.g., photosynthesis, plant and microbial respiration rates, decomposition rate, carbonic acid weathering rate (which consumes CO_2), and vegetation growth rate) at the existing 25 AmeriFlux sites across North America and extensive measurements that transcend larger areas surrounding these sites, thereby allowing the estimation of carbon sources and sinks at landscape and regional scales. This information will provide a sound scientific basis for extrapolating carbon flux measurements at AmeriFlux sites to regional and continental scales and hence, improve estimates of both the magnitude of the North American carbon sink and the major terrestrial ecosystems that account for the sink. Fluxes of other greenhouse gases, including methane, nitrous oxide, and water vapor will also be measured at several AmeriFlux sites. The investment will increase the number of users from about 125 to 200.

	(dollars in thousands)		
	FY 2001	FY 2002	FY 2003
▪ **Congressional Direction**	**1,725**	**0**	**0**

Congressional direction in FY 2001 for the National Energy Laboratory in Hawaii and the Western States Visibility Study at New Mexico Tech.

▪ **Carbon Sequestration Research**	**8,329**	**8,521**	**8,557**

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 ($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 Carbon Sequestration in Terrestrial Ecosystems (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 successfully 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.

Performance will be measured by applying an ecosystem framework to estimate annual rates of actual carbon gain by vegetation and soil, and enhanced sequestration will be estimated relative to baseline carbon quantities established for the range of ecosystems investigated by the CSiTE.

In FY 2003 university scientists will continue research on the effects of iron fertilization on plankton communities in the ocean and begin field experiments. 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.

(dollars in thousands)

FY 2001	FY 2002	FY 2003

Performance will be measured by the analysis and publication of results from the Southern Ocean Iron Fertilization Experiment (SOFeX) which 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 surface ocean, delivering data necessary to understand and assess the efficacy of using iron fertilization to enhance carbon sequestration in the ocean.

Ecological Processes **11,352** **12,383** **13,888**

BER will continue the six Free-Air Carbon Dioxide Enrichment (FACE) experiments at Maricopa, Arizona; Cedar Creek Natural History Area, Minnesota; Duke University, Durham, North Carolina; Rhinelander, Wisconsin; Mercury, Nevada; and Oak Ridge, Tennessee (ORNL) to improve understanding of the direct effects of elevated carbon dioxide and other atmospheric changes on the structure and functioning of various types of terrestrial ecosystems, including coniferous and deciduous forests, grasslands, and desert. Increasing emphasis will be on evidence 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.

Currently, the number of users conducting research at FACE facilities is affected by increased operational costs (e.g., cost of gases, electricity, security, and maintenance, replacement, and upgrade of instruments and other infrastructure at these facilities). The FY 2003 investment will provide the operational resources needed to effectively and efficiently maintain planned operation of the FACE facilities, thereby ensuring the facilities are maintained and operated in a way that benefits and attracts users and supports their needs. This investment in FACE facility operations will allow an increase in the number of users from about 200 in FY 2002 to 300 in FY 2003.

Performance will be measured by completion of a 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 for use in assessing forest responses to alterations in precipitation resulting from climate change.

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 2003 Request is $2,629,000).

	(dollars in thousands)		
	FY 2001	FY 2002	FY 2003
Human Interactions	**7,928**	**8,054**	**8,084**
▪ **Human Interactions**	**7,928**	**8,054**	**8,084**

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 new emphasis will be to improve the integrated assessment models to include other greenhouse gases as well as carbon dioxide, 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 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. 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.

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 2003 Request is $1,752,000).

The Information and Integration element stores, evaluates, and quality-assures a broad range of global environmental change data, and disseminates these 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.

	(dollars in thousands)		
	FY 2001	FY 2002	FY 2003

Performance will be measured by sustaining the number, quality, and diversity of students enrolled in the program and by end-of-summer evaluations by students and their mentors.

SBIR/STTR	**0**	**3,329**	**3,554**

In FY 2001 $3,160,000 and $188,000 were transferred to the SBIR and STTR programs, respectively. FY 2002 and FY 2003 amounts are estimated requirements for the continuation of these programs.

