Biological and Environmental Research

Program Mission

For over 50 years the Biological and Environmental Research (BER) has been investing to advance environmental and biomedical knowledge connected to energy. The program provides fundamental science to underpin the business thrusts of the Department's strategic plan. Through its support of peer-reviewed research at national laboratories, universities, and private institutions, the program 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 science in support of the Energy Policy Act of 1992.

The high quality of the research in this program is continuously evaluated through the use of merit based peer review and scientific advisory committees.

Program Goal

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.

Program Objectives

- *To Contribute to a Healthy Citizenry* - Map the fine structure of the human genome by 2003, thus providing resources to the international research community needed to identify disease genes and develop broad diagnostic and therapeutic strategies, including the development of individual risk assessments; conduct fundamental research necessary for the development of advanced medical technologies and radiopharmaceuticals; and use the unique National Laboratory facilities to determine biological structure and function at the molecular and cellular level in support of the Nation’s biomedical sciences, pharmaceutical interests, and environmental activities.
- *To Contribute to Cleanup of the Environment* - Conduct fundamental research necessary for the development of advanced remediation tools for containing wastes and cleaning up DOE's contaminated sites, particularly in support of the mission of DOE's Environmental Management (EM) office.
- *To Understand and Adapt to Global Environmental Change* - Conduct fundamental research to acquire the data and develop the understanding necessary to predict how energy production and use can affect the global and regional environment and to foster technologies that can help us mitigate and adapt to global environmental change.

Performance Measures

The quality and appropriateness of the Biological and Environmental Research (BER) program and its individual research projects are judged by rigorous peer reviews conducted by internationally recognized scientific experts using criteria such as scientific merit, appropriateness of the proposed approach, and

qualifications of the principal investigator. Highest quality research is maintained by taking appropriate and, if needed, corrective management actions based on results of the reviews. A measure of the quality of the research is the sustained achievement in advancing knowledge as indicated by the publication of research results in refereed scientific journals, by invited participation at national and international scientific conferences and workshops, and by honors received by BER-supported researchers. Progress in the field is also regularly compared to the scientific priorities recommended by the Biological and Environmental Research Advisory Committee (BERAC) and the National Science and Technology Council's (NSTC) committees on Environment and Natural Resources and on Fundamental Science.

An overarching and unique performance measure of the BER program is the diversity of program reviews conducted. 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 Global Change Research Program. In addition to panel reviews that evaluate and select individual projects and programmatic reviews by the chartered BERAC, these program elements are evaluated by interagency (and international) review bodies and by Boards and Committees of the National Academy of Sciences.

The BER program goes one step further in soliciting program reviews. Panels of distinguished scientists are 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 have studied BER program elements such as the Atmospheric Radiation Measurement (ARM) program, climate change prediction activities, the William R. Wiley Environmental Molecular Sciences Laboratory (EMSL), and the Human Genome program.

Facility operations are also monitored by peer reviews and user feedback. These facilities are provided 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; and facilities are maintained and improved.

Specific BER program performance measures are:

Biological and Environmental Research

- Excellence in basic research: All research projects will continue to be reviewed by appropriate peers and selected through a merit-based competitive process.

Life Sciences

- Structural Biology: Commission the neutron protein crystallography station at the Los Alamos Neutron Science Center (LANSCE).
- Microbial Genomics/Climate Change Technology Initiative: Complete the genetic sequencing of at least two additional microbes that produce methane or hydrogen from carbonaceous sources or that could be used to sequester carbon.
- Low Dose Radiation Research: Convene second Low Dose Radiation Research program meeting with broad participation from program investigators, other Federal agencies, regulators, interested community representatives, and Congress.
- Closing in on the final Human DNA sequence: Initiate the “finishing” of the high quality DNA sequence of human chromosomes 5, 16, and 19 to international “Bermuda” standards. Finished

sequence will include the vast majority of regions of greatest biological interest on these chromosomes but will not include the most difficult to sequence regions at the ends (telomeres) and middle (centromere) of each chromosome.

- By the end of FY 2001, the DOE Joint Genome Institute (JGI) will complete the sequencing and submission to public databases of 100 million finished and 250 million high quality draft base pairs of DNA, including both human and mouse.
- Sixty percent of the newly discovered biological structures published in the peer reviewed literature will result from data generated at synchrotron user stations served by the BER structural biology facilities program.
- A new research program, the Microbial Cell Project, will be initiated to develop a comprehensive understanding of the complete workings of a microbial cell, from the DNA sequence to the complex interaction of the genes and proteins in a cell that give the microbe its life and its unique characteristics and behaviors.
- The development and upgrade of scientific facilities (including experimental stations) will be kept on schedule and within cost.
- The operating time lost at scientific user facilities due to unscheduled downtime will be less than 10 percent of the total scheduled possible operating time, on average.
- Independent assessments will judge BER research programs to have high scientific quality.
- Exploratory research will be initiated to develop new technologies to image gene action in humans to understand how genes function in health and disease, and for monitoring gene therapy treatments.

Environmental Processes

- Work will proceed on the development and testing of the next generation coupled ocean-atmosphere-sea ice climate model, leading to better information for assessing climate change and variability at regional, rather than global scales. New and better numerical techniques and physical parameterizations of physical processes in component General Circulation Models (GCMs) will be developed, and existing methods used in atmospheric, ocean, and sea ice GCMs will be improved.
- Model-model and model-data intercomparisons of long-term climate simulations generated with coupled ocean-atmosphere GCMs will be completed. Performance of the coupled GCMs will be measured by their ability to simulate the observed seasonal cycle amplitude in near surface temperature and seasonal patterns in amounts of precipitation. Furthermore, analyses will identify potential causes for inter-model differences in their ability to simulate observed long-term patterns in both the mean state and the variation in climate at regional and global scales.
- Five Intensive Operations Periods (IOPs) will be conducted on schedule at the Atmospheric Radiation Measurement (ARM) Southern Great Plains site. Data will be obtained from the second station on the North Slope of Alaska as planned. The third station in the Tropical Western Pacific, on Christmas Island, will become operational on schedule and within budget in accordance with the program plan.
- ARM research will support about 50 principal investigators working on cloud physics and on solar and infrared radiation interactions with water vapor and aerosols. More than 75 peer reviewed

papers and twice that number of conference papers will be published. The ARM Science Team will be realigned to bring more emphasis on use of ARM observations to develop parameterizations and approaches to improve atmospheric general circulation models. Additional field studies will be conducted, focusing on the connections of ARM data with carbon cycle processes.

- AmeriFlux Sites: Intersite comparisons will be conducted of net annual carbon sequestration for twenty-five AmeriFlux sites representing major ecosystem types and land uses in North and Central America, including deciduous and coniferous temperate forests, tropical forests, croplands, grasslands, rangelands and tundra ecosystems. Initial intersite analysis completed of the effects of environmental factors such as inter-annual climate variation on the net exchange of carbon and the role of biophysical processes controlling this exchange will help define the current global carbon dioxide budget. Results will also improve predictions of future carbon dioxide concentrations, and enhance understanding of how carbon sequestration by the terrestrial biosphere is affected by climate, pollution, land use, and other factors.
- Results from the six Free-Air Carbon Dioxide Enrichment (FACE) experiments will elucidate the direct effects of elevated atmospheric carbon dioxide levels on the growth, productivity, species interactions, water use efficiency, and carbon sequestration of terrestrial plants.
- Education accomplishments: The Global Change Education program will continue providing support to 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.
- The BER Post Doctoral Fellowship program will continue making 4-10 appointments.
- Carbon Sequestration: Research programs will follow the paths set out in the roadmap document "*Carbon Sequestration Research and Development Report*." Research in enhancing the terrestrial biosphere will focus on increasing carbon fixation by plants, reducing carbon dioxide emissions from soils, and assessing potential adverse and beneficial side effects. Research in ocean sequestration will focus on enhancing the long-term removal of atmospheric carbon dioxide by oceanic microorganisms and injecting carbon dioxide into the deep ocean, with an emphasis on environmental consequences of both.

Environmental Remediation

- The first Field Research Center (FRC) for the Natural and Accelerated Bioremediation Research (NABIR) program will be selected at a DOE site in early calendar year 2000. Field site characterization will be completed and the subsurface research at the FRC will be started during 2001, providing the fundamental knowledge for development of bioremediation methodologies for containment and cleanup of hazardous materials.
- NABIR Scientists will transfer understanding of biogeochemical processes in the subsurface at selected Uranium Mill Tailing Remedial Action (UMTRA) Program sites to the UMTRA Groundwater Project.
- Preliminary quantitative field-scale assessment of the role of natural subsurface heterogeneity in promoting and retarding the transport of injected bacteria will be completed and will help evaluate

the viability and effectiveness of injecting microorganisms for in situ bioremediation of contaminated DOE sites.

- The William R. Wiley Environmental Molecular Sciences Laboratory (EMSL) will be identified and cited in research publications and research proposals by scientists in academia and at National Laboratories as an important and valuable resource for molecular-level environmental sciences research.
- It will be demonstrated that at least 75% of the users of the William R. Wiley Environmental Molecular Sciences Laboratory are satisfied or very satisfied with access to its facilities and equipment.

Medical Applications and Measurement Science

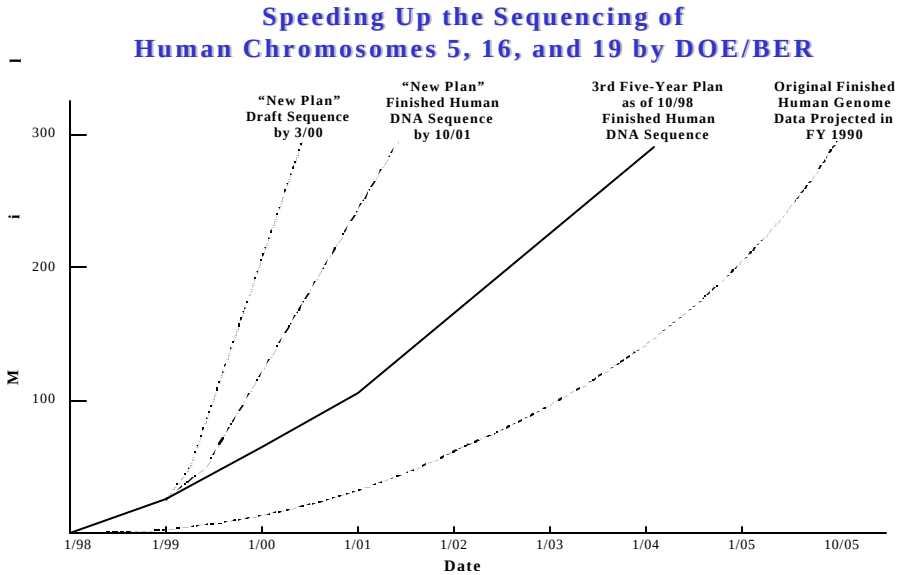
- Progress in Boron Neutron Capture Therapy (BNCT) Research: Phase I clinical trials of BNCT at reactor sources of neutrons will be completed and research on accelerator-based BNCT will be underway. These activities will provide the basis for evaluating the efficacy of BNCT and for designing phase II clinical trials that include reactor and accelerator-based sources of neutrons.
- Biomedical engineering will become a major focus of the Medical Applications program advancing fundamental concepts, creating knowledge from the molecular to the organ systems level, and developing innovative biologics, materials, processes, implants, devices, and informatics systems for the diagnosis, prevention, and treatment of disease.
- The BER Medical Applications program will initiate exploratory research to develop new messenger RNA (mRNA) based radiotracer technologies for imaging gene expression in animals in real time.

