Biological and Environmental Research

Program Mission

For over 50 years the Biological and Environmental Research (BER) program has been advancing environmental and biomedical knowledge connected to energy production, development, and use. As described in the DOE Strategic Plan, BER supports fundamental research providing the scientific foundation for the applied research missions of the Department of Energy (DOE). Through support of peer-reviewed research at national laboratories, universities, and private institutions, BER develops the knowledge needed to identify, understand, anticipate, and mitigate the long-term health and environmental consequences of energy production, development, and use. The research is also designed to provide the science base in support of the Energy Policy Act of 1992.

Program Goal

The BER program goal is to develop the information, scientific "know-how," and technology for identification, characterization, prediction, and mitigation of adverse health and environmental consequences of energy production, development, and use. Additionally, the program will provide the Department's researchers and the Nation's scientific community with leading-edge research facilities and other critical infrastructure that support this program goal.

Program Objectives

Utilize the capabilities of the U.S. research community in universities and the DOE national laboratories to provide the basic research foundation for DOE's missions in energy and the environment through targeted investments in life, environmental and medical sciences, and related disciplines.

Contribute to the environmental remediation and restoration of contaminated environments at DOE sites through basic research in bioremediation, microbial genomics, and ecological science.

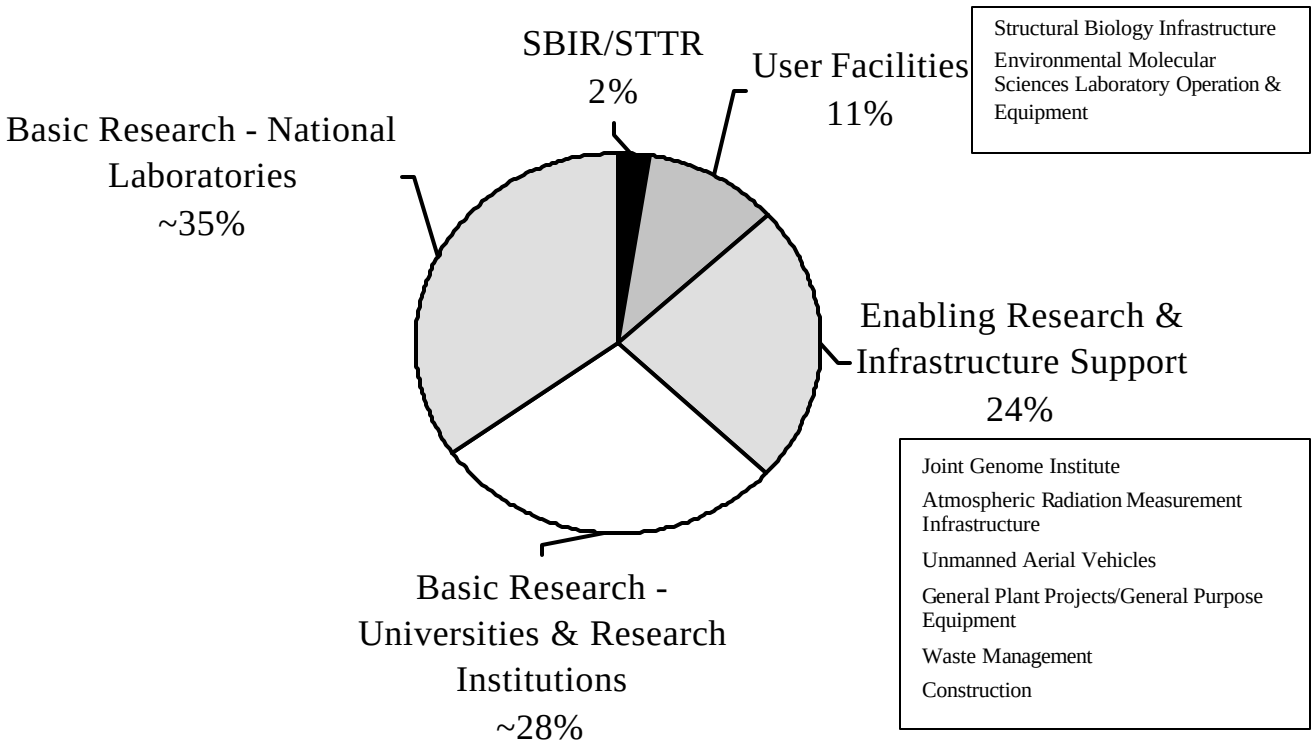
Provide new knowledge on microbes that will expand DOE's options for clean and affordable energy through research in microbial genomics and bioinformatics.

Advance our understanding of key uncertainties and find solutions for the effects of energy production and use on the environment through research in global climate modeling and simulation, the role of clouds in climate change, carbon cycle and carbon sequestration, atmospheric chemistry, and ecological science.

Help protect the health of DOE workers and the public by advancing our understanding of the health effects of energy production and use through basic research in key areas of the life sciences including functional genomics and structural biology as well as low dose radiation research.

Ensure the greatest return on public investments by utilizing the unique capabilities of the DOE laboratories to advance the life and environmental sciences, advanced imaging, and medical applications of basic research and through stewardship of these capabilities to ensure that DOE has the scientific base to meet its technologically challenging missions.

To meet these objectives, BER budget request for FY 2002 is $442,970,000, 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).



Evaluation Of Objectives

The quality and scientific relevance of the Biological and Environmental Research (BER) program and its individual research projects are maintained by rigorous peer reviews conducted by internationally recognized scientific experts. The criteria include scientific merit, appropriateness of the proposed approach, 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 soliciting 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 (TWAG), 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 the interactions between the physical sciences and the life sciences and aggressively pursues every opportunity to stretch the interface between the two scientific domains.

BER facility operations are also monitored by peer reviews and user feedback. BER provides 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 including: 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.

The overall quality of the research in the Biological and Environmental Research (BER) program will be judged excellent and relevant by external evaluation by peers, and through various forms of external recognition.

BER will continue to provide leadership in key subfields of life, environmental, and medical sciences research that are critical to DOE's mission and the Nation through external review and other mechanisms.

BER will keep within 10 percent, on average, of cost and schedule milestones for upgrades and construction of scientific user facilities.

At least 80 percent of all new research projects supported by BER will be peer reviewed and competitively selected, and will undergo regular peer review merit evaluation.

BER-funded research facilities for environmental, genomic, and structural biology research will achieve or exceed technical milestones that are ambitious and critical to either DOE mission areas or the research needs of the scientific community.

The BER scientific user facilities will be operated and maintained so that unscheduled operational downtime will be less than 10 percent of total operating time, allowing nearly 3,500 scientists to conduct experiments on an annual basis.

BER will ensure the safety and health of the workforce and members of the public and the protection of the environment in all its program activities.

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:

- Develop cutting edge technologies, facilities, and resources, including animal models, for the human genome project.
- Provide solutions to DOE problems in energy and the environment through microbial genome and bioremediation research.
- Provide the 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.
- Provide world leadership in ground-based measurement of clouds and atmospheric properties, 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.
- Provide 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 global 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 for medical applications using the unique resources in physics, chemistry, material sciences, and biology at the National Laboratories.
- Jointly manage the Environmental Management Science Program (EMSP) with the Office of Environmental Management (EM) to identify science fields relevant to the DOE cleanup mission and select the appropriate 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

Genome Sequencing – Top Scientific Advance of 2000 - In December 2000, *Science* magazine named genome sequencing the top scientific advance of 2000, including the sequencing of the human, fruit fly and microbial genomes. *Science* magazine also acknowledged the ongoing sequencing of the mouse and puffer fish. BER made seminal contributions to the sequencing of the human genome, fruit fly, and more than 50 microbial genomes and is sequencing the puffer fish and portions of the mouse genome. These contributions culminated in the publication of the draft human DNA sequence in *Nature* on February 15, 2001.

DOE Completes Draft DNA Sequence of 3 Human Chromosomes - The DOE Joint Genome Institute's Production Sequencing Facility completed the draft DNA sequence of human chromosomes 5, 16, and 19 in April 2000 as the DOE contribution to the international effort to sequence the entire human genome. These chromosomes contain genes that contribute to a number of human diseases including, leukemia, colon, breast and prostate cancer as well as kidney disease, Crohn's disease, asthma, deafness, diabetes, obesity, atherosclerosis, attention deficit disorder, schizophrenia, and mental retardation.

Making DNA Sequencing Cheaper and Faster - Technology developments (e.g., capillary based sequencers, automated sample handling, reagents for DNA cloning such as Bacterial Artificial Chromosomes, and improved dyes for staining DNA) by the DOE and its international partners have dramatically decreased the cost of DNA sequencing while increasing the speed and efficiency. It took four years to produce the first billion base pairs of draft sequence and less than eight months to produce the next two billion base pairs. DOE's Joint Genome Institute currently produces more DNA sequence in eight days than it did in 1998, its first full year of sequencing. Similarly the cost of sequencing has dropped from over $2 per "finished" base to less than 20 cents during the same period.

Asthma-Linked Genes Discovered - Two genes that contribute to the development of asthma were discovered by Lawrence Berkeley National Laboratory scientists using mice carrying different human genes. More than 14 million people in the United States suffer from asthma and other chronic respiratory ailments. Finding the two genes raises the prospect that decreasing their activity could help reduce susceptibility to asthma attacks.

Drosophila Gene Collection Facilitates Genetics Research - Genetics research took a large step forward in 2000 with the determination of the complete Drosophila (the fruit fly) DNA sequence. This DNA sequence information was made even more valuable to biologists by the creation of a BER and Howard Hughes Foundation supported resource, the Drosophila Gene Collection. This resource, a molecular library that will contain individual DNA clones corresponding to each Drosophila gene, will be a powerful tool that will help scientists understand both fruit fly and human biology, given the strong conservation of many genes between the fruit fly and humans.

Genes & Justice: Special Issue of Judicature - As part of its continuing effort to educate and alert the judiciary to the flood of genetics-related cases on the horizon, the Ethical, Legal, and Social Issues (ELSI) component of the DOE Human Genome program supported the publication of a special issue of the legal journal Judicature, focused on Genes and Justice. The journal is a publication of the American Judicature Society, whose members include judges, lawyers, legal scholars, administrators, and others associated with the U.S. court system. BER funding enabled copies to be sent to an additional 8,000 judges.

PBS Special - Intimate Strangers - Unseen Life on Earth - The astonishing breadth and diversity of microbial life and the contributions that microbes make to the health of the Earth were highlighted in a highly regarded four-part PBS series, "Intimate Strangers: Unseen Life on Earth," that was partially funded by the BER Microbial Genome program.

Starting a Dialogue on Low Dose Radiation Research - The BER Low Dose Radiation Research program sponsored a workshop that was attended by scientists, federal agencies, scientific societies, regulators, and the public, including representatives of antinuclear and environmental activist groups. The goal of this program is to support high quality, credible, and widely accepted scientific research that underpins the development of future radiation risk policy. Dialogues such as this one are key to the acceptance of the results of this research.

Environmental Processes

ARM Data Improve Models - Analyses of atmosphere radiation data from long term measurement systems at the ARM sites have improved the understanding of the radiation spectrum at the Earth's surface and led to a new radiation code developed for General Circulation Models. By all measures used to date, implementation of this new radiation code in, for example, the European Centre for Medium-Range Weather Forecasting model improved forecast skill while maintaining model calculation time comparable to that of the previous model. Improvements in the physics of these models assure as much scientific realism as possible within the severe time constraints levied on climate prediction codes. This improvement is critical to increasing the validity, accuracy, and credibility of climate models.