Total, Climate Change Research	**125,678**	**128,922**	**137,959**

Explanation of Funding Changes from FY 2002 to FY 2003

	FY 2003 vs. FY 2002 ($000)
Climate and Hydrology	
▪ Climate modeling continued at near FY 2002 level.	+117
▪ The ARM increase in funding will support new instrumentation and ARM site staff for additional user support at the ARM sites and ARM data archive to allow the replacement and maintenance of ARM instruments and needed user support for scientists who use the ARM data or the ARM sites for field research.	+4,070
▪ Unmanned Aerial Vehicle (UAV) continued at near FY 2002 level.	-8
Total, Climate and Hydrology	+4,179
Atmospheric Chemistry and Hydrology	
▪ Atmospheric science continued at near FY 2002 level.	+61
▪ Terrestrial Carbon Process and Ocean Sciences continued at near FY 2002 levels.	+81
▪ BER will participate in the Climate Change Research Initiative research area to understand the North American carbon cycle by expanding the AmeriFlux network of research sites to allow regional extrapolation of net carbon exchange measurements.	+2,920
▪ Carbon Sequestration Research Consortia continued at near FY 2002 level.	+36
Total, Atmospheric Chemistry and Hydrology	+3,098

	FY 2003 vs. FY 2002 ($000)
Ecological Processes	
▪ The increase will support core operational costs at FACE sites to allow additional users at the sites by enabling the sites to be operated and maintained so as to attract a broader community of scientific users.	+1,505
Human Interactions	
▪ Human Interactions research is continued at near FY 2002 levels.	+30
SBIR/STTR	
Increase in SBIR/STTR due to increased research funding for Climate Change Research.	+225
Total Funding Change, Climate Change Research.....	+9,037

Environmental Remediation

Mission Supporting Goals and Objectives

The goal of the Environmental Remediation subprogram is to deliver relevant scientific knowledge that advances novel biotechnology solutions for environmental cleanup operations. Research on modified microbial processes that can stabilize radioactive waste and other toxic pollution in place, will contribute to remediation and restoration of contaminated environments at DOE sites and may also improve processes for recovery of valuable metals and production of fuel stocks.

BER's research in environmental remediation is focused on gaining improved understanding of the fundamental biological, chemical, geological, and physical processes that must be marshaled for the development and advancement of new, effective, and efficient processes for the remediation and restoration of the Nation's nuclear weapons production sites. Research priorities are on bioremediation and on operation of the William R. Wiley Environmental Molecular Sciences Laboratory (EMSL).

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 this subprogram, BER also includes basic research in support of pollution prevention, sustainable technology development and other fundamental research to address problems of environmental contamination.

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 affected 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.

Clean up research activities include a modest program in clean up research that will characterize the geologic, chemical, and physical properties that affect the rate and effectiveness of a variety of environmental remediation and waste-stream cleanup methods, including bioremediation; the Environmental Management Science Program, a cooperative program with the Office of Environmental Management to provide the science to solve the cleanup problems of the Nation's nuclear weapons complex; and ecological research conducted at the Savannah River Ecology Laboratory. The latter two activities are transferred in FY 2003 from Environmental Management to the Biological and Environmental Research program.

Within Facility Operations, support of the operation of the EMSL national user facility is provided for basic research that will underpin safe and cost-effective environmental remediation methods and technologies, other environmental science endeavors, and national security. Unique EMSL facilities, such as the Molecular Science Computing Facility, the High-Field Mass Spectrometry Facility, and the High-Field Magnetic Resonance Facility, are used by the external scientific community and EMSL scientists to conduct a wide variety of molecular-level environmental science research, including improved understanding of chemical reactions in DOE's underground storage tanks, transport of contaminants in subsurface groundwater and vadose zone sediments, and atmospheric chemical reactions that contribute to changes in the atmospheric radiative balance.

BER's William R. Wiley Environmental Molecular Sciences Laboratory will use its capabilities to expand its collaborations in the areas of structural biology and functional genomics. The number of users undertaking structural biology research will also increase.