Significant Accomplishments and Program Shifts

Life Sciences

- **Warrior Bug Sequenced** - The complete DNA sequence of *Deinococcus radiodurans*, the remarkable radiation- and desiccation-resistant microbe, referred to in the popular press as "Conan the Bacterium**,"** has been determined. The Institute for Genomic Research (TIGR) in Rockville, Maryland has completed sequencing the entire 3 million base pair genome of *D. radiodurans* with funds from the BER microbial genome program. This DNA sequence information should provide additional insights into the astonishing mechanisms for DNA repair in *D. radiodurans* in addition to improving opportunities for engineering *D. radiodurans* into a potential workhorse for helping cleanup DOE waste sites.
- **Warrior Bug Tackles Waste** - *Deinococcus radiodurans*, cannot normally degrade solvents that are part of the mixed wastes at many DOE sites. A team of BER-funded scientists at the Uniformed Services University for the Health Sciences (USUHS) in Bethesda, Maryland have transferred genes from *Pseudomonas putida* into *D. radiodurans* that code for enzymes that degrade toluene and related solvents. The new *D. radiodurans* can degrade toluene and toluene-related solvents. The engineered *Deinococci* could also survive levels of toluene and trichloroethylene that would normally dissolve most other bacteria, suggesting that these engineered microbes might survive in radioactive and solvent containing mixed wastes and degrade the solvents.

- **Genomic Sequencing of a Cleanup Bug** - A microbe considered to be one of the most important for bioremediation, *Shewanella putrefaciens*, has had the complete sequence of its DNA determined. The Institute for Genomic Research (TIGR) in Rockville, Maryland determined the sequence with funding from the BER microbial genome program. *Shewanella* is normally involved in microbially influenced corrosion, anaerobic consumption of toxic organic pollutants and conversion of toxic metals and radionuclides to less chemically toxic forms. Knowing the DNA sequence of this microbe will enable scientists to develop improved bioremediation strategies for cleaning up DOE waste sites.
- **Genomic Sequencing of a "Carbon Manager"** - A microbe considered to be a player in the global carbon cycle, *Chlorobium tepidum*, has had its complete sequence of its DNA determined. The Institute for Genomic Research (TIGR) in Rockville, Maryland determined the sequence with funding from the BER Microbial Genome Program. Having this information is an important first step for developing new strategies to use the microbe to reduce carbon in the atmosphere.
- **A "Which Bugs III" Picks CCT Hit List** - Sixteen leading microbiologists met to help BER pick a list of microbes for genomic DNA sequencing as part of the Climate Change Technology research (CCT) to better understand global carbon utilization. The four microbes that made the final list all participate in "carbon management" processes, particularly carbon sequestration and energy production (e.g., methane and hydrogen production), roles that many microbiologists think are the most important of microbial life on Earth. DNA sequencing of these four microbes is being done at the DOE Joint Genome Institute's Production Sequencing Facility in Walnut Creek, California.
- **One Step Closer to a Complete Human DNA Sequence** - The DOE Joint Genome Institute's Production Sequencing Facility in Walnut Creek, California will complete a working draft of human chromosomes 5, 16, and 19 by March 2000. This is part of BER's contribution to the international effort to sequence the entire human genome by 2003 (NIH and the British Wellcome Trust fund the sequencing of most of the remaining 90 percent). This working draft represents roughly 90 percent of the entire sequence of these three chromosomes completed to 99 percent accuracy. This draft sequence, together with drafts produced by other sequencing centers around the world, will open the floodgates of biological information to scientists and reduces the time and effort needed to complete the entire high quality sequence. BER's effort to complete finished sequence for chromosomes 5, 16, and 19 is scheduled for completion by October 2001.



- **Resources to Speed Sequencing of the Human Genome** - The widely agreed on strategy for sequencing the human genome is based on the use of small pieces of DNA bacterial artificial chromosomes (BACs) that carry fragments of human DNA from known locations throughout the entire human genome. The BER human genome program funded research at The Institute for Genomic Research in Rockville, Maryland and at the University of Washington in Seattle, Washington that provided the sequencing community with a complete set of BAC-based genetic markers. These markers are needed to assemble both the draft and final human DNA sequence.
- **Production Sequencing Facility Open for Business** - The Production Sequencing Facility (PSF) is DOE's principal sequencing facility and is responsible for the Department's contribution of human DNA sequence as part of the international human genome project. Although the PSF's first priority is sequencing human DNA, it is also sequencing microbial DNA, as part of the DOE Climate Change Technology research, and mouse DNA, to take advantage of the wealth of information on mouse biology to better understand the function and control of human genes.
- **Understanding the Health Impacts of Low Dose Radiation** - In FY 1998 BER initiated a new low dose radiation research program that will develop the scientific information needed to make regulatory and cleanup decisions that protect people from the adverse health risks from exposure to radiation. A key question to be addressed by this program is whether there are levels of external radiation that do not cause biological effects greater than those induced by normal cellular processes or background radiation. The program is a collaborative and highly coordinated effort between BER and the Office of Environmental Management. Information resulting from the program is made broadly available to scientists, the public, regulators, and Congress through publications in the peer-reviewed literature and through interactive scientific meetings, web sites, and educational materials. Program information, including a ten year program plan developed by the Biological and Environmental Research Advisory Committee, is available on the web site at http://www. lowdose.com.
- **Human Subjects Research Database on the Web**. The FY 1998 update of the Department's Human Subjects Research Database is available on the World Wide Web at http://www.er.doe.gov/production/ober/humsubj/database.html. The database was begun in response to Congressional interest following the Secretary of Energy Openness Initiative in 1994. The database consists of a detailed description of 258 research projects at 35 research facilities.
- **Review of DOE-Wide Informed Consents and Education Updates**. BER staff have completed a review of informed consents and human subject educational plans for all DOE sites (and the corresponding operations offices) conducting human subjects research. These reviews by DOE, the only agency to conduct this exercise, are conducted every three years to upgrade informed consents and to encourage education on human subject issues across the DOE complex.
- In FY 1999, the performance goal "determine 70 percent of the DNA sequence of 10 additional microbes with potential use in waste cleanup or energy production" was exceeded. The performance goal "discover new biological structures with more than 60 percent of the new biological structures published in the peer-reviewed literature resulting from data generated as part of the structural biology synchrotron user station program" was fully met.

Environmental Processes

- **Massively Parallel Version of the Community Climate Model (CCM3) Developed** - A version of the CCM3 climate model at the National Center for Atmospheric Research was developed and

programmed to run on a massively parallel computer to perform coupled climate model experiments. Highly optimized atmosphere, ocean, and sea ice general circulation model codes that run effectively on massively-parallel scientific supercomputers have been completed and tested for use in climate change studies. The Parallel Climate Model (PCM), which more accurately represents the physical ocean, sea ice and atmosphere motion, has been tested on three different parallel supercomputers. This is a significant step in developing the next generation of climate models.

- **Coupled Climate Models More Accurately Simulate Regional Climate Patterns and Changes** - Combining present generation atmospheric and ocean general circulation models into a coupled climate model provides improved simulations of the present climate compared to the climate simulated by uncoupled atmospheric general circulation models alone. Inclusion of increases in carbon dioxide and sulfate aerosols yields regional climate changes similar to observed climate patterns. These results emphasize the need to develop comprehensive, fully coupled climate models and to include in the models those environmental factors that affect the radiative forcing of climate in order to accurately simulate observed patterns of climate variability and change at regional resolution.
- **Surface Heat Budget Data for the Arctic** - The Atmospheric Radiation Measurement (ARM) program provided the atmospheric research component of the multi-agency Surface Heat Budget of the Arctic Ocean (SHEBA) experiment. The SHEBA experiment addressed the interactions among sea ice, atmospheric radiation, and clouds in the Arctic and the corresponding effects on polar and global climate.
- **Looking at Clouds from Both Sides** - The joint ARM-Unmanned Aerial Vehicles and NASA study of tropical cirrus clouds was completed, providing new information on key cloud formations that moderate the radiation budget of the Earth.
- **Unbroken Data Streams** - Three state-of-the-art climate observatories have been continuously operated by the ARM program, with over two hundred instruments at the Southern Great Plains (SGP) site, the tropical western Pacific (TWP) sites at Manus and Nauru and the North Slope of Alaska sites at Barrow and Ataqasuk stations. The SGP is the largest of the three and produces a data stream of radiation and atmospheric column properties unmatched in terms of measurements, completeness, and temporal extent. Continuous operation provides virtually unbroken streams of atmospheric and surface data to climate and atmospheric scientists. Five intensive operational periods (IOPs) were conducted at the Southern Great Plains, one at Nauru and surrounding ocean in the TWP and one around Barrow on the North Slope of Alaska.
- **ARM Supports USDA Campaign** - ARM provided real-time and archive access to the ARM data for the Southern Great Plains (SGP), as well as other operational support for the United States Department of Agriculture SGP99 operation, to develop soil moisture retrieval algorithms for the NASA Advanced Microwave Scanning Radiometer, test the feasibility of soil moisture retrieval from the NASA Microwave Imager, and evaluate multi-frequency, multi-polarization active passive information using a new Jet Propulsion Laboratory aircraft instrument. The other NASA instruments are on satellites.
- **More CO_2 Facts** - Free-Air Carbon Dioxide Enrichment (FACE) experiments provide new and vital information on the response of intact ecosystems to increased atmospheric concentrations of carbon dioxide. Seven long-term experiments produced new data for many physiological and growth parameters of forest, grassland, and crop ecosystems. Initial results show that increased

carbon dioxide caused greater productivity and improved water use efficiency of these systems. A significant part of the productivity increase occurs below ground with roots, soil microflora and the formation of soil organic matter. Results from the loblolly pine FACE experiment, conducted jointly by Duke University, the Brookhaven National Laboratory, the University of Illinois, and other institutions, show that portions of the pine forest exposed for two years to a 60% increase in atmospheric carbon dioxide exhibited a 25% increase in net productivity relative to that for areas of the forest exposed to current levels of atmospheric carbon dioxide. It was estimated that if a similar response occurred globally with other forest ecosystems, the enhanced growth could, in effect, fix about 50% of the excess carbon dioxide produced by human activities by the year 2050.

