DOE Biological and Environmental Research Program

Serving Science and Society Into the New Millennium

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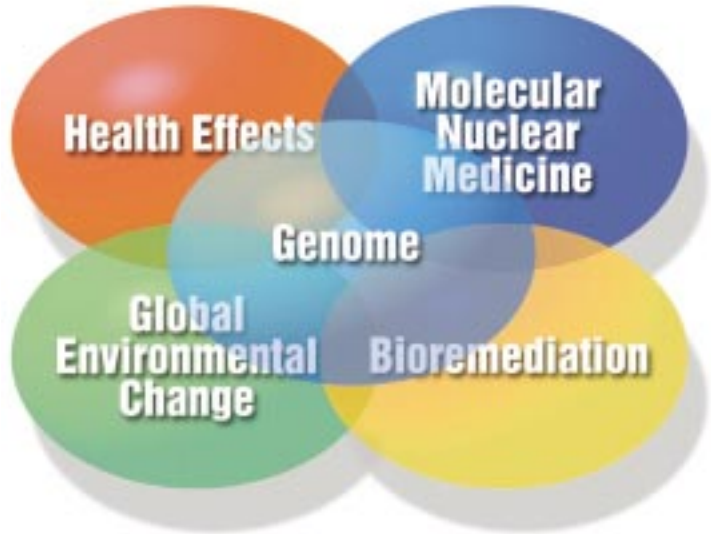
www.er.doe.gov/production/ober/ober_top.html

DOE Biological and Environmental Research Program

An Extraordinary Legacy Since 1947. . .

For over half a century since the establishment of the Atomic Energy Commission, the U.S. Department of Energy (DOE) and its predecessor agencies have pursued biological and environmental research (BER) with an unwavering commitment to understand the health and environmental consequences of energy technologies and by-products. Through multidisciplinary research, DOE continues to exploit the boundless promise of these discoveries for public benefit.



BER programs cross traditional research boundaries to seek revolutionary solutions to energy-related biological and environmental challenges.

The pioneers of the BER program hardly could have predicted the revolutionary courses that its research has taken:

- Efforts focused on the fate of radioactive fallout evolved into today's research on global climate change.
- Studies aimed at understanding the impact of energy development on environmental and ecological processes resulted in the development of reliable bioremediation tools for environmental cleanup.
- Exploratory studies of human metabolism using radiotracers produced the forerunners of high-resolution imaging devices and ultimately spawned the exciting new field of molecular nuclear medicine.
- Questions raised by early epidemiological radiation studies led to the inception of the Human Genome Project.

Scientific diversity, always a hallmark of DOE's BER program, becomes even more important as science advances at the interfaces of such disciplines as biology and information science. Multidisciplinary cooperation also links researchers from the national laboratories, academic community, and private sector.

This unique teaming continues to be a paramount objective of BER management as it pursues the stewardship of the national laboratories. BER also remains committed to academic research and education in its quest to advance science and fulfill DOE missions.

The BER program often shares achievements with others because of its resolution to continue and enhance the interagency, intraagency, and international collaborations that have been key to the success of such endeavors as the Human Genome Project and U.S. Global Change Research Program.

This brochure provides a sampling of the excellence and breadth of recent BER contributions to science and society. The future, as usual, promises unknown challenges—and unexpected opportunities. At the doorstep to the 21st century, the BER program is poised to continue its tradition of devising revolutionary solutions to energy-related biological and environmental challenges.

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. . . An Enduring Mandate

DOE is carrying forward Congressional mandates that began with its predecessors, the Atomic Energy Commission and the Energy Research and Development Agency:

Contribute to a Healthy Citizenry

- Develop innovative tools and other applications of advances in nuclear physics, engineering, and chemistry for tomorrow's biomedical sciences.
- Conduct research into advanced medical technologies and radiopharmaceuticals.
- Provide the scientific basis for individual risk assessments by determining the human genome's physical structure.
- Build and support National User Facilities for determining biological structure, and ultimately function, at the molecular and cellular level.