Cloud Climatology Data Add Rigor to Model Testing – The first detailed climatology of cloud occurrence and vertical location was produced using three years of continuous ARM cloud radar and lidar data over the Southern Great Plains site in Oklahoma. This climatology shows expected variation of cloud properties from season to season, but also demonstrates the large interannual variation. Particularly large seasonal excursions were identified in the winter due to the 1997-98 El Niño and the subsequent LaNiña. Scientists have deduced the quantitative effect of clouds on the surface radiation budget on this same three-year time scale. The combination of these two climatologies provides a unique test for climate model cloud simulations.

Continuous Climate Data From Three Climatic Regions Available - With the opening of ARM Atmospheric Radiation and Cloud Stations (ARCS) in the Republic of Nauru located in the Western Tropical Pacific and on the North Slope of Alaska at Atqasuk, the ARM program now maintains continuously operating sites to measure cloud and radiation properties in three climatic regions. These sites provide an unprecedented look at cloud properties and radiation effects in the Southern Great Plains, the Tropical Western Pacific and on the North Slope of Alaska. These data are available via the ARM Archive to all interested scientists.

New Techniques for Early Warning of the Onset of Severe Storms - ARM has developed a new tool for forecasting the onset of severe convection. Weather events with extremely strong convection are characteristic of thunderstorm and tornado conditions. Several cases of pretornadic thunderstorm conditions were detected one to two hours ahead of the thunderstorm development. This new meteorological product is based on data from a grid of Atmospheric Emitted Radiance Interferometer (AERI) systems.

Electrical Generating Plant Contributes to Regional Ozone - Field campaigns in the southeastern U.S. have determined that even though electrical generating plants make a significant contribution to the ozone burden in this area, the natural emissions of biogenic hydrocarbons, and their influence on ozone formation, are so large that any regional ozone control strategy based upon further reduction in anthropogenic hydrocarbons will likely fail. This finding is supported by observations that ozone production per unit of nitrogen oxide (NO_x) emissions by power plants appears to be inversely related to size of the NO_x source.

Field Campaigns Yield Interesting Comparisons and New Information for Pollution Control Strategies - Field campaigns in selected urban areas with air quality problems show that the sources of ozone and aerosol pollution are not the same in different areas of the country. For example, the rate of ozone production in Phoenix is two to three times lower than that in the eastern U.S. In addition, aerosol loading in Phoenix was shown to be highly correlated with tracers of internal combustion engines suggesting that transportation is a major source of aerosols and their precursors in the Phoenix basin. In contrast, in Philadelphia, emissions from local fossil fuel power plants make a significant contribution to both the ozone and aerosol burden, indicating that electric energy production is a major source of aerosol and ozone precursors in this urban area. In Nashville, TN, ozone concentrations do not appear to be very sensitive to modest reductions of man-made emissions, suggesting that large reductions in either man-made hydrocarbons or nitrous oxides would be required to reduce ozone in this area.

Warmer Terrestrial Ecosystems Take Up More Carbon Than Expected - The AmeriFlux Network is producing unique measurements of the net annual exchange of carbon dioxide (CO_2) between the atmosphere and terrestrial ecosystems. The annual net ecosystem exchange (NEE) of CO_2 is the annual carbon gain or loss by all components (i.e., both above and below ground components) of an ecosystem and is being measured in different ecosystems, including boreal forests, northern temperate forests (coniferous, hardwood, mixed), southern coniferous and hardwood forests, and non-forested grasslands and croplands. Data on NEE from the sites can be reliably compared across geographic regions or climatic gradients because of the use of common measurement protocols and cross-site calibration procedures. Analysis of the relationship between NEE and mean annual temperature across 12 sites shows that sites with a warmer mean annual temperature have a greater NEE than colder sites along a north-to-south climatic gradient of eastern United States and Canada. If scaled across the North American landscape, the measured amount of carbon gained annually (2 to 4 tonnes per hectare) by terrestrial ecosystems accounts for a significant fraction of the CO_2 emitted to the atmosphere by energy production.

Effects of Elevated Carbon Dioxide on Terrestrial Ecosystems and Vegetation Estimated - Free-Air Carbon Dioxide Enrichment (FACE) experiments are providing important new information on the response of intact terrestrial ecosystems to increased atmospheric concentrations of carbon dioxide. Seven long-term experiments have provided new results on the physiological and growth responses of vegetation in forest, grassland, and cropland ecosystems to elevated CO_2. Although it is unclear how long the growth enhancement will persist, the results to date suggest that forests provide a

substantial sink for atmospheric CO_2 and, thereby, can help to lessen its rise in the atmosphere in the future. Initial results suggest that increased CO_2 causes greater productivity of these systems. A significant part of the increased productivity occurs below ground with roots, soil microflora and the formation of soil organic matter. Results from a 2-year study in which portions of a loblolly pine forest were exposed to a 60 percent increase in atmospheric CO_2 concentration show a 25 percent increase in net productivity relative to that for areas of the forest exposed to ambient levels of atmospheric CO_2. The increase in productivity represents a substantial sink for carbon in trees during the first two years of the study. The storage of carbon in trees was accompanied by a proportionally smaller carbon sink in soils and groundwater relative to that in areas of the forest exposed to ambient CO_2 levels.

Investments in Integrated Assessment of Global Climate Change are Paying Off - In the past seven years, integrated assessment models of global climate change have been constructed that are contributing to the dialogue on scientific priorities and on the relation of policy actions to climate change. Several models supported by BER have been used to assess so-called "where and when" options for mitigating the increase in atmospheric carbon dioxide. Model results show that the costs of meeting a concentration target for carbon dioxide in the atmosphere, such as that envisioned by the Framework Convention on Climate Change, are lower by up to a factor of 10 when nations have the ability to be flexible in the timing and location of their emission reductions. Furthermore, results of the research indicate the value of flexibility in reducing emissions of several greenhouse gases rather than focusing solely on carbon dioxide to meet a particular target.

Environmental Remediation

Common Bacteria Super at Immobilizing Uranium - Research on the microorganism Geobacter promises to lead to new strategies for immobilizing metals and radionuclides in the subsurface that will result in reduced risk to humans and the environment. Natural and Accelerated Bioremediation Research (NABIR) studies have demonstrated that Geobacter can chemically reduce and precipitate common DOE contaminants, such as uranium, technetium, and chromium in subsurface environments. Moreover, Geobacter has been found to be nearly ubiquitous at subsurface sites, including those contaminated with uranium such as the Uranium Mill Tailing Remedial Action (UMTRA) Sites.

Communities of Bacteria at Selected Contaminated Sites Give Researchers Clues About How to Manipulate Communities at Other Contaminated Sites - NABIR has supported the successful development of new approaches that provide nucleic acid "fingerprints" of complex microbial communities in contaminated subsurface environments. Having these fingerprints from selected dynamic communities may provide clues on how to modify other communities with stimulants, such as nutrients that increase the ability of the organisms in those communities to carry on more effectively the desired biochemical reactions. The NABIR program has funded research that tags and amplifies the terminal fragment of RNA molecules to create a library of restriction fragment length polymorphisms (T-RFLP). This research correlates the ecology to T-RFLP signatures for various communities.

Medical Applications and Measurement Science

Making Drugs Safe for Children - PET/radiotracer studies at BNL have demonstrated that Ritalin, a drug commonly used in the treatment of attention deficit disorder, when given orally will effectively block the dopamine transmitter system without putting the child at risk or causing a "high" as observed with addictive drugs.

Treating Obesity - BNL scientists have used PET and specific radiotracers to demonstrate that the brain dopaminergic pathways are poorly developed in obese individuals. These data may enable alternative methods for treatment of obesity.

Scientists Develop Advanced Instruments to Study Disease Models in Animals - Using physics, engineering, and computational science, researchers at the UCLA-DOE laboratory have developed a prototype micro-PET scanner for studying animals. This instrument, which is now produced commercially, will become an essential method of studying animal models of human disease.

New Cancer Treatments Developed - Investigators at Memorial-Sloan Kettering Cancer Center have developed two new radiopharmaceuticals for improving the diagnosis and treatment of cancer. One utilizes the alpha emitter Bismuth 213 and the other is a genetic radiotracer (fluoro arabinyl uridine-Iodine 124).

BNCT Trials Completed - The Phase I BNCT clinical trial of patients with brain cancer performed at BNL and MIT/Harvard has been completed. The maximally tolerated neutron dose and phenyl-alanine dosages were established. This study will provide basic information enabling potential NIH-funded clinical trials.

Improved Radiation Therapy Planning – Investigators at LLNL have received the Food and Drug Administration approval for patient use of "Peregrine"—an improved computer program for planning radiation doses for cancer treatment.

FACILITY ACCOMPLISHMENTS

Life Sciences

Revealing the Structure of Life's Molecular Machines - Scientists using BER's unique structural biology beamlines at the DOE synchrotron facilities determined the high resolution structures of the RNA polymerase and the ribosome, by any measure two of nature's most sophisticated "molecular machines." These remarkable structures reveal in atomic detail how DNA is unwound, how a message for protein production is created, how this message is read by the ribosome and how the growing protein chain is made. This discovery was named by *Science* magazine as one of the runners-up for the top scientific advance of 2000.

Environmental Remediation

EMSL Develops First Combined Magnetic Resonance and Optical Microscope - Scientists at the William R. Wiley Environmental Molecular Sciences Laboratory (EMSL) worked with visiting scientists to develop a new type of microscope that uses both magnetic resonance and optical microscopy to image cells. The new type of microscope, termed the MROM (magnetic resonance optical microscope), combines the high resolution and sensitivity of an optical microscope with the chemical information provided by magnetic resonance. MROM will be used for cellular and structural biology studies providing a new non-invasive way to observe living cells in real time.

EMSL Develops an Advanced Mass Spectrometer - Scientists at the William R. Wiley Environmental Molecular Sciences Laboratory have developed an instrument to channel more sample ions into mass spectrometers, thereby allowing more accurate and sensitive measurements. The Electrodynamic Ion Funnel concentrates ions from samples into a small stream into the mass spectrometer. With this enhancement, scientists are better able to analyze low concentrations of samples. This enhancement will be of benefit to cell signaling studies and other health effects research.

EMSL Extends Collaboratory Approach - Remote use of instrumentation within the William R. Wiley Environmental Molecular Sciences Laboratory (EMSL) has now been extended to the Nuclear Magnetic Resonance (NMR) spectrometers and a few other instrument systems. EMSL staff have developed a suite of tools to enable secure operation of the NMR spectrometers remotely, while allowing real time computer display sharing and web-based data access and sharing. Additional instruments available for remote use include an ion trap mass spectrometer and the Molecular Beam Epitaxy system for the creation of thin (molecular-layer) films. Overall the collaboratory concept is increasing scientist efficiency and reducing the cost of doing research by enabling the remote use of EMSL instruments.

PROGRAM SHIFTS

For FY 2002, BER will focus on:

"Genomes to Life" -- Utilizing DOE capabilities in genomics, structural biology, imaging, computation, and engineering to explore protein complexes and their on/off switches, encoded in an organism's DNA, that make a cell a living system.