- **Plant responses to elevated CO_2 influenced by soil nitrogen availability** - A three-year study was completed on the effects of elevated atmospheric carbon dioxide and soil nitrogen availability on the growth of trembling aspen. Results show a 37% increase in the growth of the trees that were both exposed to the elevated carbon dioxide and growing in soils with high nitrogen availability. This 37% increase contrasts with only a 17% growth increase in trees exposed to the same level of carbon dioxide but growing in soils with low nitrogen availability. The results indicate that even trees growing in soils with low nitrogen availability will exhibit an increase in growth with rising atmospheric carbon dioxide levels but the magnitude of the response will be influenced by the amount of available nitrogen and perhaps other essential nutrients in the soil.

- **Data Center Serves the World** - In addition to serving as the international World Data Center for Atmospheric Trace Gases, the Carbon Dioxide Information Analysis Center (CDIAC) serves as the primary global-change data and information analysis center of the U.S. Department of Energy. More than just an archive of data sets and publications, CDIAC enhances the value of its holdings through intensive quality assurance, documentation, and integration. In recognition of this, CDIAC continued to serve as the Quality Systems Science Center for the tri-national North American Research Strategy for Tropospheric Ozone (NARSTO) and the data archive center for the AmeriFlux network of carbon dioxide flux measurement sites.

- **Chemistry of Energy-Related Pollutants** - Major field campaigns were conducted in the areas of Phoenix, Nashville, and Philadelphia to investigate dominant aspects of the chemistry and transport of energy-related pollutants. Analysis of the data continues.

- **Carbon Sequestration Research Begins Under Climate Change Technology Initiative (CCTI)** - The carbon sequestration research program was initiated by funding two multi-institutional, interdisciplinary carbon sequestration research centers. One center focuses on research to enhance carbon sequestration in the terrestrial biosphere and the second on enhancing carbon sequestration in the ocean. Both centers support research to identify and understand the natural processes and environmental and biological factors controlling the sequestration of carbon and how these processes and/or limiting factors can be modified in order to achieve the goal of enhancing the natural sequestration of carbon in both terrestrial and oceanic systems.

- In FY 1999, the following performance goal was exceeded:

  - Initiate a new joint Biological and Environmental Research – Basic Energy Sciences program in fundamental science that will underpin new opportunities and technologies in carbon capture.

Environmental Remediation

- **NABIR Research Initiated at UMTRA (Uranium Mill Tailing Remedial Action) Sites** - Interdisciplinary teams of NABIR researchers have partnered with UMTRA site managers at Shiprock, New Mexico and Gunnison, Colorado, to investigate the potential for naturally-occurring microbes to remove uranium in the aqueous phase, reducing risk to humans and the environment. For example, a small group of NABIR scientists are working closely with environmental restoration staff associated with the Uranium Mill Tailing Remediation Action (UMTRA) Groundwater Project to better characterize subsurface biogeochemical processes at a select number of UMTRA sites. Through this collaboration, both the NABIR Program and the UMTRA Program are able to leverage resources while at the same time meet program objectives.
- **Successful Completion of Interagency Program on Bioavailability of Contaminants** - A three year research program in which DOE partnered with the National Science Foundation, the Environmental Protection Agency and the Office of Naval Research, has led to a new understanding of the mechanisms that control the bioavailability of organic and metallic contaminants in soils and sediments. This knowledge is fostering new approaches to accelerate bioremediation such as through the application of co-solvents to increase bioavailability, as well as new strategies to stabilize contaminants in situ through natural processes such as complexation.
- **EMSL Attracts Large Number and Wide Variety of Users** - In its second year of full operations, the William R. Wiley Environmental Molecular Sciences Laboratory (EMSL) attracted over 600 users from academia, government laboratories, and private industry, with over half the users coming from academia.
- **EMSL Establishes Annual Users Meeting and Users Advisory Group** - The EMSL organized and hosted its first annual users meeting and established a users advisory group to help EMSL management understand the needs of the user community. The users meeting provided a forum for presentations and discussions of on-going research in the following areas: environmental chemistry and transport, massively parallel computing in the environmental molecular sciences, physics and chemistry of oxide surfaces, and structural and functional proteomics.
- **NABIR Field Research Sites** - The first Field Research Center for the Natural and Accelerated Bioremediation Research (NABIR) Program has been narrowed to one DOE site pending completion of an Environmental Assessment. This site presents significant opportunities and challenges for long-term basic research on metal and radionuclide contamination in the subsurface. In addition, the NABIR Program is leveraging its resources for field research by coordinating with environmental restoration programs at other DOE sites to allow NABIR scientists to obtain groundwater and sediment samples and conduct in situ research at these other DOE sites.
- Provide fundamental research in environmental sciences, biology, molecular sciences, and computational modeling that will underpin the cleanup of contaminated sites.

Medical Applications and Measurement Science

- **DOE Technology Applied to Biomedicine** - The BER Medical Applications program initiated pilot projects in biomedical engineering for practical utilization of knowledge of physics, chemistry, biology, and engineering to develop new technologies for the diagnosis, prevention, and treatment of disease. DOE is also partnering with other agencies as a member of BECON, the Federal Bioengineering Consortium. Patient accrual in BNCT clinical trial has stopped and careful clinical follow-up of all treated patients continues.

- **High Tech Imaging Systems Used to Study Addiction** - A new Brookhaven National Laboratory study demonstrated that cocaine addicted rats, when treated with an epilepsy drug, gamma vinyl-gamma-aminobutyric acid (GVG), reduced their intake of cocaine and didn't exhibit the ability to acquire or express behaviors associated with its addiction. Also positron emission tomography (PET) radiotracer studies in primates clearly demonstrated that GVG prevents the dopamine surge that cocaine normally causes. These promising results in animals indicate that GVG may prove to be an effective pharmaceutical treatment for cocaine addiction, and it may be useful for the treatment of other addictions.
- **Toxic Drug Effects on Brain Localized** - Brain PET imaging studies show that methamphetamine is toxic to the brain and this is associated with long term memory and motor impairment. Studies are in progress to determine if recovery occurs on drug withdrawal.

The BER program continues its commitment to and dependence on research scientists at our nation's universities. 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 their response to 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, radiopharmaceutical development, and biomedical engineering. Furthermore, university scientists work in close partnership with scientists at national laboratories in many BER programs including genomics, the Climate Change Technology Initiative (CCTI), and biomedical engineering.

Scientific Facilities Utilization

The Biological and Environmental Research request includes $52,665,000 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 request also includes operation of the William R. Wiley Environmental Molecular Sciences Laboratory where the research activities will underpin long-term environmental remediation. This funding will provide for the operation of the facilities, assuring access for scientists in universities, federal laboratories, and industry. It will also leverage both federally and privately sponsored research.

New Research Programs in the Life and Medical Sciences

The FY 2001 budget includes funds for a new research program, the Microbial Cell project. This project capitalizes on DOE's pioneering and leadership role in high throughput genomic 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 and instrumentation research. The goal of the Microbial Cell project is to develop a comprehensive understanding of the complete workings of a microbial cell, from the DNA sequence, to the identification of all the genes, to the production of all the proteins whose assembly

instructions are contained in the genes, to the complex interaction of the genes and proteins in a cell that give the microbe its life and its unique characteristics and behaviors.

The key scientific challenges are far greater than "simply" understanding how individual genes and proteins work. We need to understand how genes and proteins are regulated in a coordinated manner and how they are integrated into a functional, interactive cell. This project will challenge scientists to go beyond the leveraging of tools and technologies for high throughput DNA sequencing and will require high throughput approaches for determining the structure and function of proteins, computational biology and bioinformatics resources, the development and use of sophisticated imaging and analytical sensing technologies, and approaches for modeling and analyzing complex systems.

This information will address DOE needs in energy use and production, bioremediation, and carbon sequestration and will provide exciting, new, and previously unavailable information to the entire biological community.

The FY 2001 budget also includes an increase for a recently initiated research program in Biomedical Engineering. The Biomedical Engineering program will nurture collaborations between the DOE National Laboratories and leading medical schools and teaching hospitals. These collaborations will leverage the Laboratories' unique resources and expertise in the biological, physical, chemical, engineering, and computing sciences to provide innovative and high-risk solutions to medical application problems dealing with the diagnosis, prevention, and treatment of disease. The program is a natural extension of the nuclear medicine field that BER originated and has supported for over half a century.

Recently, the National Institutes of Health (NIH) has recognized the potential of BER to contribute to the advancement of bioengineering research and has accepted BER as a member of the Bioengineering Consortium (BECON). BECON also involved all the individual NIH institutes and the NSF with the goal of fostering new basic understandings, collaborations, and transdisciplinary training in bioengineering.

The BER Biomedical Engineering program will be coordinated with BECON activities and will utilize the BECON expertise to validate the medical relevance of cutting-edge technological advances in the National Laboratories involving, e.g., biological therapies, materials, processes, implants, devices, and information systems. Awards will be made following competitive solicitations that stress lab-academic partnerships.

Climate Change Technology Initiative

The FY 2001 budget contains two-carbon related programs; each is coordinated with several offices and agencies. The first is the Climate Change Technology Initiative (CCTI). The second is the U.S. Global Change Research Program (US/GCRP). US/GCRP research focuses on developing the fundamental understanding of the comprehensive climate system and the global and regional manifestations of climate change. CCTI focuses on the underpinning fundamental science that will enable mitigation and adaptation to climate change. The two complementary programs are described in "A U.S. Carbon Cycle Science Plan," a report proposed by the US/GCRP and the "Carbon Sequestration Research and Development Report" developed by the CCTI. All research in the CCTI is peer-reviewed fundamental scientific research that expands upon core research activities.

The component of CCTI conducted by the Office of Science is research on carbon management science. This includes the following three areas: sequestration science, science for efficient technologies and fundamental science to advance all low/no carbon energy sources. Research begun in the last two years that support advances in low/no carbon energy technologies are closely coordinated with DOE's technology programs and will provide the knowledge base for new advanced technologies to reduce carbon dioxide emissions. These activities will impact the Office of Energy Efficiency and Renewable Energy (EE) and the energy and transportation industry by providing options for increased efficiency and reduced energy consumption in manufacturing with improved sensors, controls, and processes. Other aspects of these research projects impact the Office of Fossil Energy (FE) by providing a foundation for effective and safe underground sequestration. The Office of Fossil Energy was an equal partner with the Office of Science in the development of the "Carbon Sequestration Research and Development Report."