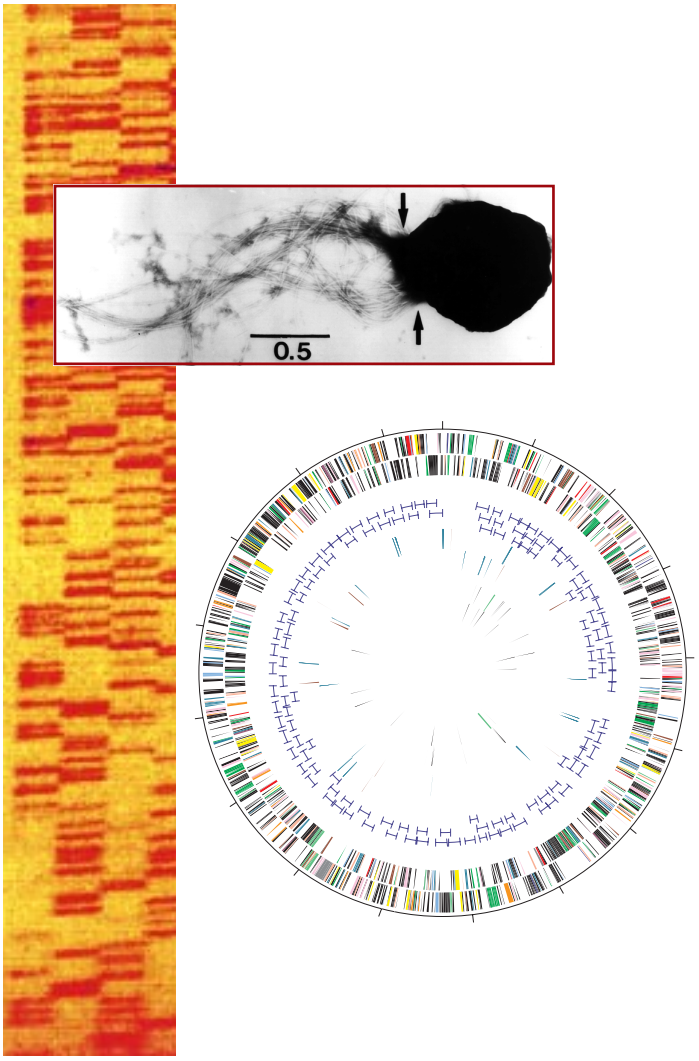
DOE National User Facilities are revealing the molecular details of life. Knowing the 3-D structure of an important molecular switch governing cell growth of the *ras* protein (at left) may enable interventions to shut off this switch in cancer cells.

Understand Global Climate Change

Predict the effects of energy production and its use on the regional and global environment by acquiring data and developing the necessary understanding of environmental processes.

Contribute to Environmental Cleanup

Conduct fundamental research to establish a better scientific basis for remediating contaminated sites.

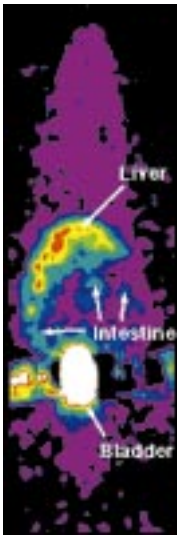


Determining the fine structure—DNA sequence—of the microorganism *Methanococcus jannaschii* (pictured at right) and other life forms in DOE's Microbial Genome Program will benefit environmental bioremediation, medicine, agriculture, and industrial and energy production. The circular representation of the single *M. jannaschii* chromosome, which was fully sequenced in 1996 by BER-supported scientists, illustrates the location of genes and other important features. The vertical bar represents a portion of a sequencing experiment.