Funding Schedule

(dollars in thousands)

	FY 2001	FY 2002	FY 2003	$ Change	% Change
Bioremediation Research	27,538	27,997	30,700	+2,703	+9.7%
Clean Up Research	45,449	47,502	38,190	-9,312	-19.6%
Facility Operations	31,248	37,333	37,948	+615	+1.6%
SBIR/STTR	0	1,569	2,692	+1,123	+71.6%
Total, Environmental Remediation	104,235	114,401	109,530	-4,871	-4.3%

Detailed Program Justification

(dollars in thousands)

	FY 2001	FY 2002	FY 2003
Bioremediation Research	**27,538**	**27,997**	**30,700**
▪ **NABIR and Bioremediation Research**	**21,571**	**22,042**	**24,720**

NABIR will 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 2003, science elements in the NABIR program include fundamental research in 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); (5) Assessment (measuring and validating the biological and geochemical processes of bioremediation); and (6) Acceleration (developing effective methods for accelerating and optimizing bioremediation rates). 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) at Oak Ridge is characterizing the subsurface water flow and contaminant transport, and modeling subsurface flow, transport, and biogeochemistry at the FRC. Initial results will be published in FY 2002 and will help determine the efficacy of removing nitrate and injecting electron donors to precipitate and, therefore, immobilize uranium. The NABIR program will take advantage of the newly completed genomic sequence of three important metal and radionuclide-reducing microorganisms to study the regulation and expression of genes that are important in bioremediation. Knowledge of the regulation of genes involved in metal-reduction, such as the cytochromes, will determine the effect of co-contaminants, such as nitrate or other metals and radionuclides on the ability of microorganisms to immobilize the metals and radionuclides. Researchers working on *Geobacter sulfurreducens*, *Desulfovibrio vulgaris,* and *Shewanella oneidiensis* will be able to use the genetic sequence and laboratory techniques such as micro-arrays to determine the enzymatic pathways for the reduction of uranium.

In FY 2003, research will focus on the completion of two critical field experiments at the NABIR FRC 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.

Performance will be measured: By the end of FY 2003, the program will demonstrate whether certain nutrient additions stimulate subsurface microorganisms to immobilize uranium, thereby reducing its concentration and transport in soil water and groundwater. The demonstration 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**.**

Performance will also be measured by the successful demonstration, in partnership with EM-50, of the reliability of using 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.

	(dollars in thousands)		
	FY 2001	FY 2002	FY 2003

- **General Plant Projects (GPP)** **4,800** **4,791** **4,811**

  The General Plant Projects (GPP) funding is 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 its requirement for safe and reliable facilities operation. This subprogram includes landlord 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 sanitary water piping in a 40 year old building used for research, refurbishing 20-year old laboratory space, and reconfiguring space in a 45 year old building to better accommodate current scientific research projects.

- **General Purpose Equipment (GPE)** **1,167** **1,164** **1,169**

  The General Purpose Equipment (GPE) funding will continue to provide general purpose equipment for PNNL and ORISE such as updated radiation detection monitors, information system computers and networks, and instrumentation that supports multi-purpose research.

Clean Up Research **45,449** **47,502** **38,190**

- **Clean Up Research** **1,502** **2,452** **2,463**

  The modest program in clean up research will characterize the geologic, chemical, and physical properties that affect the rate and effectiveness of a variety of environmental remediation and waste-stream cleanup methods, including bioremediation.

  Research will support laboratory and field studies at universities and DOE laboratories to identify and characterize the biophysical and chemical properties of environmental pollutants in contaminated environments and waste streams, especially how those properties influence the efficacy of various remediation and waste-stream cleanup methods. In FY 2003, research in in-situ approaches is continued on challenging problems of mixed wastes containing complex mixtures of organic wastes, metals, and radionuclides.

  Much of this research will be conducted in collaboration with the Office of Environmental Management (EM).

- **Environmental Management Science Program** **36,067** **37,050** **29,886**

  The goal of the Environmental Management Science Program (EMSP), transferred in FY 2003 from EM 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. The goal of the EMSP is to support basic research projects that could lead to specific demonstration projects and new clean up strategies. It is the intent or the expectation of the EMSP that the basic research projects funded offer the potential of having specific practical applications or specific timelines for the development of applications for waste cleanup.
Basic research that addresses the broad technical and scientific uncertainties associated with DOE site clean up will continue to be funded through a process of competitive peer review. 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. The Office of Environmental Management will be consulted. Research will be funded at universities, national laboratories, and at private research institutes and industries.

- **Savannah River Ecology Laboratory** **7,880** **8,000** **5,841**

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 understand contaminant behavior in the environment, to elucidate molecular mechanisms of toxicity from environmental contaminants, to develop cheaper and more environmentally sound remediation approaches, and to assess the ecological risks of environmental contaminants. 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.

