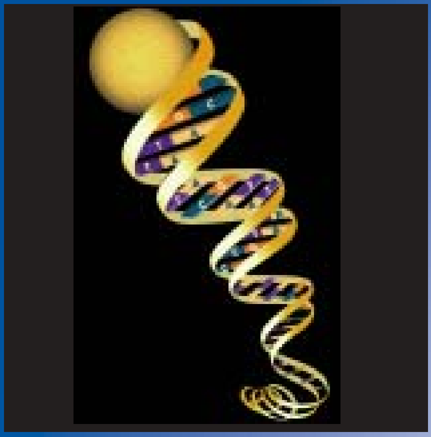
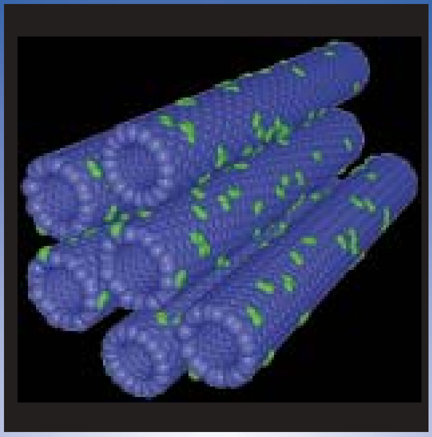
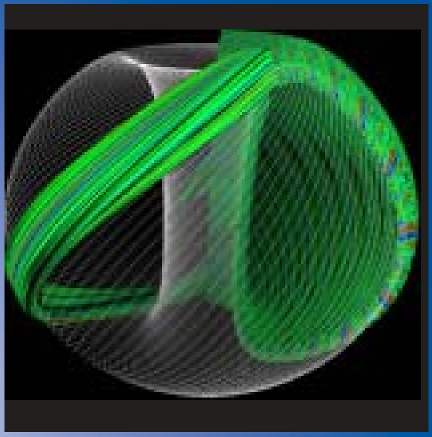
Office of Science