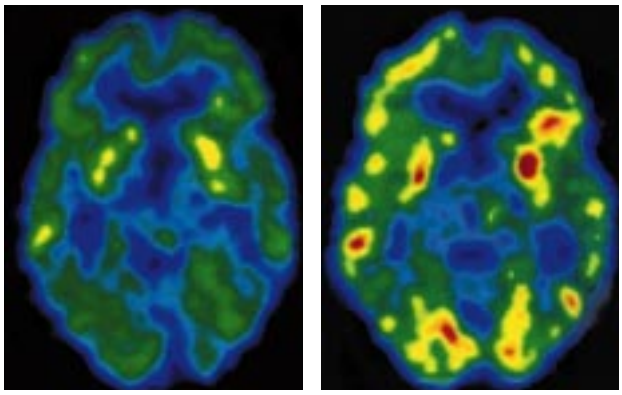
Fifty Years of Achievements Leading to Innovative Solutions

Tools for Medicine and Research

The widespread use of reactor-produced isotopes for medicine and biological research applications began almost 50 years ago with U.S. Food and Drug Administration approval of the first radiopharmaceutical for medical use—iodine-131—produced at Oak Ridge National Laboratory. Through the continued support of DOE and its predecessors, the development and application of isotope generators, along with imaging devices to visualize isotopes as they emit radiation in the body, gave rise to the highly successful field of nuclear medicine. This field encompasses imaging studies, therapeutic procedures, and laboratory tests that now are being merged with new findings in biology and genetics to discover novel ways to diagnose and treat cancer and other disorders, detect genes in action, and understand normal development and function of human organ systems.

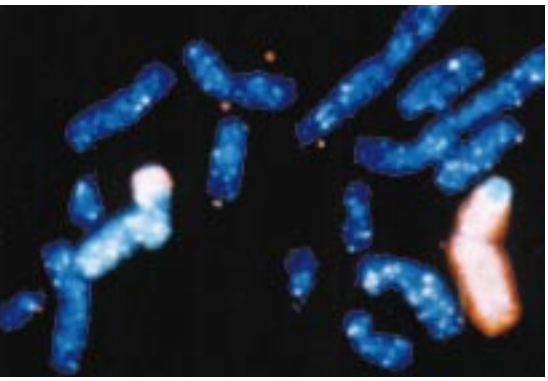


The PET scan at right captures a gene at work (lighted areas) in the liver of a live mouse and in the bladder where the radioisotopic label is excreted. A more detailed understanding of drug uptake, binding, metabolism, and clearance someday will enable the design of individualized, and thus more effective, therapies.



The PET studies above reveal brain metabolism differences in recovering alcoholics after withdrawal from alcohol (left, 10 days, and right, 30 days). In 1997 the Center for Neuroimaging (jointly sponsored by the DOE Biological and Environmental Research program and the National Institute on Drug Abuse) was established at Brookhaven National Laboratory for brain-imaging research to explore normal aging processes; such degenerative brain diseases as Alzheimer's and Parkinson's; and such disorders of human brain function as schizophrenia and those due to alcoholism, smoking, and substance abuse.

- An estimated 1 in 3 patients hospitalized in the United States undergoes a nuclear medical procedure, and nearly 100 million laboratory tests using radioisotopes are performed every year.
- Striking successes have been achieved using charged atomic particles to treat thyroid diseases, pituitary tumors, and eye cancer, among other disorders.
- Radioactive molecules used in medical imaging for positron emission tomography (PET) and magnetic resonance imaging allow noninvasive diagnosis, monitoring, and exploration of human disorders and their treatments.



Genome Projects

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The legacy of DOE research on the genetic effects of exposure to radiation and chemicals led to the world's first Human Genome Program. The program's objective, as part of today's international project, is to determine the sequence of the 3 billion subunits in human DNA. Emerging data already are becoming valuable reagents for pharmaceutical applications and explorations of functional genomics—the study of how the DNA sequence functions in the body. In January 1997 OBER merged its three major human genome centers into the collaborative Joint Genome Institute (*www.jgi.doe.gov*), with high-throughput sequencing taking place at its Production Sequencing Facility in Walnut Creek, California.

Human chromosomes (above) are "painted" by fluorescent dyes to detect abnormal exchange of genetic material frequently present in cancer. Chromosome paints also serve as valuable resources for other clinical and research applications.

New genomic technologies are being applied to environmental cleanup through the DOE Natural and Accelerated Bioremediation Research and Microbial Genome programs, healthcare and risk assessment, and such other national priorities as industrial processes and agriculture.