The Office of Science has long-standing programs in fundamental research that already impact these three categories. In FY 2001, $19,504,000 is being requested by BES and $16,257,000 by BER specifically for the CCTI. Research begun under this initiative is complementary to work in several other research programs at DOE and at other agencies. Ongoing CCTI research includes two new centers for carbon sequestration, the sequencing of the DNA of several microbes critical to biological sequestration, and over 50 single investigator and interdisciplinary projects at universities and national laboratories. Research projects span a broad array of disciplines, including ecological, biological, and geological studies of sequestration science; chemical and biological studies of alternative energy sources; new concepts in light weight energy efficient materials; and more efficient combustion and conversion processes.

Funding of Contractor Security Clearances

In FY 1999, the Department divided the responsibility for obtaining and maintaining security clearances. The Office of Security Affairs, which was responsible for funding all Federal and contractor employee clearances, now pays only for clearances of Federal employees, both at headquarters and the field. Program organizations are now responsible for contractor clearances, using program funds. This change in policy enables program managers to make the decisions as to how many and what level clearances are necessary for effective program execution. In this way, it is hoped that any backlog of essential clearances that are impeding program success can be cleared up by those managers most directly involved. The Office of Science is budgeting $90,000 for estimated contractor security clearances in FY 2000 and FY 2001 within this decision unit.

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. BER research programs and projects at the national laboratories and in the private sector actively integrate undergraduate and graduate students and postdoctoral 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. A total of 1,530 graduate students and post-doctoral investigators were supported at universities and at national laboratories in FY 1999. BER will continue its support for graduate students and post doctoral

investigators in FY 2000 and FY 2001. The actual number of graduate students and post doctoral investigators is estimated to remain at the FY 1999 level.

Graduate students and post-doctoral investigators use Office of Science user facilities such as the structural biology experimental stations at beam lines at the synchrotron light sources and the William R. Wiley Environmental Molecular Sciences Laboratory (EMSL). Using these unique research tools enables the graduate students and post-doctoral investigators to participate in and conduct leading edge research. Approximately half of all of the facility users are graduate students and post-doctoral investigators. The graduate students and post doctoral investigators are supported by resources from a wide variety of sponsors, including BER, other Departmental research programs, other federal agencies, and U.S. and international private institutions. Graduate students and post-doctoral investigators at the synchrotron light sources are included in the Basic Energy Sciences (BES) user facility statistics and are not included here. A total of 500 graduate students and post-doctoral investigators were supported at the EMSL in FY 1999.

Funding Profile

(dollars in thousands)

	FY 1999 Current Appropriation	FY 2000 Original Appropriation	FY 2000 Adjustments	FY 2000 Current Appropriation	FY 2001 Request
Biological and Environmental Research					
Life Sciences	173,379	173,264	-2,687	170,577	188,906
Environmental Processes	114,530	130,568	-3,452	127,116	131,509
Environmental Remediation	64,775	65,757	-906	64,851	63,536
Medical Applications and Measurement Science	73,206	71,911	-1,569	70,342	58,809
Subtotal, Biological and Environmental Research	425,890	441,500	-8,614	432,886	442,760
Construction	0	0	0	0	2,500
Subtotal, Biological and Environmental Research	425,890	441,500	-8,614	432,886	445,260
Use of Prior Year Balances	-3,798[a]	0	0	0	0
General Reduction	0	-3,878	3,878	0	0
Contractor Travel	0	-2,133	2,133	0	0
Omnibus Rescission	0	-2,603	2,603	0	0
Total, Biological and Environmental Research	422,092[b]	432,886	0	432,886	445,260[c]

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

[a] Share of Science general reduction for use of prior year balances assigned to this program. The total reduction is applied at the appropriation level.

[b] Excludes $10,187,000 which was transferred to the SBIR program and $611,000 which was transferred to the STTR program.

[c] Includes $1,200,000 for Waste Management activities at Pacific Northwest National Laboratory that was previously budgeted in FY 2000 by the Environmental Management program.

Funding By Site

(dollars in thousands)

	FY 1999	FY 2000	FY 2001	$ Change	% Change
Albuquerque Operations Office					
Los Alamos National Laboratory	22,362	19,280	17,971	-1,309	-6.8%
Sandia National Laboratories	3,537	1,490	3,091	+1,601	+107.4%
Albuquerque Operations Office	3,575	2,800	1,550	-1,250	-44.6%
Total, Albuquerque Operations Office	29,474	23,570	22,612	-958	-4.1%
Chicago Operations Office					
Ames Laboratory	900	660	525	-135	-20.5%
Argonne National Laboratory –East	10,198	9,040	20,780	+11,740	+129.9%
Brookhaven National Laboratory	23,413	19,163	16,758	-2,405	-12.6%
Chicago Operations Office	91,244	59,572	47,108	-12,464	-20.9%
Total, Chicago Operations Office	125,755	88,435	85,171	-3,264	-3.7%
Idaho Operations Office					
Idaho National Engineering & Environmental Lab	2,084	1,761	1,489	-272	-15.4%
Oakland Operations Office					
Lawrence Berkeley National Laboratory	39,163	43,581	40,532	-3,049	-7.0%
Lawrence Livermore National Laboratory	41,127	40,110	38,875	-1,235	-3.1%
Stanford Linear Accelerator Center	2,771	2,450	3,500	+1,050	+42.9%
Oakland Operations Office	68,606	46,704	37,871	-8,833	-18.9%
Total, Oakland Operations Office	151,667	132,845	120,778	-12,067	-9.1%
Oak Ridge Operations Office					
Oak Ridge Inst. For Science & Education	3,553	3,593	4,079	+486	+13.5%
Oak Ridge National Laboratory	28,062	25,988	29,144	+3,156	+12.1%
Oak Ridge Operations Office	366	314	132	-182	-58.0%
Thomas Jefferson National Accelerator Facility	260	0	0	0	0.0%
Total, Oak Ridge Operations Office	32,241	29,895	33,355	+3,460	+11.6%
Richland Operations Office					
Pacific Northwest National Laboratory	79,879	64,339	65,312	+973	+1.5%
Washington Headquarters	4,790	92,041	116,543	+24,502	+26.6%
Subtotal, Biological and Environmental Research	425,890	432,886	445,260	+12,374	+2.9%
Use of Prior Year Balances	-3,798[a]	0	0	0	0.0%
Total, Biological and Environmental Research	422,092[b]	432,886	445,260[c]	+12,374	+2.9%

[a] Share of Science general reduction for use of prior year balances assigned to this program. The total reduction is applied at the appropriation level.

[b] Excludes $10,187,000 which was transferred to the SBIR program and $611,000 which was transferred to the STTR program.

[c] Includes $1,200,000 in FY 2001 for Waste Management activities at Pacific Northwest National Laboratory that was previously budgeted in FY 2000 by the Environmental Management program.

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 ARM site. 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 molecular factors that control cell responses to low doses of radiation. ANL, in conjunction with ORNL and PNNL and six universities, co-hosts a terrestrial carbon sequestration research center.

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 Boron Neutron Capture Therapy (BNCT) program supports early clinical trials of this concept for treatment of brain cancers that do not respond to conventional treatment. 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) at the Duke Forest.

Idaho National Engineering and Environmental Laboratory

Idaho National Engineering and Environmental Laboratory is a Multiprogram Laboratory located on 572,000 acres in Idaho Falls, Idaho. 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 for brain and other tumors. Research into the analytical chemistry of complex environmental and biological systems using the technique of mass spectrometry is also supported.

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 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 membrane and other proteins.

Research is conducted into the use of accelerators to produce neutrons for boron neutron capture therapy, an alternative treatment for highly malignant brain tumors. The nuclear medicine program supports research into novel radiopharmaceutical 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 field geophysical - biophysical research capabilities for NABIR field sites. BER supports research into new technologies for characterization of complex environmental contamination. LBNL also develops scalable implementation technologies that will allow widely used climate models to run effectively and efficiently on massively parallel processing supercomputers.

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 a 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 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.

LLNL co-hosts, with LBNL and six universities, an 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 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 coordinates the operation and development of 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 on 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 all BER-funded science.

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 on 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 this research community.

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

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 NABIR research.

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 data system; 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.

Sandia National Laboratories

Sandia National Laboratories (SNL) is a Multiprogram Laboratory, with a total of 3,700 acres, located in Albuquerque, New Mexico, with sites in Livermore, California, and Tonapah, Nevada. SNL coordinates the operation and development of 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 Synchroton 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 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 47 states. Also included are funds for research awaiting distribution pending completion of peer review results.

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

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.

NABIR research grants are awarded following the peer review of applications received in response to solicitations published in the federal register. 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 nuclear medicine, universities conduct research into new types of radiopharmaceutical, particularly those based on application of concepts from genomics and structural biology. Emphasis is placed on radiopharmaceuticals that will be of use in advanced imaging techniques such as positron emission tomography. Research is supported into new instrumentation for medical imaging. The Boron Neutron Capture Therapy program supports studies of novel boron compounds for use in treating brain cancer, early clinical trials of the technique, and new instrumentation based on accelerators that could be used in hospitals and clinics. The 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

Research is focused on utilizing unique DOE resources and facilities to develop fundamental biological information and advanced technologies for understanding and mitigating the potential health effects of energy development, energy use, and waste cleanup. Research is conducted in five areas: structural biology, cellular biology, molecular biology, human genome, and health effects. The research:

- Develops and supports user facility infrastructure for the Nation's structural biologists; combines computer science, structural biology, and genome research for analyses and predictions of gene products at the individual protein and genomic levels; and develops new technologies and methodologies to understand the dynamic processes of protein-protein interactions at the cellular dimension that are unique to living organisms.
- Determines if low dose and low dose-rate radiation present a health risk to people that is the same as or greater than the health risk resulting from the oxidative by-products of normal physiological processes, providing a better scientific basis for achieving acceptable levels of human health protection.
- Determines the genomic DNA sequences of microbes with potential uses in energy, waste cleanup, and carbon management and uses that information to determine how microbes can be modified and/or exploited for DOE mission needs.
- Contributes to the International Human Genome Project by developing and applying new technologies and resources to map and determine the sequence of the subunits of DNA found in a typical human cell, to analyze and interpret DNA sequence data, and to study the ethical, legal, and social implications (ELSI) of information and data resulting from the genome project. Research emphasis is on high throughput, production sequencing of human DNA, rapid entry of data into public databases, and identifying the functions for a portion of the 100,000 genes that make up the human genome.
- Integrates and exploits information and technologies from genome, structural biology, and molecular biology research with human health research to understand the network of genes and proteins—that is the complex relationships between genes, the proteins they encode, and the biological functions of these proteins in the context of the whole organism.