Facility Operations: William R. Wiley Environmental Molecular Sciences Laboratory (EMSL) **31,248** **37,333** **37,948**

- **Operating Expenses** **26,798** **34,339** **35,959**

The EMSL is a scientific user facility focused on conducting interdisciplinary, collaborative research in molecular-level environmental science. Operating funds are essential 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 1000 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 the 512-processor, high performance computer system, a suite of nuclear magnetic resonance spectrometers ranging from 300 MHz to 900 MHz, a suite of mass spectrometers, including an 11.5 Tesla high performance mass spectrometer, laser desorption and ablation instrumentation, ultra-high vacuum scanning tunneling and atomic force microscopes, and controlled atmosphere environmental chambers.

(dollars in thousands)

FY 2001	FY 2002	FY 2003

The new 3-4 Teraflop high performance computer is being used for model code development in molecular geochemistry and biogeochemistry, and numerical modeling of reactive transport in the subsurface, chemical processing and catalysis, aerosol formation and chemical transformations and climate modeling and simulation. The computer also assists the EMSL focus on structural genomics.

Performance will be measured by (1) initiating operation of a new high performance computer at the EMSL and (2) having unscheduled operational downtime on EMSL instrumentation and computational resources not to exceed 10 percent.

- **Capital Equipment** **4,450** **2,994** **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 ($3,000,000) in FY 2001 supported the upgrade of user capabilities through the acquisition of additional mass spectrometers and Nuclear Magnetic Resonance (NMR) spectrometers for structural biology research.

SBIR/STTR **0** **1,569** **2,692**

In FY 2001 $1,242,000 and $74,000 were transferred to the SBIR and STTR programs, respectively. FY 2002 and FY 2003 amounts are estimated requirements for the continuation of these programs.

Total, Environmental Remediation **104,235** **114,401** **109,530**

Explanation of Funding Changes from FY 2002 to FY 2003

	FY 2003 vs. FY 2002 ($000)
Bioremediation Research	
▪ Increased support for bioremediation research to expand research on microbially-mediated transformations of metals and radionuclides and how these processes can be altered to immobilize contaminants in place in subsurface environments.	+2,678
▪ General Plant Projects continued at near FY 2002 level.....	+20
▪ General Purpose Equipment continued at near FY 2002 level.	+5
Total, Bioremediation Research	+2,703

	FY 2003 vs. FY 2002 ($000)
Clean Up Research	
▪ Clean Up Research continued at near FY 2002 level.	+11
▪ Environmental Management Science program transferred in FY 2003 from the Office of Environmental Management to the BER program continued at a reduced level.	-7,164
▪ Savannah River Ecology Laboratory transferred in FY 2003 from the Office of Environmental Management to the BER program continued at a reduced level.	-2,159
Total, Clean Up Research	-9,312
Facility Operations	
▪ EMSL funding increase provides for additional user support.	+615
SBIR/STTR	
▪ SBIR/STTR increases due to increase in research funding for the Environmental Remediation program.	+1,123
Total Funding Change, Environmental Remediation	-4,871

Medical Applications and Measurement Science

Mission Supporting Goals and Objectives

The goal of the Medical Applications and Measurement Science subprogram is to deliver relevant scientific knowledge that will lead to innovative diagnostic and treatment technologies for human health. The research builds on unique DOE capabilities in physics, chemistry, engineering, and biology. 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 such as bioterrorism.

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 in 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 in light of 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 medical imaging, 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.

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

Funding Schedule

(dollars in thousands)

	FY 2001	FY 2002	FY 2003	$ Change	% Change
Medical Applications	87,276	113,825	38,701	-75,124	-66.0%
Measurement Science	5,911	5,935	5,961	+26	+0.4%
SBIR/STTR	0	3,239	1,186	-2,053	-63.4%
Total, Medical Applications and Measurement Science	93,187	122,999	45,848	-77,151	-62.7%

Detailed Program Justification

(dollars in thousands)

	FY 2001	FY 2002	FY 2003
Medical Applications	**87,276**	**113,825**	**38,701**
▪ **Boron Neutron Capture Therapy (BNCT) and novel cell-directed cancer therapies**	**10,082**	**9,941**	**4,870**

In FY 2003, funding for the followup of all patients treated in the human clinical trials of boron neutron capture therapy (BNCT) at Brookhaven National Laboratory and the Massachusetts Institute of Technology will be completed with the transfer of clinical technology to the National Cancer Institute. The basic drug development research for BNCT will evolve into a new program of innovative approaches to cell-targeted ablation therapy for cancer with in-vivo radiation techniques. Success of the program will depend on key partnerships with scientists from the National Laboratories and academia. The emphasis of this program will be on the therapeutic use of ionizing radiation that may be achieved with radionuclide therapy and novel methods of tumor targeting. 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.