Developing computational models of microbial cells to advance understanding and help adapt them to DOE missions.

Continuing to leverage advances in genomics and instrumentation to detect and characterize the biological effects of Low Doses of Radiation.

Working with other federal agencies, continuing development of advanced predictive capabilities--Highly Parallel Climate Models with improved abilities to predict climate on regional scales.

Investing in enhanced computational capabilities at the Environmental Molecular Sciences Laboratory to solve environmental and biological problems.

Funding is decreased for the Joint Genome Institute due to a programmatic shift to increase development of DNA sequencing technology research needed to meet the growing demand for cheaper, faster, and more accurate high-throughput DNA sequencing as a basic research tool in biology.

Redirected Research Programs in the Life Sciences

The FY 2002 budget includes funds for a research program, Genomes to Life, that expands and extends current BER programs. This program capitalizes on DOE's pioneering and leadership role in high-throughput DNA sequencing; its longstanding support of microbial biochemistry, metabolism and physiology; its support of national user facilities for determining protein structures; and the capabilities of its national laboratories in computational analysis, instrumentation research, and bioengineering. This program challenges scientists to take another large step forward in their thinking, their research, and their technology development. It begins where the FY 2001 initiative, the Microbial Cell Project, leaves

off and builds on that project as part of a broader, bolder research program. This program challenges scientists to understand not only the complete workings of an individual cell from the DNA sequence to the identification of all of a microbe's proteins (the proteome) and their functions, the goal of the Microbial Cell Project, but also the regulation and behavior of complex multi-cellular systems and the responses of those systems to environmental cues. The overriding goal of this long-term research program is to understand biology well enough to be able to predict the behavior and response of biological systems--from cells to organisms.

Scientific Facilities Utilization

The Biological and Environmental Research request includes $48,754,000 to maintain support of the Department's scientific user facilities. Facilities used for structural biology research, such as beam lines at the synchrotron light sources and research reactors, are included. The BER request also includes operation of the William R. Wiley Environmental Molecular Sciences Laboratory where research activities underpin long-term environmental remediation. 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 were supported at universities and at national laboratories in FY 2000. BER will continue its support for graduate students and post-doctoral investigators in FY 2002. The number of graduate students and post-doctoral investigators will remain approximately at the FY 2001 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 2000.

COMMITMENT TO UNIVERSITIES

BER will continue its commitment to and dependence on research scientists at the Nation's universities. Approximately 45 percent of BER basic research funding supports university-based activities. 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 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, microbial cell project, 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 2000 Comparable Appropriation	FY 2001 Original Appropriation	FY 2001 Adjustments	FY 2001 Comparable Appropriation	FY 2002 Request
Biological and Environmental Research					
Life Sciences	161,338	198,791	-6,319	192,472	186,205
Environmental Processes	122,560	134,173	-4,469	129,704	129,469
Environmental Remediation	63,770	65,450	-3,989	61,461	66,137
Medical Applications and Measurement Science	68,369	100,346	-3,958	96,388	51,159
Subtotal, Biological and Environmental Research	416,037	498,760	-18,735	480,025	432,970
Construction	0	2,500	-5	2,495	10,000
Subtotal, Biological and Environmental Research	416,037[a]	501,260	-18,740	482,520	442,970
General Reduction	0	-10,872	+10,872	0	0
General Reduction for Safeguards and Security	0	-6,806	+6,806	0	0
Omnibus Rescission	0	-1,062	+1,062	0	0
Total, Biological and Environmental Research	416,037[b c]	482,520	0	482,520	442,970

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 $10,423,000 which was transferred to the SBIR program and $625,000 which was transferred to the STTR program.

[b] Includes $1,200,000 for Waste Management activities at Pacific Northwest National Laboratory that were transferred from the Office of Environmental Management in FY 2001.

[c] Excludes $7,001,000 for Safeguards and Security activities transferred to consolidated Safeguards and Security program in FY 2001.

Funding By Site

(dollars in thousands)

	FY 2000	FY 2001	FY 2002	$ Change	% Change
Albuquerque Operations Office					
Los Alamos National Laboratory	20,082	20,594	16,685	-3,909	-19.0%
National Renewable Energy Laboratory	99	0	0	0	0.0%
Sandia National Laboratories	2,597	3,139	2,756	-383	-12.2%
Albuquerque Operations Office	2,550	1,500	900	-600	-40.0%
Total, Albuquerque Operations Office	25,328	25,233	20,341	-4,892	-19.4%
Chicago Operations Office					
Ames Laboratory	948	652	690	+38	+5.8%
Argonne National Laboratory – East	13,700	24,939	17,184	-7,755	-31.1%
Brookhaven National Laboratory	21,723	16,948	18,169	+1,221	+7.2%
Chicago Operations Office	88,416	46,537	45,640	-897	-1.9%
Total, Chicago Operations Office	124,787	89,076	81,683	-7,393	-8.3%
Idaho Operations Office					
Idaho National Engineering & Environmental Lab	1,713	1,440	1,486	+46	+3.2%
Idaho Operations Office	0	962	0	-962	-100.0%
Total, Idaho Operations Office	1,713	2,402	1,486	-916	-38.1%
Oakland Operations Office					
Lawrence Berkeley National Laboratory	48,869	54,231	43,277	-10,954	-20.2%
Lawrence Livermore National Laboratory	30,784	30,869	33,561	+2,692	+8.7%
Stanford Linear Accelerator Center	3,060	3,489	4,300	+811	+23.2%
Oakland Operations Office	69,132	40,007	35,239	-4,768	-11.9%
Total, Oakland Operations Office	151,845	128,596	116,377	-12,219	-9.5%
Oak Ridge Operations Office					
Oak Ridge Inst. For Science & Education	4,754	4,315	4,375	+60	+1.4%
Oak Ridge National Laboratory	30,805	36,545	39,761	+3,216	+8.8%
Oak Ridge Operations Office	419	350	350	0	0.0%
Thomas Jefferson National Accelerator Facility	155	100	85	-15	-15.0%
Total, Oak Ridge Operations Office	36,133	41,310	44,571	+3,261	+7.9%

(dollars in thousands)

	FY 2000	FY 2001	FY 2002	$ Change	% Change
Richland Operations Office					
Pacific Northwest National Laboratory	75,292	67,142	66,172	-970	-1.4%
Washington Headquarters	939	128,761	112,340	-16,421	-12.8%
Total, Biological and Environmental Research	416,037 [a b c]	482,520	442,970	-39,550	-8.2%

[a] Excludes $10,423,000 which was transferred to the SBIR program and $625,000 which was transferred to the STTR program.

[b] Includes $1,200,000 for Waste Management activities at Pacific Northwest National Laboratory that were transferred from the Office of Environmental Management in FY 2001.

[c] Excludes $7,001,000 in FY 2000 for Safeguards and Security activities transferred to consolidated Safeguards and Security program in FY 2001.

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 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, and research in protein structure relating to the process of photosynthesis. In support of global 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 both microbes and mammalian cells and the molecular factors that control cell responses to low doses of radiation. 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, research and operation of the protein structure database, 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 nuclear medicine program supports research into novel techniques for imaging brain function in normal and diseased states.

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 take up and store carbon dioxide from 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 human 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 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. LBNL also develops and operates the carbon cycle facility at the ARM Southern Great Plains site.

LBNL co-hosts, with LLNL and six universities, an ocean carbon sequestration research center.

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 human 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, on the use of model organisms to

understand and characterize the human genome, and on the development of new technologies for rapidly determining the structures of many more proteins than is currently possible.

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.

LLNL co-hosts, with LBNL and six universities, the ocean carbon sequestration research center.

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 human 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. 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 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 conducts research on the use of model organisms to understand and characterize the human genome and the molecular mechanisms of cell responses to low doses of radiation.

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 and 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 is developing the Second Generation Model for predicting the benefits and costs of policy actions with respect to global climate change.

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

PNNL also conducts research on the molecular mechanisms of cell responses to low doses of radiation.

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 will support 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.

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

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.

All Other Sites

The BER program funds research at over 340 institutions, including colleges/universities, private industry, and other federal and private research institutions located in 40 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 Environmental Processes 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 Boron Neutron Capture Therapy program supports studies of novel boron compounds for use in treating brain cancer. The BER Measurement Science program supports research into novel types of biosensors for application in analytical chemistry of contaminated environments.

Life Sciences

Mission Supporting Goals and Objectives

BER's Life Sciences research is focused on developing, making available, and using unique DOE resources and facilities to understand and mitigate the potential health effects of energy development, energy use, and waste cleanup. 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 radiation.

BER takes advantage of the remarkable diversity of microbes found in the environment and of the small size of their genomes to identify and develop unique solutions in energy, waste cleanup, and carbon management and to understand how biological functions follow from the DNA sequence to the behavior of an entire organism.

BER is an integral part of the International Human Genome Project that has already determined and made publicly available a working draft of the human DNA sequence and is now completing the highly accurate 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 of predicting how single cells and multi-cellular organisms respond to biological and environmental cues. This new 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 underpins the BER carbon sequestration research program. Knowing the genomic sequence of microbes that are involved in carbon sequestration or that produce methane and hydrogen, will enable 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 products.

Performance will be measured by reporting accomplishments on the common performance measures on leadership, excellence and relevance; quality; and safety and health.

Genomes to Life

The Microbial Cell Project, initiated in FY 2001, began a challenging and comprehensive effort to understand the complete workings of a microbial cell from its DNA sequence to its unique characteristics and behaviors. It represents a new, systems level way of doing biology that follows from the successes in genome-scale DNA sequencing. The Genomes to Life program takes another large step forward, beginning where the Microbial Cell Project leaves off, and includes this project as part of a broader, more comprehensive research program.

The initial scientific challenge is to couple genomic DNA sequencing capabilities with new methods for probing the dynamics of cellular behavior at the molecular level and with a new overall emphasis on computation. This program will begin with DOE relevant microbes and biochemical pathways to: (1) systematically characterize and relate to cellular function the composition and dynamic changes of microbial proteomes (all the cell's proteins), and the composition and function of the 'machines of life' (the multi-protein complexes that carry out most of life's essential functions); (2) discover the architecture, dynamics, and function of key molecular networks that regulate gene expression and make useful computer models of them; (3) measure microbial gene diversity in representative, natural communities of importance to the DOE mission; and (4) develop the computational methods and infrastructure needed to simulate and predict the behavior of microbial cells and communities in response to environmental perturbations related to DOE's mission.

The broad goals of this new program are complementary to the efforts of other federal agencies and many private sector companies. The BER program will focus on scientific challenges that can be uniquely addressed by DOE and its national laboratories in partnership with scientists at universities and the private sector. BER will aim for activities that are out of reach of individual investigators or even small teams, a feature that will distinguish this program from complementary programs at other agencies like the National Institutes of Health and the National Science Foundation. This research promises unimaginable discoveries for biotechnology, pharmaceuticals, and medicine and will lead to new tools for the promotion of human health, for new therapies and for new predictive capabilities of human susceptibilities. The project will also address DOE needs in energy use and energy production, bioremediation, and carbon sequestration, providing exciting, new, and previously unavailable knowledge to the entire biological community. Many of the experimental tools developed using microbes in the initial phases of this project will also be useful in other programs, e.g., the DOE Low Dose Radiation Research program, to help clarify the biological mechanisms responsible for adverse human responses to these materials. Having the capability to characterize the molecular machines involved in adverse responses to specific toxicants and to develop models to help predict these responses will be powerful tools that can be used to better protect people by identifying those individuals at greatest risk from exposure to weapons-related materials.