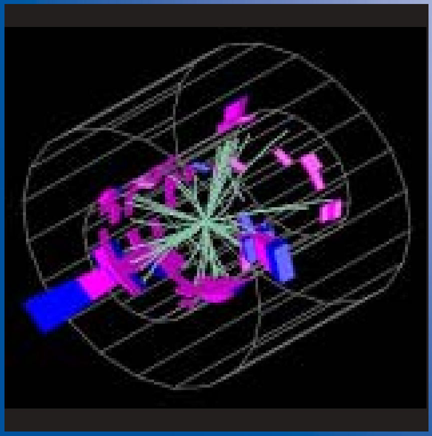
U.S. DEPARTMENT OF ENERGY

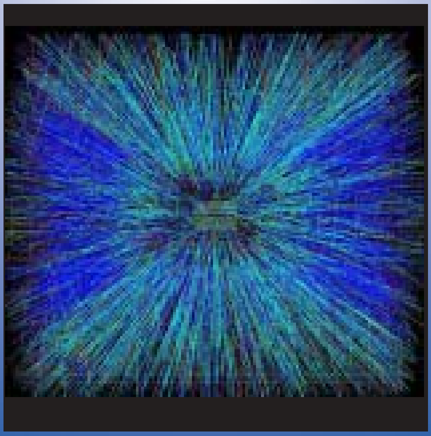
Basic Science for the Nation's Future

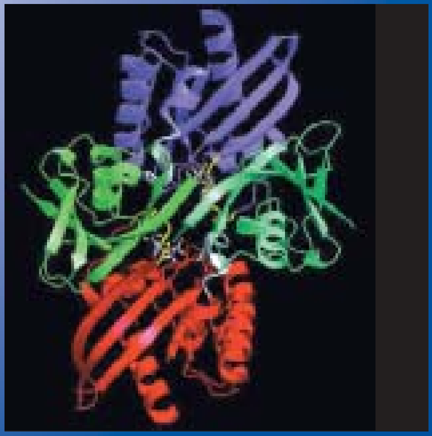




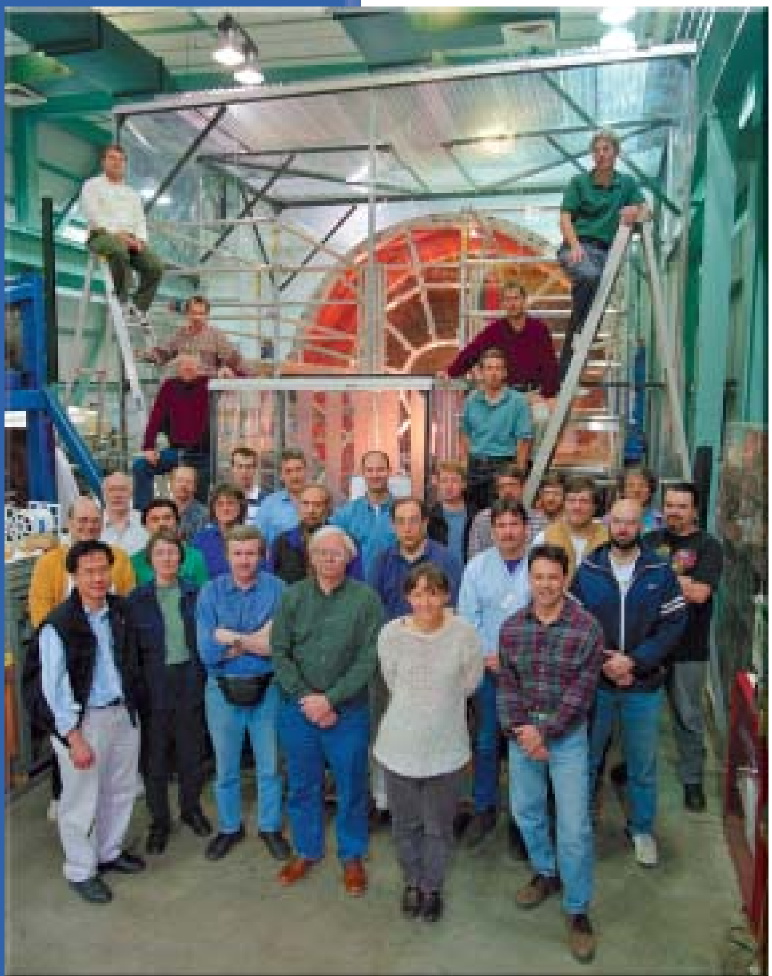








Basic Science for the Nation's Future



Multidisciplinary team research is at the heart of the Office of Science's endeavors. This team of physicists, engineers, and computing scientists designed and fabricated one of the world's most powerful detectors for nuclear science.

The research programs and scientific user facilities at universities and national laboratories funded and managed by the U.S. Department of Energy's (DOE) Office of Science are one of our Nation's premier sources of knowledge and discovery in the physical sciences, computation, mathematics, life sciences, environmental and energy research, and other vital scientific areas. Investments in basic research and forefront scientific facilities help maintain US leadership in many key scientific disciplines and ensure that DOE can fulfill missions in energy and national security.

Office of Science research programs—which comprise one of the most diverse research portfolios in the Federal government—are an essential part of a balanced national research portfolio that will maintain our strength in science and technology and produce new intellectual capital.

Investments in these programs enable US researchers to move quickly to capitalize on scientific developments worldwide. Scientific knowledge, economists agree, leads to technological improvements that increase the quality of life for all Americans, ensure economic security, and advance national security. This scientific knowledge is generated through investments that span research fields and academic disciplines.

Basic Research

The Office of Science is the dominant supporter of basic research in the physical sciences (e.g., physics, chemistry, etc.) in the US and plays a major role in supporting multidisciplinary basic research that contributes to other scientific fields, including life sciences, mathematics, computation, engineering, and environmental sciences. In addition, the Office of Science is a principal supporter of graduate students and postdoctoral researchers in their early careers and is the steward of a network of major scientific facilities that is essential to the vitality of the US research community.

In addition, major advances in medical diagnostic tools, microelectronics, advanced materials, nanoscience, computation, lasers, and other scientific innovations supported by Office of Science programs continue to improve the lives of millions of Americans and have added greatly to the Nation's store of scientific knowledge.

For example, basic research initiated by the Office of Science in 1986 culminated in the publication of a complete draft of the Human Genome sequence in February 2001. This blueprint for humanity holds the promise of curing major diseases and understanding fundamental life processes, while it continues to teach us about our origins and our potential.

The Office of Science's success with the Human Genome Project illustrates that advances in one field of science can often have unexpected impacts on other seemingly unrelated fields. For example, breakthroughs in the physical sciences have enabled rapid advances in medical and life sciences, communications, and information technology. Companies developing new medicines often depend on computer-based modeling and theoretical advances in chemistry, physics, and life sciences supported by the Office of Science.