Performance will be measured by the 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.

(dollars in thousands)

FY 2001	FY 2002	FY 2003

Performance will be measured: By the end of FY 2003, all the boron neutron capture therapy (BNCT) clinical trials will be completed with clinical data collection, and transfer of the clinical data to the National Cancer Institute as the foundation for an advanced treatment modality for cancer.

- **Radiopharmaceutical Design and Synthesis** **26,065** **24,340** **24,445**

BER will 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 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 as well as often 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.

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.

Performance will be measured: By the end of FY 2003, 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.

- **Multimodal Imaging Systems and Medical Photonics**..... **10,004** **9,753** **9,386**

In FY 2003, BER will emphasize support in multimodal imaging systems for study of human brain function and continue to explore the combination of nuclear medicine imaging systems with magnetic resonance imaging. The research will continue to develop innovative imaging instrumentation and will transfer the relevant technology into clinical medicine. PET and MRI instrumentation systems will be developed to image small animals with high resolution. The program will continue to support research in brain imaging including substance abuse, mental illness, Parkinson's disease, Alzheimer's disease, and studies of neurochemical metabolism.

Performance will be measured: By the end of FY 2003, 1-3 advanced radiotracer imaging camera devices, that approach the fundamental limits of spatial resolution and detector sensitivity, will be available to detect breast cancer to differentiate benign as compared to malignant growth, and will measure biological function in small animals as the models of human disease.

BER will also expand its research program at the National Laboratories by capitalizing on their unique resources and expertise in the biological, physical, chemical, and computational, sciences to develop new research opportunities for technological advancement related to human health. Due to the medical nature of the program, all research activities are joint activities between the National Laboratories and medical research centers. The program emphasizes biomedical imaging, novel sensing devices, spectroscopy, and related informatics systems. It will advance fundamental concepts, create knowledge from the molecular to the organ systems level, and develop innovative processes, instruments, and informatics systems to be used for the prevention, diagnosis, and treatment of disease and for improving health care in the Nation. Emphasis is placed on:

Biomedical Imaging – is the development of novel medical imaging systems. BER will combine optical imaging with other traditional medical imaging systems such as MRI, PET, and SPECT (single photon emission computed tomography) and will develop small imaging systems that image in real-time under natural physiological conditions. A major objective is improving the reliability and cost-effectiveness of medical imaging technologies. 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. The BER program has played a leading role in the development of new positron emission tomography (PET) instrumentation as well as new chemistries for applying PET to diagnosis of cancer and other diseases. A high priority is placed on transfer of the new PET technologies into clinical research and practice.

Medical Photonics – is the development of advanced optical systems, including lasers, that will enhance the monitoring, detection, and treatment of disease. BER will expand its development of an artificial retina that can convert light signals into physiological electrical impulses.

(dollars in thousands)

FY 2001	FY 2002	FY 2003

Smart Medical Instrumentation – is the development and fabrication of "smart" medical instruments that can operate within the body either remotely or independently to monitor, detect, and treat various medical dysfunctions. This includes the development and fabrication of biological sensors that can be used to detect or monitor various physiological functions and disease in the body in real-time.

The ultimate goal of the program is to support basic research and technology development that will ultimately lead to the development of technology that can be transferred to the National Institutes of Health for clinical testing or to industry for further commercial development. This research takes advantage of unique resources at DOE facilities and 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.

Performance will be measured by the enhancement of 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, and over the next five years, mutually beneficial research partnerships between the BER Advanced Medical Technology Program and the Intramural Clinical Research Programs at the National Institutes of Health (NIH) will deliver two new biosensor and infrared thermography technologies using the physical science expertise of the DOE national laboratories. The technologies will aid in the detection of disease at an early stage.