The laser-based flow cytometer (at left), developed at DOE national laboratories, enables researchers to sort cells according to DNA amount and composition. In addition to its use in genomic research, this capability can help doctors choose an appropriate level of therapy by determining the severity of malignancies: the greater the variation from the normal chromosomal complement, the more aggressive the tumor.

Radiation Risks and Protection Guidelines

BER studies have provided the foundation for laws and standards that protect the population, including workers exposed to radiological sources:

- Guidelines for the safe use of diagnostic X rays and radiopharmaceuticals.
- Safety standards for the presence of radionuclides in food and drinking water.
- Radiation-detection systems and dosimetry techniques.

- Research experience and training provided for radiation biologists and health physicists, radioecologists, and nuclear medicine experts.
- Assessments of health risks from exposure to low doses of ionizing radiation.

DNA Damage and Cancer

Studies of DNA damage have uncovered similar mechanisms in damage caused by radiation exposure, X rays, ultraviolet light, and cancer-causing chemicals. Developed with the support of the Office of Biological and Environmental Research, the Ames Salmonella Assay tests a new compound for carcinogenicity—its potential to damage DNA. This test is one of the first hurdles a compound must clear on its way to regulatory and public acceptance.

Global Climate Change

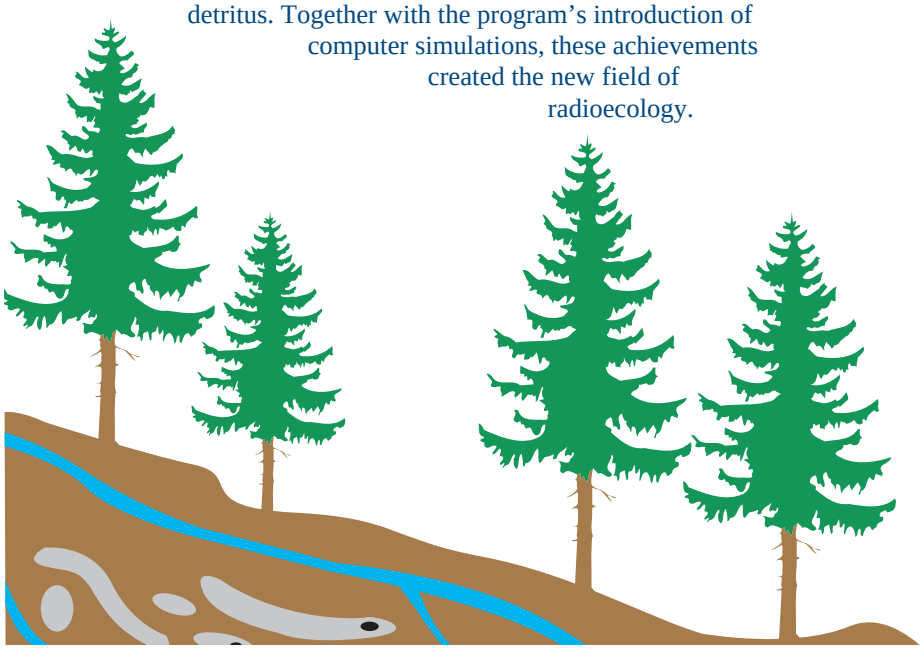
Important achievements in environmental research have led to enhanced capabilities for studying global and regional climate changes, including more accurate predictions of those induced by increasing atmospheric concentrations of greenhouse gases. International agreements aimed at preventing dangerous climatic change from such emissions will demand increasing attention in years to come.