Climate Change Technology Initiative

The Life Sciences subprogram's support of microbial genome research also underpins the Climate Change Technology Initiative. Knowing the genomic sequence of microbes that produce methane and hydrogen, will enable the identification of the key genetic and protein components of the organisms that regulate these gases. Understanding more fully how the enzymes and organisms operate, we will be able to evaluate their potential use 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, sequester the carbon dioxide, and produce hydrogen.

Microbial Cell Project

The goal of the Microbial Cell Project is to develop a comprehensive understanding of the complete workings of a microbial cell, from the DNA sequence, to the identification of all the genes, to the production of all the proteins whose assembly instructions are contained in the genes, to the complex interaction of the genes and proteins in a cell that give the microbe its life and its unique characteristics and behaviors. This information can be used to address DOE needs in energy use and production, bioremediation, and carbon sequestration and will provide exciting, new, and previously unavailable information to the entire biological community.

Performance Measures

- Microbial Genomics/Climate Change Technology Initiative: Complete the genetic sequencing of at least two additional microbes that produce methane or hydrogen from carbonaceous sources or that could be used to sequester carbon dioxide.
- High Throughput DNA Sequencing: By the end of FY 2001, the DOE Joint Genome Institute (JGI) will complete the sequencing and submission to public databases of 100 million finished and 250 million high quality draft base pairs of DNA, including both human and mouse.
- Develop program plan and make initial awards in Microbial Cell Project.

Funding Schedule

(dollars in thousands)

	FY 1999	FY 2000	FY 2001	$ Change	% Change
Structural Biology	26,900	27,474	35,645	+8,171	+29.7%
Molecular and Cellular Biology	35,572	31,376	44,029	+12,653	+40.3%
Human Genome	90,679	88,886	90,270	+1,384	+1.6%
Health Effects	20,228	18,328	14,476	-3,852	-21.0%
SBIR/STTR	0[a]	4,513	4,486	-27	-0.6%
Total, Life Sciences	173,379	170,577	188,906	+18,329	+10.7%

[a] Excludes $4,060,000 which has been transferred to the SBIR program and $243,000 which has been transferred to the STTR program.

Detailed Program Justification

(dollars in thousands)

	FY 1999	FY 2000	FY 2001
Structural Biology			
■ Infrastructure support and development for the Nation's structural biologists. Continue to coordinate with the National Institutes of Health and the National Science Foundation on the development and operation of experimental stations at DOE national user facilities such as the synchrotrons and neutron beam sources. Operate the neutron protein crystallography station at the Los Alamos Neutron Science Center (LANSCE). Initiate development of a new station for small angle neutron scattering at the High Flux Isotope Reactor at ORNL and support improvements in beamlines at SSRL. Support a protein database for three-dimensional protein structures. University-based scientists are the principal users of these user facilities. GPP funds ($3,000,000) will be used to complete a Laboratory Module at the Advanced Photon Source at Argonne National Laboratory. 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 $6,000,000. The Laboratory Module will provide space for four additional beamlines needed by the structural biology user community. In FY 2001, $4,500,000 is included for a major item of equipment, the DNA Repair Protein Complex Beamline project (Total Estimated Cost $4,500,000) 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 functionally important conformation changes in and the regulation of assembly of multiprotein complexes.....	15,471	16,000	23,500
■ Basic research in structural biology cuts across basic biology, molecular biology (including genomics), computational biology, and instrumentation development. Robust computational processes will be developed to predict the three-dimensional architecture and dynamic behavior of individual proteins and			

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
protein complexes involved in the recognition and repair of DNA damage or the bioremediation of metals and radionuclides. New technologies and methodologies will be developed to understand the dynamic processes of protein-protein interactions and gene networks that are unique to living organisms.	11,429	11,474	12,145
Total, Structural Biology.....	26,900	27,474	35,645

Molecular and Cellular Biology

- The field of microbial genomics continues to be one of the most exciting, high profile, and rapidly growing fields in biology today, expanding from the DOE-initiated program through other federal agencies and private industry. The BER Microbial Genome Program has supported the complete genomic sequencing of 15 of the approximately 50 bacteria whose DNA has been sequenced. The sequencing of more than 40 additional microbes is in progress in the scientific community. The broad impacts of this research emphasize a central principle of the BER genome programs – complete genomic sequences yield answers to fundamental questions in biology. Microbes are being sequenced and characterized in several parts of the BER program with potential impacts across several DOE missions including: the Climate Change Technology research (methane or hydrogen producing microbes or microbes involved in carbon dioxide sequestration), microbes for cleaning up the environment, alternative fuel sources (methane production or energy from biomass), and microbes that produce industrially useful enzymes. As the number of complete and in-progress microbial genomes grows, the microbial genome program is shifting its emphasis from a predominant focus on genomic sequencing to a broader emphasis on the use and discovery of new knowledge from microbes whose genomic DNA sequences have been determined. The program is closely coordinated with CCTI and the new Microbial Cell program, prividing them basic sequence information. The program will begin to place an increased emphasis on (1) identifying a broader array of potentially useful microbes, especially from DOE relevant sites, such as waste sites; and (2) new strategies for determining the DNA sequence of microbes for which the complete sequence of a very closely related microbe is already known, to avoid the need for costly and time consuming sequencing of many important microbes from scratch. A new emphasis will be placed on the development of high throughput technologies to determine the function of the thousands of new genes that have been and continue to be

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
discovered as part of the determination of the complete DNA sequence of microbes. Between one quarter and one third of all genes identified through DNA sequencing are new genes whose functions are not known. To fully leverage the biological capabilities of a microbe for clean up, fuel production, etc., the function of most or all of that microbe's genes needs to be known. Together with the microbial genes whose functions we already know, these new genes represent a treasure chest of biological potential that can be used or modified to address DOE mission needs.	9,633	8,594	14,117
■ The Climate Change Technology Initiative (CCTI) continues to determine the DNA sequence of microbes that produce methane or hydrogen from carbonaceous sources or that could be used to sequester carbon dioxide. The genomic sequence of five microbes involved in carbon management will have been determined by FY 2001. Research to characterize key reaction pathways or regulatory networks in these microbes, that focus on the development of practical uses for microbes within the CCTI, will be emphasized. Together, with the new, high-throughput technologies that will be developed to determine the function of new genes discovered from the sequencing of a microbe's DNA, the information on the DNA sequence, key reaction pathways, and regulatory networks will be used to address the fuel production or carbon sequestration goals of the CCTI.....	2,434	5,841	7,495
■ The Microbial Cell Project –Understand the complete workings of a microbial cell and use this information to address DOE needs in energy use and production, bioremediation, and carbon sequestration. The Microbial Cell Project represents a fundamental shift in our approach to biology. Instead of looking from the outside of an organism in, starting with its behavior and features and finding the responsible genes, we will 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. 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. Identify and characterize a minimum set of genes, proteins, and metabolic capabilities that are both necessary and sufficient for the microbe to survive. Characterize			

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
the cell machinery and regulatory pathways responsible for making, transporting, and using all of the products needed for a microbe to survive. Use microbes to address DOE mission needs, e.g., degradation or sequestration of hazardous wastes; efficient degradation of cellulose for producing food stocks and fuels. Key scientific challenges include understanding how individual genes and proteins work; how they are regulated in a coordinated manner; and how they are integrated into functional, interactive cells. Key technical challenges include the use and continued development of tools for high throughput DNA sequencing, protein structure determination, computational biology and bioinformatics, sophisticated imaging and analytical sensing technologies, and complex systems analysis. Initially the Microbial Cell Project will focus on genomic DNA sequencing, comparative genomic DNA sequence analysis, protein structure determination, computational analysis of protein structure, analysis of metabolic pathways, computational models of regulatory pathways, analysis of protein-protein interactions, and imaging protein distributions and interactions.	0	0	9,735
■ Congressional direction for FY 1999 for the Institute for Molecular Biology and Medicine, University of Scranton, Scranton, Pennsylvania.	10,189	0	0
■ Molecular biology research, as a general research area, comes to an end and is replaced by microbial genome research. Funding continues for 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.	1,000	1,000	1,000
■ The low dose radiation research program supports basic research to determine if low dose and low dose-rate radiation present a health risk to people that is the same as or greater than the health risk resulting from the oxidative by-products of normal physiological processes. This information is a key determinant in decisions that are made to protect people from adverse health risks from exposure to radiation. Research is funded as part of a collaborative and highly coordinated program with the Office of Environmental Management. Information resulting from the program is made broadly available to scientists, the public, regulators, and Congress through interactive scientific meetings, web sites, and educational materials. Research conducted in this			

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
Program 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. This information 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. In FY 2000, the research was funded within Cellular Biology and Health Effects. In FY 2001, the research has been consolidated in Cellular Biology.	8,000	14,203	11,682
■ Congressional direction in FY 2000 for a Study of Avian Populations at the Nevada Test Site.	0	94	0
■ Congressional direction in FY 2000 for a review of the Hiroshima neutron dosimetry.	0	1,644	0
■ Cellular biology research, as a general research area, comes to an end and is replaced by the low dose radiation research program.	4,316	0	0
Total, Molecular and Cellular Biology	35,572	31,376	44,029

Human Genome

- The Joint Genome Institute (JGI) and its Production Sequencing Facility (PSF) are primarily focused on high throughput sequencing of DNA. 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, is expanded to include other National Laboratories that diversify and strengthen its overall capabilities. FY 2001 is the fourth year of a major five year scale-up of DNA sequencing capacity at the PSF. In FY 2000 the PSF will have completed draft sequences of human chromosomes 5, 16, and 19 as part of its commitment to the International Human Genome Project. In FY 2001 the PSF will make substantial progress towards finishing the high quality sequence of those three chromosomes to international "Bermuda" quality standards. University scientists, working with the JGI, play a key role in completing DOE's share of determining the human DNA sequence. The PSF will initiate draft sequencing

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
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.	50,000	59,500	59,500
■ Research 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. Research is conducted 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. Use of sequence information to understand human biology and disease will require new strategies and tools capable of high throughput, genome-wide experimental and analytic approaches. Research is conducted to develop high throughput approaches for analyzing gene regulation and function. A table follows displaying both DOE and NIH genome funding.	38,119	26,719	28,218
■ The Ethical Legal and Societal Issues (ELSI) program continues to broaden its emphasis on research related to the uses, impacts, and implications of genetic information in the workplace and the use of the workplace as a research environment.	2,560	2,667	2,552
Total, Human Genome	90,679	88,886	90,270