- **Congressional Direction** **41,125** **69,791** **0**

Congressional direction in FY 2001 for School of Public Health, University of South Carolina; Nuclear Medicine and Cancer Research Capital Program, University of Missouri-Columbia; Discovery Science Center in Orange County, California; Children's Hospital Emergency Power Plant in San Diego; Center for Science and Education at the University of San Diego; Bone Marrow Transplant Program at Children's Hospital Medical Center Foundation in Oakland, CA; North Shore Long Island Jewish Health System, New York; Museum of Science and Industry, Chicago; Livingston Digital Millenium Center, Tulane University; Center for Nuclear Magnetic Resonance, University of Alabama-Birmingham; Nanotechnology Engineering Center at the University of Notre Dame of South Bend, Indiana; National Center for Musculoskeletal Research, Hospital for Special Surgery, New York; High Temperature Super Conducting Research and Development, Boston College; Positron Emission Tomography Facility, West Virginia University; Advanced Medical Imaging Center, Hampton University; Child Health Institute of New Brunswick, New Jersey; Linear Accelerator for University Medical Center of Southern Nevada; Medical University of South Carolina Oncology Center; National Foundation for Brain Imaging; Science and Technology Facility at New Mexico Highlands University; and Inland Northwest Natural Resources Research Center at Gonzaga University.

(dollars in thousands)

FY 2001	FY 2002	FY 2003

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 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.

(dollars in thousands)

	FY 2001	FY 2002	FY 2003
Measurement Science	**5,911**	**5,935**	**5,961**

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.

SBIR/STTR	**0**	**3,239**	**1,186**

In FY 2001 $2,357,000 and $143,000 were transferred to the SBIR and STTR programs, respectively. FY 2002 and FY 2003 amounts are estimated requirements for the continuation of these programs.

Total, Medical Applications and Measurement Science	**93,187**	**122,999**	**45,848**

Explanation of Funding Changes from FY 2002 to FY 2003

	FY 2003 vs. FY 2002 ($000)
Medical Applications	
▪ Boron Neutron Therapy (BNCT) program is completed and research on novel cell-directed cancer therapies is initiated	-5,071
▪ Radiopharmaceutical Design and Synthesis and Multimodal Imaging Systems and Medical Photonics are continued at near FY 2002 levels.	-262
▪ Decrease due to Congressional direction in FY 2002.	-69,791
Total Funding Change, Medical Applications	-75,124
Measurement Science	
▪ Measurement Science will continue at near FY 2002 levels	+26

	FY 2003 vs. FY 2002 ($000)
SBIR/STTR	
▪ SBIR/STTR decreases due to decrease in research funding for the Medical Applications and Measurement Science program	-2,053
Total Funding Change, Medical Applications and Measurement Science	-77,151

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Construction

Mission Supporting Goals and Objectives

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 2001	FY 2002	FY 2003	$ Change	% Change
Construction	2,495	11,405	0	-11,405	--

Detailed Program Justification

(dollars in thousands)

	FY 2001	FY 2002	FY 2003
Construction	**2,495**	**11,405**	**0**

- The Laboratory for Comparative and Functional Genomics at Oak Ridge National Laboratory will provide a modern gene function research facility to help understand the function of newly discovered human genes, to support DOE research programs and to provide protection for 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.

  Performance will be measured: By the end of FY 2003, construction of the Center for Comparative and Functional Genomics at Oak Ridge National Laboratory will be completed on schedule.

Explanation of Funding Changes from FY 2002 to FY 2003

	FY 2003 vs. FY 2002 ($000)
Construction	
▪ Full funding for the construction of the Laboratory for Comparative and Functional Genomics provided in FY 2002.	-11,405

Capital Operating Expenses & Construction Summary

Capital Operating Expenses

(dollars in thousands)

	FY 2001	FY 2002	FY 2003	$ Change	% Change
General Plant Projects	8,094	4,791	4,811	+20	+0.4%
Capital Equipment	44,538	17,543	17,047	-496	-2.8%
Total Capital Operating Expenses	52,632	22,334	21,858	-476	-2.1%

Construction Projects

(dollars in thousands)

	Total Estimated Cost (TEC)	Prior Year Appropriations	FY 2001	FY 2002	FY 2003	Unappropriated Balance
01-E-300, Laboratory for Comparative and Functional Genomics, ORNL	13,900	0	2,495	11,405	0	0
Total, Construction		0	2,495	11,405	0	0

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

(dollars in thousands)

	Total Estimated Cost (TEC)	Prior Year Appropriations	FY 2001	FY 2002	FY 2003	Acceptance Date
DNA Repair Protein Complex Beamline, ALS	4,490	0	4,490	0	0	FY 2001
Total, Major Items of Equipment		0	4,490	0	0	