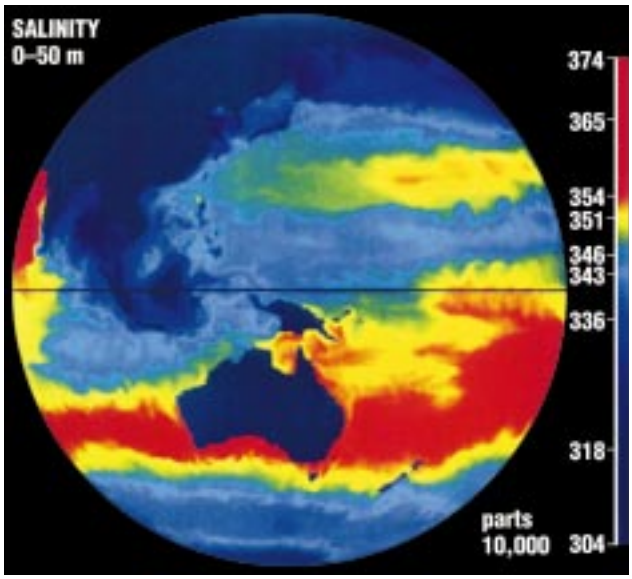
Regional and Global Movement of Pollutants

BER research helped to establish the earliest and most authoritative monitoring network in the world to detect airborne radioisotopes. The use of atmospheric tracers has led to the improved ability to predict the dispersion of pollutants.

The New Science of Radioecology

The BER program pioneered the use of radioactive tracers to follow the movements of animals, routes of chemicals through food chains, and decomposition of forest detritus. Together with the program's introduction of computer simulations, these achievements created the new field of radioecology.





High-performance computing is promoting faster and more realistic solutions to long-term climate change.

Communicating Science, Pursuing Excellence

Publications for Sharing Knowledge

Research supported by the BER program results in up-to-date, widely disseminated information:

- Some 2000 presentations each year at technical meetings
- Over 2500 refereed journal articles annually, as well as books and online reports
- Progress reports on program developments

Awards for Excellence

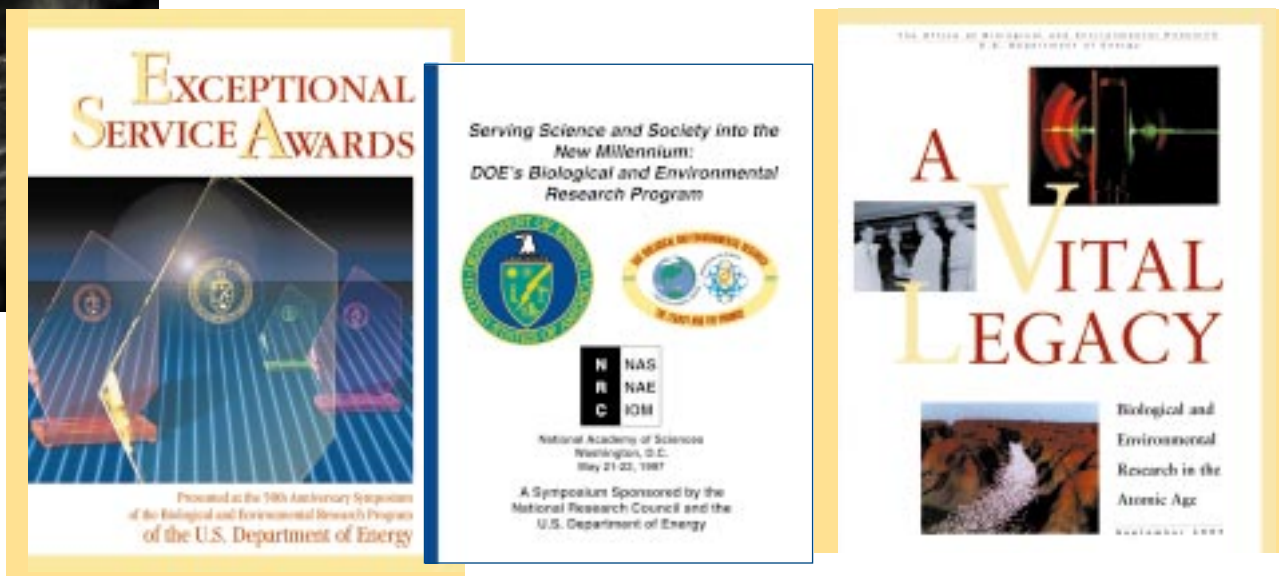
BER-supported scientists have been recipients of more than 200 awards, including:

- 11 Nobel Prizes (1934–99)
- 68 R&D 100 Awards (1977–99)
- 9 Enrico Fermi Awards (1971–99)
- 29 E.O. Lawrence Awards (1963–99)
- 101 Alexander Hollaender Distinguished Postdoctoral Fellows (1987–99)

Symposium Celebrates 50 Years of Achievements

www.ornl.gov/hgmis/publicat/miscpubs/ober-lay.pdf

In May 1997 DOE and the National Research Council of the National Academy of Sciences cosponsored a symposium celebrating the legacy and promise of 5 decades of achievements in biological and environmental research by DOE and its predecessor agencies. Looking ahead, renowned speakers and panelists identified promising new BER program directions, challenges, and prospects for future research and its applications. A recognition awards ceremony honored scientists representing a range of diverse contributions to the BER program. A BER booklet profiling the 13 awardees is available in print and on the Web (*www.ornl.gov/hgmis/publicat/berawards*), and some graphics from the meeting exhibits are online (*www.ornl.gov/hgmis/publicat/ber50/berint.html*).

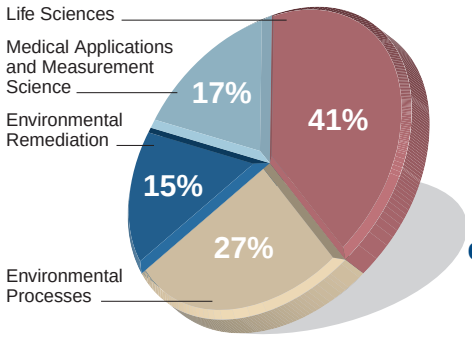


Program Management

Organization and Budget

Headquartered in Germantown, Maryland, the DOE Office of Biological and Environmental Research (OBER) is organized and managed in 3 divisions by 30 professional staff members representing diverse disciplines. Program areas are outlined in the chart at right. OBER's budget for FY 1999 was $436.7 million.

DOE Biological and Environmental Research Funding Distribution



Office of Biological and Environmental Research

Ari Patrinos, Associate Director

Life Sciences Division
Marvin Frazier, Director

- **Structural Biology**
- **Molecular and Cellular Biology**
- **Human Genome**
- **Microbial Genome**
- **Health Effects**
  - Risk of Low-Dose, Low-Dose-Rate Exposures

Medical Sciences Division
Michael Viola, Director

- **Medical Applications**
  - Radioisotope Development
  - Radiopharmaceuticals
  - Instrumentation
  - Clinical Feasibility
  - Boron Neutron Capture Therapy
  - Molecular Nuclear Medicine
- **Measurement Science**
- **Structural Biology Facilities**
- **Genome Instrumentation**
- **Computational Structural Biology**
- **Environmental Management Science Program**

Environmental Sciences Division
Jerry Elwood, Acting Director

- **Climate and Hydrology**
  - Climate Modeling and CHAMMP (Computer Hardware, Advanced Mathematics, and Model Physics)
  - Atmospheric Radiation Measurement
  - Unmanned Air Vehicle
- **Atmospheric Chemistry and Carbon Cycle**
  - Atmospheric Science
  - Carbon Cycle
  - Ocean Sciences
- **Ecological Processes**
  - Ecosystem Function and Response
  - Vegetation
- **National Institute of Global Environmental Change**
- **Environmental Remediation**
  - Natural and Accelerated Bioremediation Research
  - Environmental Molecular Sciences Laboratory

OBER Web site: ***www.er.doe.gov/production/ober/ober_top.html***

Where Research Takes Place

To accomplish programmatic goals, OBER relies on investigators supported in all three components of the nation's research community: national laboratories, universities, and the private sector.

About 60% of OBER research is conducted in national laboratories and other specialized facilities that comprise an important resource of skilled investigators working in multidisciplinary teams. Most remaining research is supported by over 500 OBER awards each year to more than 200 universities, hospitals, and research organizations in the private and public sectors.