U.S. Human Genome Project Funding

	(dollars in millions)			
	Prior Years	FY 1999	FY 2000	FY 2001
DOE Total Funding.....	542.5	90.7	88.9	90.3
NIH Funding.....	1,452.4	264.9	336.0	TBD
Total U.S. Funding.....	1,994.9	355.6	424.9	TBD

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
Health Effects			
■ Low dose radiation research (consolidated in Cellular Biology in FY 2001) was also funded in Health Effects in FY 2000. The low dose radiation research program, provides information that is a key determinant in decisions made to protect people from adverse health risks from exposure to radiation. This information 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.	0	2,321	0
■ Model organism research capitalizes on our understanding and the manipulability of the genomes of organisms, including yeast, nematode, fruitfly, Zebra fish, and mouse, to speed understanding of human genome organization, regulation, and function. This research is a key link between human genomic sequencing, that provides a complete parts list for the human genome, and the development of information (a high-tech owner's manual) that is useful in understanding normal human development and disease processes	9,337	11,501	11,027
■ Technology development research results in new approaches, tools, or technologies for determining the structures of many more proteins than is currently possible. This research is closely coordinated with structural biology and genomic (both human and microbial) research.	3,000	4,506	3,449
■ Biological research, as a general research area, comes to an end and is replaced by low dose radiation, model organisms, and technology development research.	7,891	0	0
Total, Health Effects	20,228	18,328	14,476
SBIR/STTR			
■ In FY 1999, $4,060,000 and $244,000 were transferred to the SBIR and STTR programs, respectively. The FY 2000 and FY 2001 amounts are the estimated requirements for the continuation of these programs.	0	4,513	4,486
Total, Life Sciences	173,379	170,577	188,906

Explanation of Funding Changes From FY 2000 to FY 2001

	FY 2001 vs. FY 2000 ($000)
Structural Biology	
■ Increased GPP funding for completion of a Laboratory Module to house four structural biology beamlines at the Advanced Photon Source at Argonne National Laboratory.	+3,000
■ Increased funding for a Major Item of Equipment, a DNA repair protein complex beamline, at the Advanced Light Source at Lawrence Berkeley National Laboratory.	+4,500
■ Increased basic research to understand the structures of protein complexes involved in the recognition and repair of DNA damage and in the bioprocessing of metals and radionuclides.	+671
Total, Structural Biology	+8,171
Molecular and Cellular Biology	
■ Increased technology development research that develops high throughput approaches for understanding the functions of newly discovered microbial genes.	+5,523
■ Increased CCTI research to identify and characterize genes and proteins involved in biofuel production or carbon sequestration.	+1,654
■ New research program, Microbial Cell Project, to understand the complete workings of a microbial cell from DNA sequence to the function and interactions of proteins	+9,735
■ Decrease research to understand the health impacts of low doses of radiation.	-2,521
■ Congressional direction in FY 2000 for a Study of Avian Populations at the Nevada Test Site.	-94
■ Neutron dosimetry research requested by Congress in FY 2000 is completed	-1,644
Total, Molecular and Cellular Biology	+12,653
Human Genome	
■ Increased basic research in long-term DNA sequencing technology because completion of the DNA sequence increases the need for faster, cheaper DNA sequencing technology to understand individual sequence variation and the sequence of important model organisms	+1,499

	FY 2001 vs. FY 2000 ($000)
■ Continue Ethical Legal and Societal Issues (ELSI) program at approximately same level as FY 2000	-115
Total, Human Genome	+1,384
Health Effects	
■ Decrease because research to understand the health impacts of low doses of radiation is consolidated in Cellular Biology above.	-2,321
■ Decrease due to transition of several projects in model organisms research, that develop new strategies for understanding the function of newly required human genes, to human genome research.	-474
■ Decrease technology development research for developing high throughput approaches that determine protein structure, to allow for growth in higher priority areas as a first step in the phase-out of this research program as NIH begins to make large investments in this area.	-1,057
Total, Health Effects	-3,852
SBIR/STTR	
■ Decrease in SBIR/STTR.	-27
Total Funding Change, Life Sciences	+18,329

Environmental Processes

Mission Supporting Goals and Objectives

There are four contributing areas to the overall research program on environmental processes: Climate and Hydrology; Atmospheric Chemistry and Carbon Cycle; Ecological Processes; and Human Interactions. Research is focused on understanding the basic chemical, physical, and biological processes of the Earth's atmosphere, land, and oceans and how these processes may be affected by energy production and use, primarily the emission of carbon dioxide from fossil fuel combustion. A major part of the research is designed to provide the data that will enable an objective assessment of the potential for, and consequences of, global warming. The program is comprehensive with an emphasis on understanding the radiation balance from the surface of the Earth to the top of the atmosphere (including the role of clouds) and on enhancing the quantitative models necessary to predict possible climate change at the global and regional scales. The components of the Atmospheric Radiation Measurement (ARM) program continue to work in an integrated fashion to produce the experimental and modeling results that will be necessary to resolve the greatest uncertainty in climate prediction - the role of clouds and solar radiation. Climate modeling using massively-parallel supercomputers will simulate climate change, predict climate, and evaluate model uncertainties due to changes in atmospheric concentrations of greenhouses gases on decade to century time scales. The Atmospheric Science program acquires 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. The Carbon Cycle program is designed to study the natural carbon cycle, including quantifying the role of the terrestrial biosphere as a sink or source of carbon dioxide. The program on Ecosystem Research is designed to provide information on the effects of atmospheric and climate changes on terrestrial organisms and ecosystems, including the potential direct effects of increasing atmospheric carbon dioxide levels. The Environmental Processes subprogram includes funding for DOE's contribution to the U.S. Global Change Research Program that was codified by Congress in the Global Change Research Act of 1990 and for part of the Office of Science activities under the Climate Change Technology Initiative.

Climate Change Technology Initiative

The Atmospheric Chemistry and Carbon Cycle category supports basic research that promotes an understanding of the role that the terrestrial biosphere, atmospheric chemistry and transport, and human activities play in determining the composition and quality of the atmosphere. Complementing the activities in support of the U.S. Global Change Research Program, science for the Climate Change Technology Initiative (CCTI) seeks the understanding necessary to exploit the biosphere's natural processes to enhance the sequestration of atmospheric carbon dioxide. It also seeks the understanding necessary to assess the environmental implications of purposeful enhancement and/or disposal of carbon in the terrestrial biosphere and the ocean. The CCTI includes research to identify and understand the environmental and biological factors or processes that limit the sequestration of carbon in these systems, and to develop approaches for overcoming such limitations to enhance sequestration. The research includes studies on ocean carbon sequestration, especially the role of marine microorganisms and by terrestrial ecosystems.

Performance Measures

- Five Intensive Operations Periods (IOPs) will be conducted on schedule at the Atmospheric Radiation Measurement (ARM) Southern Great Plains site. Data will be obtained from the second station on the North Slop of Alaska as planned. The third station in the Tropical Western Pacific, on Christmas Island, will become operational on schedule and within budget in accordance with the program plan.
- Compare initial results from the six Free-Air Carbon Dioxide Enrichment (FACE) experiments, summarizing the direct effects of elevated atmospheric carbon dioxide levels on the growth, productivity, species interactions, water use efficiency, and carbon sequestration of terrestrial plants.

Funding Schedule

(dollars in thousands)

	FY 1999	FY 2000	FY 2001	$ Change	% Change
Climate and Hydrology	65,839	67,213	72,309	+5,096	+7.6%
Atmospheric Chemistry and Carbon Cycle	26,952	34,979	35,644	+665	+1.9%
Ecological Processes	13,691	11,924	12,010	+86	+0.7%
Human Interaction	8,048	9,614	8,170	-1,444	-15.0%
SBIR/STTR	0[a]	3,386	3,376	-10	-0.3%
Total, Environmental Processes	114,530	127,116	131,509	+4,393	+3.5%

Detailed Program Justification

(dollars in thousands)

FY 1999	FY 2000	FY 2001

Climate and Hydrology

- **Climate Modeling:** Improved simulations provide the scientific basis for predicting climate and its implications for future decades. Develop next generation coupled atmosphere-ocean general circulation models with improved resolution to approximately 200 km grid size. Additionally, develop improved climate observational databases for testing and verifying the models. Support will continue for needed computational resources

[a] Excludes $2,800,000 which has been transferred to the SBIR program and $169,000 which has been transferred to the STTR program.

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
on the supercomputers at the LANL Advanced Computing Laboratory. Increased budget will support the following: Analyze, develop, and implement methods to downscale global climate model simulations to smaller scales for regional studies of environmental changes using a hierarchy of applied and engineering models. Develop and employ technologies that can quickly and efficiently work with large and distributed and archived sets of both observational and modeling data to produce data sets suitable for study of regional changes in climate and their impacts. Two multi-institutional teams involving national laboratories and universities will be established to access the primary data archive and computational facilities. With its partners in the multi-agency U.S. Global Change Research Program, DOE will continue to fund two multi-institutional model development consortia for research on fully coupledcomprehensive models for simulating multi-decade and multi-century changes of the global environment at regional resolution. Included in these activities is implementation of collaboratory technology to facilitate interaction and speed progress.	22,092	23,845	27,962
■ **Atmospheric Radiation Measurement (ARM):** The Atmospheric Radiation Measurement (ARM) infrastructure program develops, supports, and maintains the three ARM sites and associated instrumentation. Continue operation of over two hundred instruments at the Southern Great Plains site. Begin limited operations of the third Tropical Western Pacific station. Provide data to scientific community through the ARM Archive. .	28,454	27,371	27,371
■ **Atmospheric Radiation Measurement (ARM):** ARM research will support about 50 principal investigators working on cloud physics and on solar and infrared radiation interactions 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 scientists at other agencies, such as NASA and NOAA. More than 75 peer reviewed papers and twice that number of conference papers will be published. Realignment of the ARM Science Team to bring more emphasis on use of ARM observations to develop parameterizations and approaches useful to GCMs will be entering its second cycle. ARM Fellows established at the National Center for Atmospheric Research and at the European Center for Medium-range Weather Forecasting will increase ARM's involvement with centers that focus on the			

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
development and testing of climate models. Enhance interactions with prominent climate modeling centers, including those supported by the NSF and by NOAA. Formal coordination of ARM Science Team activities will be implemented through the established working groups. Additional field studies will focus on connection of ARM data with carbon cycle research.	12,425	13,145	14,093
■ **Atmospheric Radiation Measurement (ARM)/Unmanned Aerial Vehicles (UAV):** One mission will be executed in concert with the ARM International Water Vapor Project to aid in the testing and evaluation of ground measurement of water vapor profiles. Data analysis from the absorption experiment conducted in FY 2000 will be assessed to determine if further missions are required.....	2,868	2,852	2,883
Total, Climate and Hydrology.....	65,839	67,213	72,309

Atmospheric Chemistry and Carbon Cycle

■ 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 are conducted in both atmospheric chemistry and environmental meteorology and acquired data are used to develop and validate predictive models for energy-related processes. Included are studies of chemical and physical processes affecting air pollutants such as sulfur and nitrogen oxides, tropospheric ozone, etc., 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 or released to the atmosphere. Much of this effort involves multi-agency collaboration. University scientists play key roles in this research program.	14,307	12,641	12,318
■ Continue supporting the existing AmeriFlux Program, and implement flux and carbon process measurements at 10 additional locations. The flux measurements will be linked to North American atmospheric measurement campaigns examining atmosphere-biosphere CO_2 exchange relationships.			