Funding Schedule

(dollars in thousands)

	FY 2000	FY 2001	FY 2002	$ Change	% Change
Structural Biology	25,869	34,759	27,847	-6,912	-19.9%
Molecular and Cellular Biology	30,862	51,277	51,191	-86	-0.2%
Human Genome	87,499	86,438	88,238	+1,800	+2.1%
Health Effects	17,108	15,409	14,251	-1,158	-7.5%
SBIR/STTR	0	4,589	4,678	+89	+1.9%
Total, Life Sciences	161,338	192,472	186,205	-6,267	-3.3%

Detailed Program Justification

(dollars in thousands)

	FY 2000	FY 2001	FY 2002
Structural Biology	**25,869**	**34,759**	**27,847**
Basic Research	**12,561**	**13,715**	**12,547**

In an advance named by *Science* magazine as runner-up for the top scientific advance of 2000, scientists using BER's unique structural biology beamlines at the DOE synchrotron facilities determined the high resolution structures of the RNA polymerase and the ribosome, by any measure two of nature's most sophisticated "molecular machines." These remarkable structures reveal in atomic detail how DNA is unwound, how a message for protein production is created, how this message is read by the ribosome, and how the growing protein chain is made.

These two molecular machines illustrate a central phenomenon in biology that most proteins do not act independently or statically in living systems. In carrying out their functions within cells, proteins form complexes with other proteins and interact with a variety of structural, regulatory, and ligand molecules on which proteins carry out their designated functions. The role of structure in determining protein interactions with diverse molecules in a cell is still poorly understood. As illustrated by these remarkable first structures of the ribosome and RNA polymerase, understanding how these and other molecular machines carry out their biological functions requires that we observe dynamic changes in protein structure and study protein modifications, translocation, and subcellular concentrations.

Novel research approaches are being supported to develop and use both experimental and computational approaches to characterize molecular machines of interest to DOE mission needs. Research is supported to predict or identify, from DNA sequence information, proteins that are involved in the recognition or repair of radiation-induced DNA damage or in the bioremediation of metals and radionuclides; 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-DNA interactions that occur in these molecular machines; (2) to image, including high resolution, real-time optical imaging, these machines at work in cells; and (3) to precisely measure their intracellular compartmentalization and translocations.

In FY 2002, basic research is decreased as emphasis shifts to development and use of structural biology user facilities.

Performance will be measured by the development of computational models that can successfully identify proteins that interact with protein complexes involved in DNA damage recognition and repair or bioremediation of metals and radionuclides from analysis of DNA sequence.

The decrease in basic structural biology research will be used to increase user support at synchrotron and neutron source facilities.

Infrastructure Development **13,308 21,044 15,300**

BER supports and develops user facilities for the Nation's structural biologists. It coordinates with the National Institutes of Health (NIH) and the National Science Foundation the 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).

With the NIH, BER will improve the beamlines at the SSRL and improve the infrastructure at the Advanced Photon Source (APS) at Argonne National Laboratory. GPP funds ($2,994,000 in FY 2001) will be used to complete a Laboratory Module at the APS. Initiated in FY 2000 with $3,000,000 from the National Institutes of Health's Institute of General Medical Sciences (NIGMS), the module is part of an NIGMS/DOE partnership to advance the field of structural biology. The estimated total federal cost of this laboratory module is $5,994,000. The Laboratory Module will provide space for four additional beamlines needed by the structural biology user community.

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 facilities at the DOE synchrotron light sources and by the successful testing of a new pixel array detector prototype for crystallography at a synchrotron light source.

By the end of FY 2002, BER will begin the process leading to commissioning the DNA Repair Protein Complex Beamline (FY 2001 Major Item of Equipment (MIE) – TEC $4,490,000) at the Advanced Light Source at Lawrence Berkeley National Laboratory. 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

(dollars in thousands)

functionally important conformational changes of multiprotein complexes and on factors that regulate the assembly of those complexes.

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 at ORNL. **Performance will be measured** by having ten external user groups use the Los Alamos Neutron Science Center's (LANSCE) protein crystallography station productivity during its first year of operation.

BER also supports, with NSF, the Protein Data Bank for three-dimensional protein structures.

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 successful integration of new advanced mass spectrometry and nuclear magnetic resonance instrumentation at the Environmental Molecular Sciences Laboratory (EMSL) into the structural biology user facility at EMSL and the successful use of this new instrumentation by at least five external groups.

The major change in FY 2002 is due to the completion of the one-time General Plant Projects (GPP) and MIE projects in FY 2001 described above. In addition, there has been some redistribution of funds to support the general development and use of structural biology user facilities (increase of $1,340,000).

Molecular and Cellular Biology	**30,862**	**51,277**	**51,191**
Microbial Genomics	**8,473**	**14,909**	**10,928**

Microbial genomics research addresses DOE mission needs – The program continues to sequence and characterize microbes that could 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 make industrially useful enzymes. 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 information on the biological capabilities of that organism and is the first step in developing strategies to more efficiently use or to reengineer that microbe to address DOE needs.

Scientific needs of the DOE microbial genome program – Now that the DNA sequence of more than 20 microbes with potential uses in energy, waste cleanup, and carbon sequestration have been determined, the emphasis of the microbial genome is shifting from microbial DNA sequencing to the use of DNA sequence information. In FY 2001, the microbial genome program will focus on 5 scientific challenges:

Functional analysis - It is presently difficult to predict biological function from microbial genomic sequence data. The program is developing better experimental and computational methods to identify novel open reading frames that code for proteins and predict their

functions at a whole-genome scale.

Bioinformatics – More than a third of the 50+ 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 sequence homologies, reconstructing phylogenetic trees, 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 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, and on the development of technologies that enable genomic analyses of these consortia without the need for isolating individual microbes.

Microbial genomics research continues to underpin carbon sequestration research, the microbial cell project, and the Genomes to Life program. **Performance will be measured** by determining the complete DNA sequence of at least four additional microbes that could be used to sequester carbon or for biomass conversion. The reduced budget for FY 2002 reflects the reduced emphasis, greater efficiency, and reduced cost of microbial DNA sequencing as well as shifts of funds and emphasis to other programs, such as carbon sequestration research, the Microbial Cell Project, and Genomes to Life.

Carbon Sequestration Research **5,496** **7,127** **7,138**

Microbes play a substantial role in the global cycling of carbon through the environment. The genomic sequence of up to ten microbes involved in carbon sequestration will have been determined by FY 2002. The main emphasis of the program in FY 2002 is to leverage this new genomic DNA sequence information to now 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 capable of carbon sequestration more efficiently or to even reengineer these microbes to enhance their capacity to sequester excess atmospheric carbon.

Genomic sequencing will be started on a member of the genus *Populas* (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.

The increase in FY 2002 will be used to increase research to identify and characterize genes and proteins involved in carbon sequestration.

Microbial Cell Project and Genomes to Life **0** **9,591** **19,470**

DOE is well positioned to meet this challenge because of its unique resources and demonstrated ability (e.g., in genomics, structural biology, and imaging) to develop and use new technologies and tools to solve complex problems in biology that are then widely adopted by other agencies and industry.

Initiated in FY 2001, the Microbial Cell Project (MCP) represents a fundamental shift in the approach to biology. Instead of looking at an organism from the outside in, starting with its behavior and features and finding the responsible genes, scientists could start with the complete DNA sequence or parts list and work from the inside out to identify and understand the structures, functions, and interactions of an organism's entire complement of genes and gene products (the proteins). The goal of the MCP is to develop a comprehensive understanding of the complete workings of a microbial cell by: deciphering the individual gene sequence; understanding how the sequence is controlled; understanding the production of the genes' protein products; and understanding the complex interaction of all the genes and proteins in a cell. The MCP is focused on four key research challenges with a specific emphasis on DOE mission relevant protein complexes, pathways, and processes and their biochemistry, physiology, and regulation as a basis for understanding function. This unprecedented understanding of a biological system would provide remarkable opportunities to address DOE needs in energy use and energy production, bioremediation, and carbon sequestration.

Functional Analysis of the Microbial Proteome (all the proteins) – The program will develop whole genome approaches to predict and categorize the function and the regulation of proteins, protein complexes, pathways and processes relevant to DOE mission needs. Research will use new high-throughput technologies/tools to better understand expression patterns and protein profiles and will exploit available tools for functional manipulation of these proteins to better understand biochemical pathways relevant to the DOE. The research will also identify domains in gene sequences that mediate protein-protein interactions that are part of these pathways.

Biochemical and Physiological Characterization – The program will define the global interactions among components of these biochemical pathways to understand how individual proteins, metabolites or other cellular biomolecules interact to form functional networks. Research will make

use of new high-throughput technologies/tools to better quantify the protein biochemistry occurring inside a cell in response to different conditions and to better understand regulatory molecules and noncoding regulatory sequences that corresponds to the biochemical pathways being studied. The program also explores the physical mechanisms of intracellular communication and information exchange that underlie the regulation of these DOE-related biochemical pathways.

Intracellular localization – The program will determine the intracellular distribution, localization, movement, temporal variations, and topological or mechanical constraints on the function of proteins involved in these pathways and their regulatory networks. This research also includes the development and use of technology for imaging microbial cell constituents in real time.

Cell modeling – Research is conducted to simulate these biochemical pathways and regulatory networks with computational models capable of making accurate predictions of the responses of these pathways and regulatory networks to perturbations in the microbe's environment. The goal of this research is to enable the use of terascale computers to explore fundamental biological processes and predict the behavior of a broad range of protein interactions and molecular pathways in prokaryotic microbes of importance to DOE.

The Genomes to Life program takes a large step forward, beginning where the FY 2001 Microbial Cell Project leaves off, incorporating it as part of a broader and bolder research program. This program was recommended by the BER Advisory Committee (BERAC). A large, diverse subcommittee drafted a research agenda for BER to challenge scientists to understand not only the complete workings of individual cells but also the regulation and behavior of complex multi-cellular systems and their responses to the environment. The overriding goal of this long-term research program is to understand biology well enough to be able to predict the behavior and response of biological systems–from cells to organisms. The initial scientific challenge is to couple genomic DNA sequencing capabilities with new methods for probing the dynamics of cellular behavior at the molecular level (the cell's proteins at work) with a new, overall emphasis on computation.

The Genomes to Life program will begin with DOE relevant microbes and biochemical pathways to:

(1) Identify life's molecular machines, the multiprotein complexes that carry out the functions of living systems.

(2) Characterize the gene regulatory networks and processes that control life's molecular machines.

(3) Characterize the functional repertoire of complex microbial communities in their natural environments.

(4) Develop computers and other computational capabilities needed to create models that describe the complexity of biological systems to enable prediction of their behavior and productive use of their functions to serve DOE's environmental and health measures.