As a further service to science and society, OBER makes advanced instrumentation available through its National User Facilities and other unique resources. Access to these facilities enables the broader scientific community to increase the understanding of relationships between biological structure and function, study disease pathways, develop new pharmaceuticals, and conduct basic research in molecular biology and environmental processes.

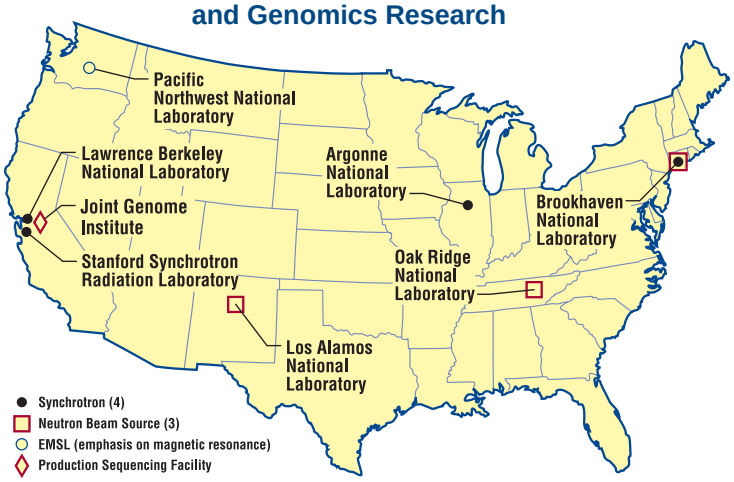
OBER investigators also compete for and are awarded some $200 million each year from other governmental agencies and industry to help them fulfill their scientific missions.

www.er.doe.gov/production/ober/humsubj/index.html

PROTECTING HUMAN SUBJECTS

The Human Subjects Research Program at DOE ensures that the rights and welfare of human research subjects are protected while advances in biomedical, environmental, nuclear, and other research continue to lead to discoveries benefiting humanity.

Some Major DOE Facilities for Structural Biology and Genomics Research



Participating in the BER Program

Research

New ideas and expertise are the lifeblood of all research, and grant applications addressing DOE's scientific objectives are solicited periodically through announcements in the *Federal Register* and other publications. BER program research undergoes rigorous peer evaluation through reviews of competing grant applications by panels of experts, reviews involving ad hoc panels of specialists, and an advisory committee of leading scientists who recommend future directions and priorities. Information about the DOE application process may be found in *Application Guide, 10 CFR Part 605* on the Web *(www.er.doe.gov/production/grants/grants.html*).

Opened in 1997, the William R. Wiley Environmental Molecular Sciences Laboratory (EMSL) at Pacific Northwest National Laboratory is the newest of the collaborative National User Facilities. EMSL supports innovative approaches for meeting the goals of DOE's biological and environmental missions.

Education and Training

Two postdoctoral fellowship programs have been established to allow 15 to 20 superior young scientists to pursue their research interests for up to 2 years at one of the DOE-sponsored laboratories. These are the Alexander Hollaender Distinguished Postdoctoral Fellowship Program and the Postdoctoral Fellowships in Computational Molecular Biology (supported jointly with the Alfred P. Sloan Foundation).

For more information contact:

- Hollaender Fellowships: Barbara Dorsey; Oak Ridge Institute for Science and Education; P.O. Box 117; Oak Ridge, TN 37831-0117 (423/576-9975 or 800/569-7749, *dorseyb@orau.gov*, *www.orau.gov/ober/hollaend.htm*)
- Sloan-DOE Fellowships: Melissa Stoudenheimer; Sloan Foundation; 630 Fifth Avenue, Ste. 2550; New York, NY 10111-0242 (212/649-1649, *stoudenheimer@sloan.org*, *www.sloan.org/science/CMB.html*)

Research projects supported at DOE national laboratories serve as vehicles for training hundreds of graduate and undergraduate students and postdoctoral investigators each year, with comparable numbers participating in grants to universities and other institutions. To foster development of the biological and environmental sciences workforce, the BER program facilitates access to the national laboratories' resources for research and training and encourages collaborative research and development agreements between the laboratories and industry.

Brochure Web address: *www.er.doe.gov/production/ober/ber50.html*