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
An expected outcome of these coordinated studies is an improved estimate of the strength of the terrestrial carbon sinks. AmeriFlux network operations will continue to measure net exchange of CO_2 and other greenhouse gases. Net ecosystem carbon uptake is estimated from the flux measurements, and the systems also provide unique data on water vapor exchange and energy balance of ecosystems. Refinement and testing of carbon cycle models will continue, and both mechanistically based and carbon accounting models will be used to estimate potential carbon sequestration for different linkages with biogeochemicalcycles and climate variation. Using tools of microbiology, linkages between carbon and nitrogen cycles in marine microbes will be investigated in partnership with other institutions conducting traditional research in oceanography.	8,752	14,118	14,564
■ Congresssional direction in FY 1999 and 2000 for the National Energy Laboratory in Hawaii.....	971	1,405	0
■ Under the Climate Change Technology Initiative, enhance support of two carbon sequestration research centers. One center which is led by ORNL, PNNL, and ANL, and involving six collaboratory universities, focuses on terrestrial sequestration ($3,000,000). The other center, which is led by LBNL and LLNL, and involves collaboration with six universities and research institutions, focuses on ocean sequestration ($2,000,000). The centers develop the information needed to develop ways of enhancing the natural sequestration of carbon in terrestrial soils and vegetation and in the deep ocean. Support research 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 support research needed to assess the environmental implications of enhancing carbon sequestration and storage in the ocean and in terrestrial systems...	2,922	6,815	8,762
Total, Atmospheric Chemistry and Carbon Cycle	26,952	34,979	35,644

Ecological Processes

- Continue the five 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 of functioning of various types of terrestrial

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
ecosystems, including coniferous and deciduous forests, grasslands, and desert. Continue the long-term experimental investigation on the Walker Branch Watershed in Tennessee to improve understanding of the direct and indirect effects of alterations in annual average precipitation on the functioning and structure of a southeastern deciduous forest ecosystem. University scientists play key roles in this program.....	13,691	11,924	12,010
Human Interactions			
■ The Integrated Assessment program, with a strong academic involvement, continues to support research that will lead to better estimates of the costs and benefits of possible actions to mitigate global climate change. New emphasis in improving the integrated assessment models is on including other greenhouse gases other than carbon dioxide, carbon sequestration, and international trade. The Information and Integration program stores, evaluates, and quality-assures a broad range of global environmental change data and disseminates these to the broad research community. Included is the Quality Systems Science Center for the tri-lateral (Mexico, United States, and Canada) North American Strategy for Troposheric Ozone (NARSTO), a public partnership for atmospheric research in support of air quality management. University scientists play key roles in this program.			
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.	8,048	8,209	8,170
■ Congressional direction in FY 2000 for the Utton Transboundary Center.	0	1,405	0
Total, Human Interactions	8,048	9,614	8,170
SBIR/STTR			
■ In FY 1999 $2,800,000 and $169,000 were transferred to the SBIR and STTR programs respectively. The FY 2000 and FY 2001 amounts are the estimated requirements for the continuation of these programs.	0	3,386	3,376
Total, Environmental Processes	114,530	127,116	131,509

Explanation of Funding Changes from FY 2000 to FY 2001

	FY 2001 vs. FY 2000 ($000)
Climate and Hydrology	
■ Increase in support of implementing model development for simulating multi-decade and multi-century environmental changes at regional resolution.	+4,117
■ Increase in support of connection of ARM data with carbon cycle research and continued development of improvements for climate models.	+948
■ ARM UAV continues at near FY 2000 level.	+31
Total, Climate and Hydrology	+5,096
Atmospheric and Carbon Cycle	
■ Continue Atmospheric Science programs at approximately same level of effort of FY 2000	-323
■ Increase support for studies to understand the biochemical processes and pathways linking carbon fixation and nitrogen cycling in marine microorganisms.	+446
■ Increase in support of expanding research at the carbon sequestration research centers	+1,947
■ Congressional direction in FY 2000 for the National Energy Laboratory in Hawaii.	-1,405
Total, Atmospheric and Carbon Cycle	+665
Ecological Processes	
■ Increase in support of Free Air Carbon Dioxide Enrichment experiments that continue at near FY 2000 level.	+86
Human Interactions	
■ Continue support for education at approximately same level as FY 2000	-39
■ Congressional direction in FY 2000 for the Utton Transboundary Center.	-1,405
Total, Human Interactions	-1,444
SBIR/STTR	
■ Decrease in SBIR/STTR.	-10
Total Funding Change, Environmental Processes	+4,393

Environmental Remediation

Mission Supporting Goals and Objectives

The research is primarily focused on gaining a better 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. Priorities of this research are 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 the conditions under which bioremediation will be a reliable, efficient, and cost-effective technique. This subprogram also includes basic research in support of pollution prevention, sustainable technology development and other fundamental research to address problems of environmental contamination. Facility Operations supports the operation of the EMSL national user facility for basic research that will underpin safe and cost-effective environmental remediation methods and technologies and other environmental priorities. Unique EMSL facilities such as the Molecular Science Computing Facility, the High-Field Mass Spectrometry Facility, and the High-Field Magnetic Resonance Facility will be 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, movement of contaminants in subsurface groundwater and vadose zone sediments, and atmospheric chemical reactions that contribute to changes in the atmospheric radiative balance. 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 will explore societal issues surrounding bioremediation research and promote open and two-way communication with affected stakeholders, avoiding dictating solutions. Research in the Systems Integration, Prediction, and Optimization element is being initiated to help define and develop 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.

Performance Measures

- The first Field Research Center (FRC) for the Natural and Accelerated Bioremediation Research (NABIR) program will be selected at a DOE site in early calendar year 2000. Field site characterization will be completed and subsurface research at the FRC will be started during 2001, providing the fundamental knowledge for development of bioremediation methodologies for containment and clean-up of hazardous materials. NABIR research teams will be developed to build on the strengths of the individual NABIR projects and begin the process of integrating individual

research efforts across the program elements, including the fundamental research in environmental and molecular sciences that underpins the development of bioremediation techniques for containing hazardous wastes and cleaning up contaminated DOE sites.

Funding Schedule

(dollars in thousands)

	FY 1999	FY 2000	FY 2001	$ Change	% Change
Bioremediation Research	31,234	31,129	27,093	-4,036	-13.0%
Clean Up Research	3,632	3,383	1,467	-1,916	-56.6%
Facility Operations	29,909	28,823	32,415	+3,592	+12.5%
Waste Management	0	0	1,200	+1,200	+100.0%
SBIR/STTR	0[a]	1,516	1,361	-155	-10.2%
Total, Environmental Remediation	64,775	64,851	63,536	-1,315	-2.0%

Detailed Program Justification

(dollars in thousands)

FY 1999	FY 2000	FY 2001

Bioremediation Research

- In NABIR, progress will be made in understanding the intrinsic bioremediation (natural attenuation) of DOE relevant metal and radionuclide contaminants, as well as manipulated, accelerated bioremediation using chemical amendments. Laboratory and field experiments (such as at the UMTRA sites) will be conducted to understand the fundamental mechanisms underlying chemical processes, complexation/transformation of contaminants, and to understand microbial transport. The number of field experiments at other sites will be reduced as the first Field Research Center is implemented. The Field Research Center is currently planned for Oak Ridge National Laboratory pending successful completion of a National Environmental Policy Act (NEPA) review. Field site characterization of the first NABIR Field Research Center will proceed and distribution of research samples to investigators will be initiated. Science elements in the NABIR program include fundamental research in the following subjects: a) Biotrans-formation and Biodegradation (microbiology to elucidate the mechanisms of biotransformation and biodegradation of complex

[a] Excludes $1,444,000 which has been transferred to the SBIR program and $86,000 which has been transferred to the STTR program.

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
contaminant mixtures); b) 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); c) Biomolecular Science and Engineering (molecular and structural biology to enhance our understanding of bioremediation and improve the efficacy of bioremedial organisms and identify novel remedial genes); d) Biogeochemical Dynamics (dynamic relationships among *in situ* geochemical, geological, hydrological, and microbial processes); e) Assessment (measuring and validating the biological and geochemical processes of bioremediation); f) Acceleration (flow and transport of nutrients and microorganisms, focused on developing effective methods for accelerating and optimizing bioremediation rates); and g) System Engineering, Integration, Prediction, and Optimization, (conceptual and quantitative methods for describing community dynamics, biotransformation, biodegradation, and biogeochemical dynamics processes in complex geologic systems). University scientists form the core of the NABIR science team that networks with the broader academic community as well as with scientists at other agencies.	25,299	25,173	21,113
■ 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.....	4,766	4,692	4,811
■ General Purpose Equipment (GPE) funding for 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.....	1,169	1,264	1,169
Total, Bioremediation Research.....	31,234	31,129	27,093

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
Clean Up Research			
■ A modest program will be maintained 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.	3,632	3,383	1,467
Facility Operations: William R. Wiley Environmental Molecular Sciences Laboratory (EMSL)			
■ The EMSL is a national 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 600 users. University scientists form the core of the EMSL science team that networks with the broader academic community as well as with scientists at 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.	27,933	26,842	27,426
■ 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. Additional capital equipment funds ($3,000,000) are requested to expand the user capabilities of EMSL to include high-throughput functional genomics and structural biology. This expansion will include acquisition of additional mass spectrometers and Nuclear Magnetic Resonance spectrometers (NMRs), including the first commercial prototype of a high throughput, 9.4 Tesla Fourier Transform Mass Spectrometer specifically built for proteomics studies	1,976	1,981	4,989
Total, Facility Operations	29,909	28,823	32,415