The broad goals of Genomes to Life are complementary to other federal agencies and many private sector companies' efforts. The program will focus on scientific challenges that can be uniquely

addressed by DOE and its national laboratories in partnership with academic scientists. BER will aim for activities that are out of reach of individual investigators or even small teams. There are unique opportunities in interagency coordination, novel management, new technology innovation, and transition to use in production-scale experimental approaches. For the first time the opportunity exists to understand microbial cells and communities of microbes in enough detail to predict, test, and understand their responses to changes in their environment. This predictive capability will enable these microbes to be used more effectively or to be reengineered to address DOE mission needs in energy use and production, environmental cleanup, and carbon sequestration. This capability also promises broader, unimaginable discoveries for biotechnology and medicine and will, eventually, lead to new tools to predict human susceptibilities.

The increase in the FY 2002 request of $9,879,000 is due to the initiation of the research program described above, Genomes to Life, that includes the Microbial Cell Project (request of $9,735,000 in FY 2001) as a key component. This program funding level was recommended by the Biological and Environmental Research Advisory Committee.

Human Frontiers Science Program..... **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. 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.

Low Dose Radiation Research Program..... **14,175** **18,458** **12,655**

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 radiation, information that is critical to adequately and appropriately protect people and to make the most effective use of our national resources.

In FY 2002, BER will 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 and the development of risk policy. In particular, research will focus on:

Bystander effect – is 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.

(dollars in thousands)

FY 2000	FY 2001	FY 2002

Genomic instability – is the loss of genetic stability, a key event in the development of cancer, induced by radiation and expressed as genetic damage 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.

Adaptive response – is the ability of a low dose of radiation to induce cellular changes that perturb 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 understand 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 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 if genetic differences exist making some individuals more sensitive to radiation-induced damage since these differences could result in sensitive 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 remediating contaminated DOE sites and achieving acceptable levels of human health protection, both for cleanup workers and the public, in a more cost-effective manner that could save billions of dollars. 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 BER issuing an interim progress report on the success of the Low Dose Radiation Research program in producing science that will be useful to policy makers. This interim report will be timely since all awards made during the first full year of funding in this program will have completed their 3-year cycle of funding.

(dollars in thousands)

FY 2000	FY 2001	FY 2002

In FY 2000, the research was funded within both the Cellular Biology and Health Effects programs. In FY 2001, the research was consolidated into the Cellular Biology program. The decrease in FY 2002 enables the program to support research at a level consistent with previous requests (FY 2001, $11,682,000).

Study of Avian Populations at the Nevada Test Site **94** **192** **0**

Congressional direction in FY 2000 for a Study of Avian Populations at the Nevada Test Site.

Hiroshima Neutron Dosimetry **1,624** **0** **0**

Congressional direction in FY 2000 for a review of the Hiroshima neutron dosimetry.

Human Genome **87,499** **86,438** **88,238**

Joint Genome Institute **64,400** **60,000** **57,200**

Status of the DOE Joint Genome Institute (JGI) - The Joint Genome Institute (JGI) and its Production Sequencing Facility (PSF) have been primarily focused on high-throughput sequencing of DNA as DOE's contribution to the international human genome project. The JGI, a virtual institute initially formed from the combined strengths and expertise of DOE Human Genome Centers at the Los Alamos, Lawrence Livermore, and Lawrence Berkeley National Laboratories, has expanded to include Oak Ridge, Pacific Northwest, and Brookhaven National Laboratories that diversify and strengthen its overall capabilities. Oak Ridge adds unique capabilities in bioinformatics, including DNA sequence analysis, that were key to the JGI's completion of the draft DNA sequence of human chromosomes 5, 16, and 19 in FY 2000. Pacific Northwest adds unique capabilities in the high-throughput proteome analysis using mass spectrometry, a capability that is key to identifying and understanding the function of the genes (and their protein products) identified by DNA sequencing. Brookhaven adds unique capabilities in development and use of novel approaches for determining the DNA sequence of difficult-to-sequence regions of the genome.

Scientific needs of the JGI - FY 2001 is the fourth year of a major five-year scale-up of DNA sequencing capacity at the PSF. The PSF has completed the draft sequence of its three human chromosomes 5, 16, and 19. In FY 2002 the PSF will complete the high quality sequence of these three human chromosomes to international "Bermuda" quality standards. Scientists at Stanford University and LANL, working with the JGI, play a key role in completing DOE's share of determining the human DNA sequence. The PSF will also complete draft sequencing of regions of the mouse genome that are comparable to these three human chromosomes. This comparative information is critical to understanding gene function, networks, and regulation.

The need for DNA sequencing does not end with the completion of the reference human DNA sequence. Sequencing the reference human genome gives us a complete set of instructions for human biology, but it does not give us the key for understanding what all those instructions mean or how they work together to make a fully functional biological system--a human. To help scientists

decipher the new wealth of human genomic information, the biological instruction set for humans, information is needed on the biological function of the more than 50,000 newly identified genes, information on how these genes work together to make us who we are and how we are different, and information on the genetic variation that predisposes us to good health or to disease. In short, the goal is to not only know the human DNA sequence--the instruction set--but to understand what it is telling us, i.e., how it actually works. Much of this understanding will come from additional DNA sequencing, comparative sequencing, in which portions of the reference human DNA sequence are compared to fragments of other human DNA sequence or to the sequence of model organisms such as the mouse and Fugu fish. These comparisons will help us define genetic differences between people and understand the functions and regulation of all human genes. These comparisons will also require the generation of as much as ten times more DNA sequence data than will be contained in the reference human DNA sequence.

As an example of the research challenge that still lies ahead, less than 3 percent of human DNA actually contains the instructions for the approximately 30,000 genes that make up our genomes. The remaining DNA, erroneously referred to as "junk DNA," is far from junk for it contains the instructions for making all of these 30,000 genes work at the right times and places throughout our lives – from development to good health and disease to death. Today, scientists are not able to recognize or identify these genetic instructions, or regulatory elements, using computational methods like we can for the genes themselves. Experimental approaches are needed to identify these elements and to define their roles in making our genes work together. The only way to currently find these sequences is by comparatively sequencing the DNA from other, distantly related animals. By comparing the DNA sequences from different species, scientists can identify, in human DNA, the essential regulatory elements by their common association with related genes from different species. The JGI and PSF will continue to use their substantial resources and capabilities for comparative sequencing of the DNA from several different organisms to identify and catalog the regulatory elements associated with the thousands of genes that have already been identified from the initial sequencing effort on human chromosomes 5, 16, and 19.

DOE continues to coordinate its human genome research activities with the activities at the National Human Genome Research Institute and the other partners in the International Human Genome Consortium.

The decrease in funding for the Joint Genome Institute is due to a programmatic shift to increase development of DNA sequencing technology research needed to meet the growing demand for cheaper, faster, and more accurate high-throughput DNA sequencing as a basic research tool in biology.

Performance of the JGI will be measured by the successful achievement of three DNA sequencing goals:

(1) The DOE JGI will complete the high quality DNA sequencing of the vast majority of regions of greatest biological interest of human chromosomes 5, 16, and 19 and will submit the data to GenBank, the public DNA sequence database.

(dollars in thousands)

FY 2000	FY 2001	FY 2002

(2) The JGI will also complete the DNA sequence of the most difficult to sequence regions at the ends (telomeres) and middles (centromeres) of human chromosomes 5, 16, and 19 and submit the data to GenBank.

(3) The JGI's PSF will produce approximately 6 billion base pairs of DNA sequence from model organisms (in addition to its human DNA sequencing) needed to interpret and understand human DNA sequence information. This comparative DNA sequencing is currently the only efficient and cost-effective way to identify and characterize the regulatory elements (the biological on/off switches and the rheostats) that control the expression of human genes.

Tools for DNA Sequencing and Sequence Analysis..... **20,432** **23,950** **28,547**

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 to improve strategies for sequencing the "difficult regions" at the ends and middle of chromosomes and new computational tools for genome-wide data analysis. Novel sequencing strategies such as microchannel capillary electrophoresis offer great promise for the sequencing needs of the future.

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 2002, BER will increase efforts to develop high-throughput approaches for analyzing gene regulation and function.

DNA sequencing technology research increases to meet growing demand for cheaper, faster, and more accurate high-throughput DNA sequencing as a basic research tool in biology.

Ethical Legal and Societal Issues (ELSI)..... **2,667** **2,488** **2,491**

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 focus 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 2000	FY 2001	FY 2002
DOE Total Funding (FY 87-99)	691.5	87.5	86.4	88.2
NIH Funding (FY 88-99)	1,524.1	335.1	382.4	426.7[a]
Total U.S. Funding	2,215.6	422.6	468.8	514.9

(dollars in thousands)

	FY 2000	FY 2001	FY 2002
Health Effects	**17,108**	**15,409**	**14,251**
Low Dose Radiation Research	**2,321**	**0**	**0**

Low dose radiation research (consolidated in Cellular Biology in FY 2001) was also funded in Health Effects in FY 2000.

Functional Genomics Research	**10,860**	**12,210**	**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 yeast, nematode, fruit fly, Zebra fish, 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-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 both as important models of human genetic diseases. It 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 and Fugu fish to understand the function of human genes is increased in FY 2002 ($2,041,000). These funds will take advantage of the newly available DNA sequence of the Fugu fish and for mouse chromosomes homologous to human chromosome 5, 16, and 19.

[a] Estimate from NIH.

	(dollars in thousands)		
	FY 2000	FY 2001	FY 2002
Technology Development Research	**3,927**	**3,199**	**0**
Technology development research ends as technology development needs are met with the initiation of the Genomes to Life program at DOE described here and the Structural Genomics program at the National Institutes of Health.			
SBIR/STTR increased with Life Sciences program increase	**0**	**4,589**	**4,678**
In FY 2000, $4,259,000 and $264,000 were transferred to the SBIR and STTR programs, respectively. FY 2001 and FY 2002 amounts are the estimated requirements for the continuation of these programs.			
Total, Life Sciences	**161,338**	**192,472**	**186,205**

Explanation of Funding Changes from FY 2001 to FY 2002

	FY 2002 vs. FY 2001 ($000)
Structural Biology	
Decrease in basic structural biology research to support increases for structural biology user facilities.	-1,168
Decrease in one-time GPP funding of user facility at the Advanced Photon Source and the MIE beamline development at the Advanced Light Source (-$7,084,000). However, there is an increase in support for structural biology user facilities at synchrotron sources and neutron sources (+$1,340,000).	-5,744
Total, Structural Biology	-6,912
Molecular and Cellular Biology	
Reduced emphasis on microbial DNA sequencing and increased support for Genomes to Life.	-3,981
Continue carbon sequestration at near FY 2001 level	+11
Redirected program, Genomes to Life, includes Microbial Cell Project and focuses on understanding cellular processes and multicellular systems so well that 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, or carbon sequestration.	+9,879

	FY 2002 vs. FY 2001 ($000)
Continue Low Dose Radiation Research at about previously requested levels (FY 2001, $11,682,000).	-5,803
Decrease due to Congressional Direction for the study of biological effects of low level radioactivity at University of Nevada in FY 2001.	-192
Total, Molecular and Cellular Biology	-86
Human Genome	
Decrease in funding for the Joint Genome Institute is due to a programmatic shift to increase development of DNA sequencing technology research needed to meet the growing demand for cheaper, faster, and more accurate high-throughput DNA sequencing as a basic research tool in biology.	-2,800
DNA sequencing technology research increases to meet growing demand for cheaper, faster, and more accurate high-throughput DNA sequencing as a basic research tool in biology	+4,597
Ethical Legal and Societal Issues program continues at approximately same level.	+3
Total, Human Genome	+1,800
Health Effects	
Increase research to understand the function of human genes that could lead to better understanding of the causes of disease or to preventions or cures.	+2,041
Decrease research for high-throughput approaches that determine protein structure as NIH begins to make large investments in this area.	-3,199
Total, Health Effects	-1,158
SBIR/STTR	
■ Increase in SBIR/STTR due to increase in research funding for the Life Sciences program.	+89
Total Funding Change, Life Sciences	-6,267

Environmental Processes

Mission Supporting Goals and Objectives

The Environmental Processes 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 energy 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 Environmental Processes subprogram (minus the carbon sequestration element) represents DOE's contribution to the 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 ($8,763,000).

The Environmental Processes subprogram is comprehensive with a major emphasis 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 the 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 includes developing 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 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 address the net exchange of carbon among major types of terrestrial ecosystems and the atmosphere. Research is also conducted to determine the effects of atmospheric and climate changes on terrestrial organisms, ecosystems, and resources.

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.

Performance will be measured by reporting accomplishments on the common performance measures on leadership, excellence and relevance; quality; and safety and health.

Funding Schedule

(dollars in thousands)

	FY 2000	FY 2001	FY 2002	$ Change	% Change
Climate and Hydrology	67,496	70,326	70,775	+449	+0.6%
Atmospheric Chemistry and Carbon Cycle	33,837	35,579	34,844	-735	-2.1%
Ecological Processes	11,858	12,431	12,437	+6	-
Human Interaction	9,369	8,020	8,084	+64	+0.8%
SBIR/STTR	0	3,348	3,329	-19	-0.6%
Total, Environmental Processes	122,560	129,704	129,469	-235	-0.2%

Detailed Program Justification

(dollars in thousands)

	FY 2000	FY 2001	FY 2002
Climate and Hydrology	**67,496**	**70,326**	**70,775**
Climate Modeling	**24,151**	**27,103**	**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 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 how BER will successfully develop and test a fully coupled atmosphere-ocean-land-sea ice climate model of higher spatial resolution than is presently available. BER will support multi-disciplinary teams of scientists at multiple institutions using DOE supercomputers to perform model simulations, diagnostics, and testing. BER efforts will include ensembles of long-term (decade to century) coupled model simulations that will be made available to the broader climate research and assessment communities to enable probability-based assessments of climate change and variability at regional resolution.

In FY 2002, BER will continue to enhance the partnership with the Advanced Scientific Computing Research program and increase the computing resources for climate simulation and accelerate 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 support 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 ($2,191,000).

Performance will be measured by developing and testing a fully coupled atmosphere-ocean-land-sea climate model of higher spatial resolution than is presently available. Support multi-disciplinary teams of scientists at multiple institutions using DOE supercomputers to perform model simulations, diagnostics, and testing. These efforts will include ensembles of long-term (decade to century) couples model simulations that will be made available to the broader climate research and assessment communities to enable probability based assessment of climate change and variability at regional resolution.

Atmospheric Radiation Measurement (ARM) Research **13,020** **13,124** **13,486**

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. 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. 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). To facilitate the knowledge transfer from the ARM Program to the premier modeling centers, the ARM program supports scientific "Fellows" at NSF's National Center for Atmospheric Research and at the European Center for Medium-Range Weather Forecasting in the U.K. In FY 2002, the ARM program will continue at approximately the FY 2001 level.

Performance will be measured by improving the radioactive flux calculations and associated heating rates in climate models using ARM data and science by 10 percent.

Atmospheric Radiation Measurement (ARM) Infrastructure . **27,653** **27,371** **27,371**

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 limited 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 are enhanced periodically by additional measurements 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.

Performance will be measured in FY 2002 by less than 5 percent downtime of 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) **2,672** **2,728** **2,737**

Atmospheric Chemistry and Carbon Cycle **33,837** **35,579** **34,844**

Atmospheric Science programs **12,688** **12,571** **12,571**

The Atmospheric Science programs 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, and 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 2002 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 Environmental Protection Agency, the National Aeronautics and Space Administration, and the National Oceanic and Atmospheric Administration 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 air quality and climate impacts of 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 ($2,191,000).

Western States Visibility Study at New Mexico Tech	**0**	**1,246**	**0**

Congressional direction in FY 2001 for the Western States Visibility Study.

Terrestrial Carbon Processes and Ocean Sciences	**12,958**	**12,731**	**13,716**

BER will continue supporting the successful AmeriFlux Program, including the measurements of carbon flux and water vapor exchange at approximately 25 sites across North America. These measurements will be linked to field measurement campaigns across North America that will test the representativeness of point measurements and allow the estimation of carbon sources and sinks on a regional basis. The fluxes of other greenhouse gases, e.g., methane and nitrous oxide, will be measured at several AmeriFlux sites.

In FY 2002, funding is increased to support the refinement and testing of carbon cycle models (based on mechanistic representations and simple carbon accounting). The models will be used to estimate potential carbon sequestration for a variety of biogeochemical cycles and climate variations.

(dollars in thousands)

FY 2000	FY 2001	FY 2002

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).

Performance will be measured by quantifying the net exchange of carbon dioxide in five additional ecosystems in the AmeriFlux network.

National Energy Laboratory in Hawaii **1,500** **479** **0**

Congressional direction in FY 2000 and FY 2001 for the National Energy Laboratory in Hawaii.

Carbon Sequestration Research Centers **6,691** **8,552** **8,557**

BER will continue support for two carbon sequestration research centers. One center, led by ORNL, PNNL, and ANL, and involving six collaboratory universities, focuses on terrestrial sequestration ($3,000,000). The other center, led by LBNL and LLNL, involves collaboration with six universities and research institutions, and focuses on ocean sequestration ($2,000,000). The centers develop the information to enhance the natural sequestration of carbon in terrestrial soils and vegetation and in the deep ocean. BER will continue research at universities and laboratories 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 both terrestrial plants and, ultimately, to 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 at universities and laboratories that specifically examine 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 DOE Ocean Carbon Sequestration Center 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 ocean carbon sequestration. Initial in situ experiments will be designed to determine the feasibility and potential environmental impacts of deep ocean injection of 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 developing and testing the feasibility of soil, microbial manipulation, and ecosystem management approaches for enhancing the magnitude of net annual carbon sequestration.

(dollars in thousands)

FY 2000	FY 2001	FY 2002

In FY 2002 university scientists will continue research on the effects of iron fertilization on plankton communities in the ocean and begin field experiments. The Southern Ocean is the largest high-nutrient, low-chlorophyll region in the world. The joint DOE-NSF Southern Ocean Iron Enrichment Experiment (SoFEX) will help scientists understand the potential to enhance ocean carbon sequestration through iron enrichment.

Ecological Processes **11,858** **12,431** **12,437**

BER will continue the six Free-Air Carbon Dioxide Enrichment (FACE) experiments 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 and succession 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 to climate change and to carbon sequestration.

NIGEC will support experimental studies to document how climate warming and increasing CO_2 levels in the atmosphere affect biophysical processes in terrestrial ecosystems ($2,629,000).

Performance will be measured by exposing plants at least 95% of the time during the growing season to elevated CO_2 to test for long-term physiological responses to CO_2 enrichment.

Human Interactions **9,369** **8,020** **8,084**

Human Interactions **7,964** **8,020** **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 trade 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.

(dollars in thousands)

FY 2000	FY 2001	FY 2002

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. ($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) North American Strategy for Tropospheric Ozone (NARSTO), 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. **Performance will be measured** by how well the Global Change Education program will continue to support both undergraduate and graduate students in DOE-related global change research. Over 30 DOE-sponsored students participate in the program, including the DOE Summer Undergraduate Research Experience (SURE), the DOE Graduate Research Environmental Fellowships (GREF), and the NSF Significant Opportunities in Atmospheric Research and Science (SOARS) Program.

Utton Transboundary Center	**1,405**	**0**	**0**

Congressional direction in FY 2000 for the Utton Transboundary Center.

SBIR/STTR	**0**	**3,348**	**3,329**

In FY 2000 $3,201,000 and $185,000 were transferred to the SBIR and STTR programs, respectively. FY 2001 and FY 2002 amounts are the estimated requirements for the continuation of these programs.

Total, Environmental Processes	**122,560**	**129,704**	**129,469**

Explanation of Funding Changes from FY 2001 to FY 2002

	FY 2002 vs. FY 2001 ($000)
Climate and Hydrology	
Climate Modeling program will continue at approximately the FY 2001 level.	+78
Atmospheric Radiation Measurement (ARM) program will continue at approximately the FY 2001 level.	+362
Atmospheric Radiation Measurement (ARM) Unmanned Aerial Vehicles (UAV) program will continue at FY 2001 level.	+9
Total, Climate and Hydrology	+449
Atmospheric Chemistry and Carbon Cycle	
Atmospheric Sciences research continues at approximately FY 2001 levels with the decrease due to Congressional Direction for the Western Visibility Study at New Mexico Tech	-1,246
Terrestrial Carbon is increased to support expanded studies of carbon cycling processes of Ameri Flux sites.	+985
Decrease due to Congressional Direction for the National Energy Laboratory in Hawaii	-479
Carbon Sequestration continues at FY 2001 levels	+5
Total, Atmospheric Chemistry and Carbon Cycle	-735
Ecological Processes	
Ecological Processes programs continue at approximately FY 2001 level.	+6
Human Interactions	
Integrated Assessment program will continue at FY 2001 level.	+64
SBIR/STTR	
SBIR/STTR decrease due to decrease in research funding for environmental processes	-19
Total Funding Change, Environmental Processes	-235

Environmental Remediation

Mission Supporting Goals and Objectives

BER's research in environmental remediation is primarily 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 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 pore 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 mobility 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 and Biodegradation 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 two-way communication with affected stakeholders to help ensure understanding and acceptance of proposed solutions to remediating contaminants. The research in the Systems Integration, Prediction, and Optimization element is focused on defining and developing an integrative model to aid collaboration and direction across research teams within the NABIR program. All NABIR elements and EMSL activities have a substantial involvement of academic scientists.

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 and other environmental science endeavors. 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 also will increase.

Performance will be measured by reporting accomplishments on the common performance measures on leadership, excellence and relevance; quality; and safety and health.