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
Waste Management			
■ Provides for packaging, shipment, 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.	0	0	1,200
SBIR/STTR			
■ In FY 1999, $1,444,000 and $86,000 were transferred to the SBIR and STTR programs, respectively. The FY 2000 and FY 2001 amounts are the estimated requirements for the continuation of these programs.	0	1,516	1,361
Total, Environmental Remediation	64,775	64,851	63,536

Explanation of Funding Changes from FY 2000 to FY 2001

	FY 2001 vs. FY 2000 ($000)
Bioremediation Research	
■ Funding for research at distributed field research sites is decreased to focus field research at NABIR Field Research sites.	-4,060
■ Increase in General Plant Projects that continue at near FY 2000 level.	+119
■ Decrease in General Purpose Equipment that continues at near FY 2000 level.	-95
Total, Bioremediation Research	-4,036
Cleanup Research	
■ Cleanup research on ex-situ approaches, which are now highly developed, is being reduced to focus on more challenging problems of in situ cleanup.	-1,916
Facility Operations	
■ Increase in support of science conducted at the national user facility, EMSL.	+584
■ Increase in capital equipment budget for EMSL.	+3,008
Total, EMSL	+3,592

	FY 2001 vs. FY 2000 ($000)
Waste Management	
■ Increase provides for packaging, shipment, and disposition of hazardous, radioactive, or mixed wastes generated at the Pacific Northwest National Laboratory in the course of normal operations.	+1,200
SBIR/STTR	
■ SBIR/STTR decrease due to decrease in research funding.	-155
Total Funding Change, Environmental Remediation	-1,315

Medical Applications and Measurement Science

Mission Supporting Goals and Objectives

The Medical Applications category supports research to develop beneficial applications of nuclear and other energy-related technologies for medical diagnosis and treatment. The research is directed at discovering new applications of radiotracer agents for medical research as well as for clinical diagnosis and therapy. A major emphasis is placed on application of the latest concepts and developments in genomics, structural biology, computational biology, and instrumentation. Much of the research seeks breakthroughs in noninvasive imaging technologies such as positron emission tomography. Biomedical engineering is an area of emphasis in the medical applications program. Research is directed to fundamental studies in artificial organs, biological and chemical sensors, imaging, lasers, informatics and other areas of technical expertise in the DOE laboratories.

The Measurement Science category focuses on research in analytical chemistry to develop new instrumentation to meet the needs of the environmental and life sciences research programs of the Biological and Environmental Research program. Research is also supported that will meet needs for new instrumentation to characterize contaminated environments in support of the Department's environmental cleanup program.

The Medical Applications and the Measurement Science subprogram has a substantial involvement of academic scientists.

Performance Measures

- Within the Medical Applications category, BER will initiate exploratory research to develop new messenger RNA (mRNA) based radiotracer technologies for imaging gene expression in animals in real time.

Funding Schedule

(dollars in thousands)

	FY 1999	FY 2000	FY 2001	$ Change	% Change
Medical Applications	67,362	64,100	51,465	-12,635	-19.7%
Measurement Science	5,844	4,619	5,849	+1,230	+26.6%
SBIR/STTR	0[a]	1,623	1,495	-128	-7.9%
Total, Medical Applications and Measurement Science	73,206	70,342	58,809	-11,533	-16.4%

Detailed Program Justification

(dollars in thousands)

	FY 1999	FY 2000	FY 2001
Medical Applications			
■ Complete patient follow-up of all patients treated in human clinical trials of boron neutron capture therapy (BNCT) at Brookhaven National Laboratory and Massachusetts Institute of Technology to assess the maximum safe dosages of boron compound and neutron radiation. This is a collaborative program of university and laboratory scientists. Capital equipment funds will be used to support research on an accelerator-based facility for BNCT as an alternative to the use of nuclear reactors.	10,769	11,290	10,795
■ Develop new approaches to radiopharmaceutical design and synthesis using concepts from genomics as well as computational biology and structural biology. Complete research into radiolabeling of monoclonal antibodies for cancer diagnosis and therapy. 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. Continue to emphasize development of techniques for the simultaneous use of multiple radiotracers to study physiological processes. Additional funding will be used to support new, cutting edge research on imaging gene expression and developing new approaches to radiopharmaceutical design and synthesis. The development of technology to image gene expression in cells and organs using mRNA-based radiotracer technology will strongly impact developmental biology and			

[a] Excludes $1,883,000 which has been transferred to the SBIR program and $113,000 which has been transferred to the STTR program.

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
genome and medical sciences. In FY 2001, $5,841,000 is included to develop facilities and infrastructure at the University of South Carolina School of Public Health. This will support research to improve the health and environmental quality of communities served by DOE facilities; train potential new DOE employees and re-train current employees in public health and environmental health sciences using distance-based education modalities; and employ energy efficient design and construction techniques that serve as a model for future academic public health facilities.	19,766	20,938	30,445
■ Develop new concepts in multimodal imaging systems for study of human brain function and complete evaluation of the combination of nuclear medicine imaging systems with magnetic resonance imaging. Research to develop imaging instrumentation and transfer of relevant technology into clinical medicine. Capital equipment funds are provided in support of development of new instrumentation such as a PET camera for small animal imaging. Additional funding will also be used to support research in brain imaging. Additional funding will be used to develop a research program at the National Laboratories in biomedical engineering that capitalizes on their unique resources, and expertise in the biological, physical, chemical and engineering sciences to develop new research opportunities for technological advancement related to human health. The program will emphasize material sciences, sensors, tissue engineering, spectroscopy, informatics, and micro-fabricated machines. It will advance fundamental concepts, create knowledge from the molecular to the organ systems level, and develop innovative biologies, materials, processes, implants, devices, and informatics systems to be used for the prevention, diagnosis, and treatment of disease and for improving health care in the Nation. The programs will depend on critical collaboration with university scientists.	5,294	4,415	10,225
■ Congressional direction in FY 1999 for Gallo Prostate Cancer Research and Treatment Center, City of Hope National Medical Center, National Foundation for Functional Brain Imaging, State University of New York - Stony Brook, University of California – Davis, University of Alabama, New Mexico Highlands University, West Virginia National Education and Technology Center and the University of South Carolina Medical Center.	31,533	0	0

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
■ 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.	0	27,457	0
Total, Medical Applications	67,362	64,100	51,465
Measurement Science			
■ Complete research into new sensor instrumentation for characterization of chemical composition of contaminated subsurface environments in support of the Department's environmental cleanup efforts of highly radioactive chemical wastes. Continue research into new imaging instrumentation for life sciences and biomedical sensors applications. Capital equipment funds are provided for components needed for research into new instrumentation.			
Continue research in medical applications of laser technology at the National Laboratories and at universities. Additional funding will support the lasers in medicine program and imaging instrumentation.	5,844	4,619	5,849
SBIR/STTR			
■ In FY 1999, $1,883,000 and $113,000 were transferred to the SBIR and STTR programs, respectively. The FY 2000 and FY 2001 amounts are the estimated requirements for the continuation of these programs.	0	1,623	1,495
Total, Medical Applications and Measurement Science	73,206	70,342	58,809

Explanation of Funding Changes from FY 2000 to FY 2001

	FY 2001 vs. FY 2000 ($000)
Medical Applications	
■ Reduction in BNCT research that continues at near FY 2000 level to follow up all patients treated during trials.	-495
■ Increase in new research to image the expression of genes in cells, tissues, and whole organisms, a capability that will dramatically impact much of biology and medical sciences. Also, includes an increase of $5,841,000 to develop infrastructure at the University of South Carolina School of Public Health.	+9,507
■ Increase in biomedical engineering research that bridges the gap between molecules and organ systems by developing new innovative biologics, materials, processes, implants, devices, and informatics systems for use in medicine ($5,000,000); and increase in nuclear medicine imaging research on multimodal systems, including brain imaging, to understand organ function ($810,000)	+5,810
■ 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's 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.	-27,457
Total Funding Change, Medical Applications	-12,635
Measurement Science	
■ Increase provides for research in the medical applications of laser science and technology.	+1,230
SBIR/STTR	
■ Decrease in SBIR/STTR.	-128
Total Funding Change, Medical Applications and Measurement Science	-11,533

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 1999	FY 2000	FY 2001	$ Change	% Change
Construction	0	0	2,500	+2,500	+100.0%
Total, Construction	0	0	2,500	+2,500	+100.0%

Detailed Program Justification

(dollars in thousands)

	FY 1999	FY 2000	FY 2001
Construction			
■ The FY 2001 requested budget authority for the Laboratory for Comparative and Functional Genomics at Oak Ridge National Laboratory will provide a modern gene function research facility to support DOE research programs and 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.	0	0	2,500
Total, Construction	0	0	2,500

Explanation of Funding Changes from FY 2000 to FY 2001

	FY 2001 vs. FY 2000 ($000)
Construction	
■ Begin construction of the Laboratory for Comparative and Functional Genomics.	+2,500

Capital Operating Expenses & Construction Summary

Capital Operating Expenses

(dollars in thousands)

	FY 1999	FY 2000	FY 2001	$ Change	% Change
General Plant Projects	4,766	4,692	7,811	+3,119	+66.5%
Capital Equipment	22,116	11,635	27,650	+16,015	+137.6%
Total Capital Operating Expenses	26,882	16,327	35,461	+19,134	+117.2%

Construction Projects

(dollars in thousands)

	Total Estimated Cost (TEC)	Prior Year Appropriations	FY 1999	FY 2000	FY 2001	Unappropriated Balance
01-E-300, Laboratory for Comparative and Functional Genomics, ORNL	13,900	0	0	0	2,500	11,400
Total, Construction		0	0	0	2,500	11,400

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

(dollars in thousands)

	Total Estimated Cost (TEC)	Prior Year Appropriations	FY 1999	FY 2000	FY 2001	Acceptance Date
DNA Repair Protein Complex Beamline	4,500	0	0	0	4,500	FY 2001
Total, Major Items of Equipment		0	0	0	4,500	

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	2,500	2,500	2,175
2002	10,000	10,000	6,980
2003	1,400	1,400	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

(dollars in thousands)

	Prior Years	FY 2000	FY 2001	Outyears	Total
Project Cost					
Facility Cost					
Design	0	0	580	0	580
Construction	0	0	1,595	11,725	13,320
Total, Line item TEC	0	0	2,175	11,725	13,900
Other project costs					
Conceptual design costs[a]	20	0	0	0	20
NEPA documentation costs[b]	0	15	0	0	15
Other project related costs[c]	0	485	0	0	485
Total, Other Project Costs	20	500	0	0	520
Total Project Cost (TPC)	20	500	2,175	11,725	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.