Funding Schedule

(dollars in thousands)

	FY 2000	FY 2001	FY 2002	$ Change	% Change
Bioremediation Research	31,908	26,338	26,911	+573	+2.2%
Clean Up Research	1,846	1,556	2,463	+907	+58.3%
Facility Operations	28,816	31,054	34,054	+3,000	+9.7%
Waste Management	1,200	1,197	1,200	+3	+0.3%
SBIR/STTR	0	1,316	1,509	+193	+14.7%
Total, Environmental Remediation	63,770	61,461	66,137	+4,676	+7.6%

Detailed Program Justification

(dollars in thousands)

	FY 2000	FY 2001	FY 2002
Bioremediation Research	**31,908**	**26,338**	**26,911**
NABIR and Bioremediation Research	**25,952**	**20,371**	**20,931**

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 understand the fundamental mechanisms underlying chemical processes, complexation/transformation of contaminants, and microbial transport. The Field Research Center is in operation at the Oak Ridge National Laboratory. Field site characterization of the first NABIR Field Research Center and distribution of research samples to investigators will continue. In FY 2002, funding will increase support focused field research at the NABIR Field Research Center. Science elements in the NABIR program include fundamental research in the following subjects: (1) Biotransformation and Biodegradation (microbiology to elucidate the mechanisms of biotransformation and biodegradation of complex contaminant mixtures); (2) Community Dynamics and Microbial Ecology (ecological processes and interactions of biotic and abiotic components of ecosystems to understand their influence on the degradation, persistence, mobility, and toxicity of mixed contaminants); (3) Biomolecular Science and Engineering (molecular and structural biology to enhance the understanding of bioremediation and improve the efficacy of bioremedial organisms 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); (6) Acceleration (flow and transport of nutrients and microorganisms, focused on developing effective methods for accelerating

and optimizing bioremediation rates); and (7) System Engineering, Integration, Prediction, and Optimization, (conceptual and quantitative methods for describing community dynamics, biotransformation, biodegradation, and biogeochemical processes in complex geologic systems). 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 at Oak Ridge was started in FY 2000. To make the Center operational, initial activities will address laboratory and logistical infrastructure, characterize the subsurface water flow and contaminant transport, and model the flow, transport, and biogeochemistry so that appropriate sites and procedures can be selected for the initial experiments. 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 understand 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.

Performance will be measured by demonstrating that uranium concentrations in groundwater can be measurably decreased using bioremediation at the Field Research Center.

General Plant Projects (GPP) **4,692 4,800 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 enhanced effort will accelerate rehabilitation and upgrade 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.

(dollars in thousands)

	FY 2000	FY 2001	FY 2002
General Purpose Equipment (GPE)	**1,264**	**1,167**	**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	**1,846**	**1,556**	**2,463**

The modest program in clean up research will be restored to 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.

New 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 2002, research in in-situ approaches is enhanced to focus 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 efforts undertaken by the Science and Technology element of the DOE Office of Environmental Management (EM) including the Environmental Management Science Program (EMSP) that is jointly managed by EM and SC.

Facility Operations: William R. Wiley Environmental Molecular Sciences Laboratory (EMSL)	**28,816**	**31,054**	**34,054**
Operating Expenses	**26,835**	**26,604**	**32,065**

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 800 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.

Increased funding in FY 2002 ($5,461,000) will be used to lease and operate a 2 to 3 teraflop high performance computer for the EMSL to replace its current ¼ teraflop computer, which is no longer effective for leading edge computation studies in the environmental molecular sciences. The new high performance computer will be used for theoretical studies, 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 will also greatly assist the EMSL focus on structural genomics.

Performance will be measured by (1) an expansion of the EMSL's collaboratory capabilities to two additional instruments, and (2) unscheduled operational downtime on EMSL instrumentation and computational resources will not exceed 10 percent.

Capital Equipment **1,981** **4,450** **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.

Waste Management **1,200** **1,197** **1,200**

Provides for packaging, shipping, and disposition of hazardous, radioactive, or mixed waste generated at Pacific Northwest National Laboratory in the course of normal operations. These activities were funded by Environmental Management prior to FY 2001.

SBIR/STTR **0** **1,316** **1,509**

In FY 2000 $1,430,000 and $86,000 were transferred to the SBIR and STTR programs, respectively. FY 2001 and FY 2002 amounts are the estimated requirements for the continuation of these programs.

Total, Environmental Remediation **63,770** **61,461** **66,137**

Explanation of Funding Changes from FY 2001 to FY 2002

	FY 2002 vs. FY 2001 ($000)
Bioremediation Research	
Increase in support for focused field research at the NABIR Field Research Center. .	+560
Continue GPP funding at FY 2001 level.	+11
Continue GPE funding at FY 2001 level.	+2
Total, Bioremediation Research.....	+573
Clean Up Research	
Clean up research on in-situ approaches is being enhanced to focus on challenging problems of in situ cleanup of mixed wastes containing complex mixtures of organic wastes, metals, and radionuclides	+907
Facility Operations	
Increase will support the lease and operation of a 2 to 3 teraflop computer ($5,461,000) for the EMSL to play a significant role in molecular modeling and structural genomics	+5,461
Decrease due to one-time FY 2001 Capital Equipment funding for mass spectrometers and Nuclear Magnetic Resonance (NMR) spectrometers at EMSL.	-2,461
Total, Facility Operations	+3,000
Waste Management	
Continue Waste Management program at FY 2001 level.	+3
SBIR/STTR	
SBIR/STTR increases due to increase in research funding for cleanup research.	+193
Total Funding Change, Environmental Remediation.....	+4,676

Medical Applications and Measurement Science

Mission Supporting Goals and Objectives

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 for the life sciences, including Genomes to Life, and having broad medical applications.

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

Performance will be measured by reporting accomplishments on the common performance measures on leadership, excellence and relevance; quality; and safety and health.

Funding Schedule

(dollars in thousands)

	FY 2000	FY 2001	FY 2002	$ Change	% Change
Medical Applications	63,104	88,138	43,872	-44,266	-50.2%
Measurement Science	5,265	5,626	5,961	+335	+6.0%
SBIR/STTR	0	2,624	1,326	-1,298	-49.5%
Total, Medical Applications and Measurement Science	68,369	96,388	51,159	-45,229	-46.9%

Detailed Program Justification

(dollars in thousands)

	FY 2000	FY 2001	FY 2002
Medical Applications	**63,104**	**88,138**	**43,872**
Boron Neutron Capture Therapy (BNCT)	**9,662**	**10,454**	**10,041**

In FY 2002, funding is decreased as 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 is completed. These analyses will complete BER's assessment of the maximum safe dosages of boron compounds and neutron radiation.

Working with the National Institutes of Health and the National Cancer Institute, basic research on 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 new program will be on the therapeutic use of ionizing radiation that may be achieved with radionuclide therapy or techniques such as boron neutron capture therapy. The specific goals include the development of novel ligands 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 ligands; (2) efficient screening techniques for selecting candidate ligands 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 ligands that perform sufficiently well in pre-clinical evaluations to deserve consideration for clinical trials by NIH and/or private industry.

Radiopharmaceutical Design and Synthesis	**20,753**	**26,637**	**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 in 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, and among various diseases, such as of the heart, brain and cancer, 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. **Performance will be measured** by the successful development of unique radiopharmaceutical tracers that will enable PET medical imaging to more precisely diagnose neuro-psychiatric illnesses (Alzheimer's Disease, Parkinson's Disease, multiple sclerosis, and others) and cancer in humans. This research is closely coordinated with the NIH Institutes of Drug Abuse, of Mental Health and of Neurological Disorders and Stroke.

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 may be highly challenging but not an unattainable goal. This research includes an emphasis on nucleic acid biochemistry, radioligand 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 biological applications of optical and radionuclide imaging devices, all contributing to the goal of 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 people. This information will have applications ranging from understanding the development of a disease to the efficacy of treatments for the disease and will strongly impact developmental biology and genome research, including the Genomes to Life program, and medical sciences. **Performance will be measured** by the successful development of innovative methods and instrumentation to image gene expression in real time in cells, tissues and whole organisms.

In FY 2001, Congressional Direction provided a one-time increase for molecular nuclear medicine. The increase provided infrastructure support for molecular biology and molecular nuclear medicine.

Multimodal Imaging Systems and Medical Photonics **5,043** **9,922** **9,386**

In FY 2002, BER will decrease support in multimodal imaging systems for study of human brain function and 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. Capital equipment funds will develop new instrumentation such as a PET camera for small animal imaging. 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 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.

(dollars in thousands)

FY 2000	FY 2001	FY 2002

BER will also expand its research program at the national laboratories in 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 partnerships between 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. An emphasis is placed on:

Biomedical Imaging – is the development of novel medical imaging systems. Emphasis is placed on combining optical imaging with other traditional medical imaging systems such as MRI, PET, and SPECT and on the development of small imaging systems that image in real-time under natural physiological conditions. A major objective is improvement of the reliability and cost-effectiveness of medical imaging technologies. 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.

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 situ 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 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 as follows: in close partnership with NIH, develop novel technology and instrumentation to image single molecules, genes, cells, organs, and whole organisms in real time under natural physiological conditions with a high degree of precision, including MIR, PET, and SPECT. Technology and detector systems will be developed to capitalize on recent findings of the human genome project that will enable imaging of gene expression in real time which will have a critical impact on biomedical research and medical diagnosis.

(dollars in thousands)

	FY 2000	FY 2001	FY 2002
Congressional Direction	**27,646**	**41,125**	**0**

Congressional direction in FY 2000 for Gallo Institute of the Cancer Institute of New Jersey; City of Hope National Medical Center; National Foundation for Brain Imaging; University of Missouri Research Reactor; North Shore Long Island Jewish Health System; Burbank Hospital Regional Center; Midwest Proton Radiation Institute; Medical University of South Carolina Cancer Research Center; Center for Research on Aging at Rush Presbyterian St. Lukes Medical Center; University of Nevada Las Vegas Cancer Complex; Science Center at Creighton University; and the West Virginia National Education and Technology Center. 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.

Measurement Science	**5,265**	**5,626**	**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. **Performance will be measured** by the development of new environmental sensors that are better, faster, and cheaper 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 increased in FY 2002 for research to develop new instrumentation for the life sciences, including Genomes to Life and having broad medical applications. BER will continue research on medical applications of laser technology at the national laboratories and at universities.

(dollars in thousands)

	FY 2000	FY 2001	FY 2002
SBIR/STTR	**0**	**2,624**	**1,326**

In FY 2000, $1,533,000 and $90,000 were transferred to the SBIR and STTR programs, respectively. FY 2001 and FY 2002 amounts are the estimated requirements for the continuation of these programs.

Total, Medical Applications and Measurement Science	**68,369**	**96,388**	**51,159**

Explanation of Funding Changes from FY 2001 to FY 2002

	FY 2002 vs. FY 2001 ($000)
Medical Applications	
Boron Neutron Therapy (BNCT) program is decreased	-413
The infrastructure support for molecular biology and molecular nuclear medicine has been successfully completed	-2,192
Decrease in Multimodal Imaging Systems is a result of a redirection in the Nuclear Medicine program	-536
Decrease due to Congressional Direction in FY 2001.	-41,125
Total Funding Change, Medical Applications	-44,266
Measurement Science	
Measurement Science will increase capital equipment funding to develop new instrumentation for the life sciences, including Genomes to Life and having broad medical applications.	+335
SBIR/STTR	
Decrease in SBIR/STTR as overall research program decreased with completion of Congressional direction	-1,298
Total Funding Change, Medical Applications and Measurement Science	-45,229

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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 2000	FY 2001	FY 2002	$ Change	% Change
Construction	0	2,495	10,000	+7,505	+300.8%

Detailed Program Justification

(dollars in thousands)

	FY 2000	FY 2001	FY 2002
Construction	**0**	**2,495**	**10,000**

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 BER successfully managing the development and upgrade of the Laboratory for Comparative and Functional Genomics at ORNL on schedule and within cost.

Explanation of Funding Changes from FY 2001 to FY 2002

	FY 2002 vs. FY 2001 ($000)
Construction	
Continue construction of the Laboratory for Comparative and Functional Genomics at the approved funding profile level	+7,505

Capital Operating Expenses & Construction Summary

Capital Operating Expenses

(dollars in thousands)

	FY 2000	FY 2001	FY 2002	$ Change	% Change
General Plant Projects	4,692	7,794	4,811	-2,983	-38.3%
Capital Equipment	13,960	22,702	17,633	-5,069	-22.3%
Total Capital Operating Expenses	18,652	30,496	22,444	-8,052	-26.4%

Construction Projects

(dollars in thousands)

	Total Estimated Cost (TEC)	Prior Year Approp-riations	FY 2000	FY 2001	FY 2002	Unapprop-riated Balance
01-E-300, Laboratory for Comparative and Functional Genomics, ORNL	13,900	0	0	2,495	10,000	1,405
Total, Construction		0	0	2,495	10,000	1,405

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

(dollars in thousands)

	Total Estimated Cost (TEC)	Prior Year Approp-riations	FY 2000	FY 2001	FY 2002	Acceptance Date
DNA Repair Protein Complex Beamline, ALS	4,490	0	0	4,490	0	FY 2001
Total, Major Items of Equipment		0	0	4,490	0	

01-E-300, Laboratory for Comparative and Functional Genomics, Oak Ridge National Laboratory, Oak Ridge, Tennessee

1. Construction Schedule History

	Fiscal Quarter				Total Estimated Cost ($000)	Total Project Cost ($000)
	A-E Work Initiated	A-E Work Completed	Physical Construction Start	Physical Construction Complete		
FY 2001 Budget Request *(Preliminary Estimate)*	1Q2001	3Q2001	3Q2001	1Q2004	13,900	14,420

2. Financial Schedule

(dollars in thousands)

Fiscal Year	Appropriations	Obligations	Costs
2001	2,495	2,495	2,175
2002	10,000	10,000	6,980
2003	1,405	1,405	4,550
2004	0	0	195

3. Project Description, Justification and Scope

The Laboratory for Comparative and Functional Genomics (LCFG) will provide a modern gene function research facility to support Department of Energy research programs and provide protection for the genetic mutant mouse lines created during the past 50 years. The LCFG will replace the deteriorated mouse housing-facility located at the Y-12 Weapons Plant on the Oak Ridge Reservation to meet these programmatic needs.

The current Biology facilities are fifty years old and the buildings and building systems are in need of major upgrades which include asbestos abatement, roof replacement, HVAC replacement, underground utility system replacement, electrical systems upgrade, and exterior repairs to the building. Animal care accreditation depends on improving the housing conditions. The LCFG will provide cost-effective housing for the experimental animals that are vital to the next phase of the Genome program. It will be designed for efficient utilization of space and will be energy efficient and easy to maintain. It will accommodate the entire DOE live mutant mouse colony in Oak Ridge, which will be reduced in size by utilizing cryogenic preservation technology. The facility will be designed to permit the establishment of specific pathogen free colonies of mice.

The facility will be a single story building of approximately 32,000 sq.ft. comprised of four functional areas: support, animal housing, quarantine and laboratory support. The heating, ventilation and air-conditioning system will utilize 100% fresh air to achieve 10-15 air changes per hour and maintain temperatures between 68EF and 74EF with humidity levels of 40% to 60%. The system will be capable of maintaining +/- 2EF control in each animal housing room including the quarantine area. The lighting system will be timer controlled with variable intensity level between 130-325 lux. Sound levels will be maintained below 85 decibels. The internal water system will use reverse osmosis or special chlorination treatment to ensure adequate water chemistry. Floor, walls and ceilings will be constructed of durable, moisture-proof, fire-resistant, seamless materials to allow the highest possible levels of sanitation. Non-toxic paints and glazes will be used within the facility. The building will be equipped with silent fire alarm systems.

The building will be equipped with two tunnel washers, two rack washers, two pass-through autoclaves and two bulk autoclaves, a bedding dispenser, bedding disposal system and ventilated animal cage systems equipped with automatic watering. The HVAC system will include a 24-hour monitoring system. Other equipment includes slotted hood vents, down draft tables and surgical lighting in the laboratory support area to support animal procedures.

Site preparation will consist of clearing, grading, and excavating for the new structure; extension of access streets to the site; and landscaping and seeding. Outside utilities will consist of extending the required utilities from the building to the closest, and an adequately sized supply source. Utilities will include steam, sanitary sewers, potable and fire protection water, natural gas, and electricity.

Obligations for FY 2001 will be used to award the Engineer/Procure/Construct Contract (EPCC) with sufficient funds to accomplish the detail design, initiate construction, and to order long-lead items. First year funding will also support project management and inspection of construction.

The researchers and animals are currently housed in facilities at the East end of the Y-12 Weapons Plant. Most of the buildings that have been used for biology were constructed in the late 1940s or early 1950s for other

purposes. The building housing the animals has deteriorated with age and cannot be maintained cost effectively and the building systems need to be upgraded to assure continued compliance with accreditation standards for animal research facilities. In addition to being expensive to operate and maintain, the existing facility does not provide a barrier maintenance facility for maintaining immune deficit and other lines of mice that require a pathogen-free environment.

The principle programmatic reasons for constructing the new facility are to ensure adequate, cost effective housing for the national resource embodied in the mutant mouse colony to support the next phase of the Genome Program - the identification of gene function.

In addition, benefits include:

Enabling the DOE Mammalian Genetics User Facility to more effectively support the national research community and DOE researchers at other institutions.

Providing substantially more effective collaboration between the Life Sciences Division and other Oak Ridge National Laboratory (ORNL) facilities and Divisions such as Environmental Sciences, Chemical and Analytical Sciences, Solid State, and Computing and Mathematical Sciences Divisions as well as the Center for Computational Sciences.

Enhancing ORNL's ability to attract first rate young scientists to facilities that represent state-of-the-art laboratories that are cost effective in operation and efficient in the conduct of biological research.

Facilitating the access for visiting scientists worldwide by eliminating the restrictions stemming from the close proximity of a high-security weapons plant.

Developing facilities that offer unique resources of the organization and the world-class capabilities of the staff.

Continuing the contribution to higher education via administration of and participation in the University of Tennessee - Oak Ridge Graduate School of Biomedical Sciences.

4. Details of Cost Estimate [a]

(dollars in thousands)

	Current Estimate	Previous Estimate
Design Phase		
Preliminary and Final Design Costs (Design, Drawings, and Specifications)	465	N/A
Design Management Costs (0.3% of TEC)	40	N/A
Project Management Costs (0.2% of TEC)	30	N/A
Total, Design Costs (3.8% of TEC)	535	
Construction Phase		
Buildings	7,815	N/A
Utilities	140	N/A
Standard Equipment	3,530	N/A
Inspection, design and project liaison, testing, checkouts and Acceptance	250	N/A
Construction Management (0.6% of TEC)	80	N/A
Project Management (1.2% of TEC)	160	N/A
Total, Construction Costs	11,975	
Contingencies (10% of TEC)		
Design Phase	45	N/A
Construction Phase	1,345	N/A
Total, Contingencies (10% of TEC)	1,390	
Total Line Item Costs (TEC)	13,900	N/A

5. Method of Performance

Detail design, procurement and construction will be accomplished by a fixed price Engineer/Procure/ Construct Contractor (EPCC).

[a] The cost estimate is based on a conceptual design completed in April 1998. The DOE Headquarters escalation rates were used as appropriate over the project life.

6. Schedule of Project Funding

	Prior Years	FY 2000	FY 2001	FY 2002	Outyears	Total
Project Cost						
Facility Cost						
Design	0	0	580	0	0	580
Construction	0	0	1,595	6,980	4,745	13,320
Total, Line item TEC	0	0	2,175	6,980	4,745	13,900
Other project costs						
Conceptual design costs[a]	20	0	0	0	0	20
NEPA documentation costs[b]	0	15	0	0	0	15
Other project related costs[c]	0	485	0	0	0	485
Total, Other Project Costs	20	500	0	0	0	520
Total Project Cost (TPC)	20	500	2,175	6,980	4,745	14,420

[a] A conceptual design report (CDR) was completed in April 1998 at a cost of $20,000.

[b] NEPA for this project is expected to require a NEPA Categorical Exclusion Determination (CXD). Estimated cost is $15,000.

[c] Soil borings and other sampling and documentation associated with site characterization to be completed in FY 2000 at an estimated cost of $60,000. A detailed requirements document (including Design Criteria) and Engineer/ Procure/Construct Contractor (EPCC) selection activities will be completed in FY 2000 at an estimated cost of $340,000. Technical and project management support through FY 2000 are estimated at a cost of $85,000.

7. Related Annual Funding Requirements

(FY 2004 dollars in thousands)

	Current Estimate	Previous Estimate
Annual facility operating costs[a]	675	N/A
Facility maintenance and repair costs[b]	130	N/A
Programmatic operating expenses directly related to the facility[c]	740	N/A
Capital equipment not related to construction but related to the programmatic effort in the facility[d]	205	N/A
Utility costs	510	N/A
Other costs[e]	205	N/A
Total related annual funding	2,465	N/A

[a] This includes janitorial and other miscellaneous support services. Approximately five staff years of effort will be required to provide these services. This is approximately $360,000 less than the cost for operating the existing facility. The savings result from having a modern facility with a more functional design.

[b] The FY 1998 facility maintenance and utility cost for the existing ORNL animal housing facilities totaled approximately $1,350,000. Based on experience with functionally comparable buildings at the ORNL site with energy conservation features incorporated in the construction, the estimated maintenance and utilities cost for the proposed facility are approximately $130,000 for maintenance and $510,000 for utilities. Thus, the savings in operating funds is estimated to be nearly $710,000, per year.

[c] The FY 1998 programmatic operating expenses of the existing animal housing facilities were approximately $740,000. This includes funding for animal care support personnel. This level of funding will not increase as a result of the proposed relocation of facilities.

[d] The conduct of modern biological research by the LCFG such as that involved in the Human Genome Project and Structural Biology requires the periodic purchase of capital scientific equipment. Recurring annual cost of capital equipment is approximately $205,000.

[e] The estimated expenditures for programmatic related maintenance are approximately $205,000 per year. This includes funding for three maintenance personnel to perform programmatic related maintenance. The relocation to the proposed facility will result in an estimated savings of approximately $50,000 per year. The new animal support equipment will require a smaller portion of the operating budget for maintenance.

8. Design and Construction of Federal Facilities

All DOE facilities are designed and constructed in accordance with applicable Public Laws, Executive Orders, OMB Circulars, Federal Property Management Regulations, and DOE Orders. The total estimated cost of the project includes the cost of measures necessary to assure compliance with Executive Order 12088, "Federal Compliance with Pollution Control Standards"; section 19 of the Occupational Safety and Health Act of 1970, the provisions of Executive Order 12196, and the related Safety and Health provisions for Federal Employees (CFR Title 29, Chapter XVII, Part 1960); and the Architectural Barriers Act, Public Law 90-480, and implementing instructions in 41 CFR 101-19.6. This project includes the construction of new buildings and/or building additions; therefore, a review of the GSA Inventory of Federal Scientific Laboratories is required. The project will be located in an area not subject to flooding determined in accordance with the Executive Order 11988.