Scientific Facilities

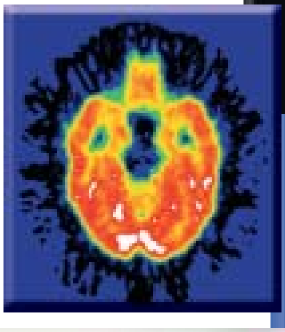
This growing connectivity between the sciences is evident at the Office of Science's scientific user facilities. For example, only 100 of the 1,600 researchers (6%) using the Office of Science's synchrotron light sources in 1990 were from the life sciences. Today, more than 6,000 researchers use the light sources, and 2,400 of them (40%) are from the life sciences.

X-ray crystallography is an excellent example of the interdependence of scientific disciplines at the forefront of medical research. A grant from the National Institutes of Health may fund a research team that includes biologists, but it may also include a materials scientist or solid-state physicist, an optics expert, a computational

(continued on page 6)

"Medical advances may seem like wizardry. But pull back the curtain, and sitting at the lever is a high-energy physicist, a combinational chemist or an engineer."

**—Harold Varmus,
Nobel Laureate
and former Director
of the National Institutes
of Health**



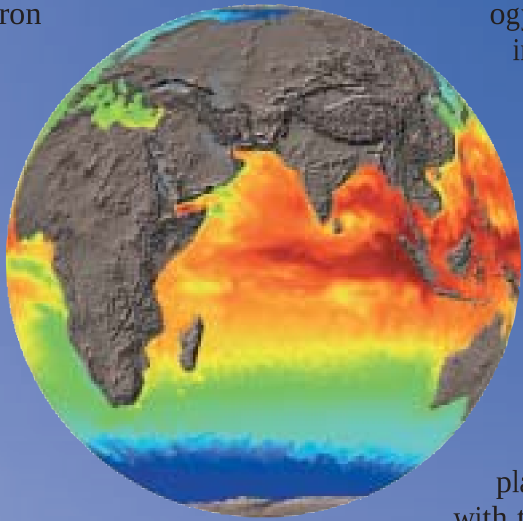
Positron Emission Tomography, pioneered by the Office of Science, is essential to advances in medicine.

Protein crystallography at synchroton radiation sources can reveal the molecular structure and biological function of cells.

National laboratories developed a way to "paint" specific chromosomes. With this technique, scientists can quickly identify chromosome aberrations.

Office of Science Programs

Office of Science programs lead the Nation in many areas of the physical and computational sciences, and they contribute significantly to major advances in biological research. Accelerators, light sources, neutron beam facilities, plasma and fusion science facilities, genome centers, and advanced computational centers are just some of the major instruments of science supported and managed by Office of Science programs to enhance the Nation's science base and infrastructure.



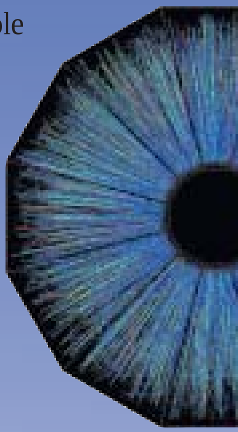
The Office of Science Programs

The **Advanced Scientific Computing Research** program's mission is to discover, develop, and deploy the computational and networking tools that enable scientific researchers to analyze, model, simulate, and predict complex physical, chemical, and biological phenomena important to the Department of Energy. This research is changing the ways in which modern science is conducted.

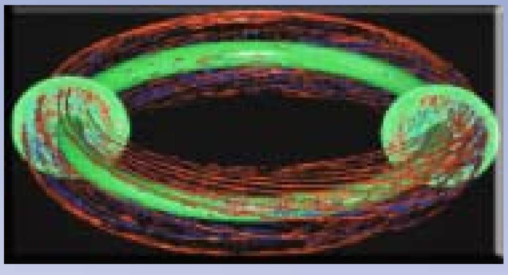
The **Basic Energy Sciences** program is a principal sponsor of fundamental research for the Nation in the areas of materials sciences and engineering, chemistry, geosciences, and bioscience as it relates to energy. This research underpins the DOE missions in energy, environment, and national security; advances energy-related basic science on a broad front; and provides unique user facilities for the scientific community and industry.

The **Biological and Environmental Research** program develops the knowledge needed to identify, understand, anticipate, and mitigate the long-term health and environmental consequences of energy production, development, and use. As the founder of the Human Genome Project, BER continues to play a major role in biotechnology research and also invests in basic research on global climate change and environmental remediation.

The **Fusion Energy Sciences** program's mission is to advance plasma science and fusion science and technology. The program emphasizes the underlying basic research in plasma and fusion sciences, with the long-term goal of harnessing fusion as a viable energy source. The program supports research to understand the physics of plasmas; to identify and explore innovative and cost-effective development paths to fusion energy; and as a partner in international efforts, to advance the science and technology of energy-producing plasmas.

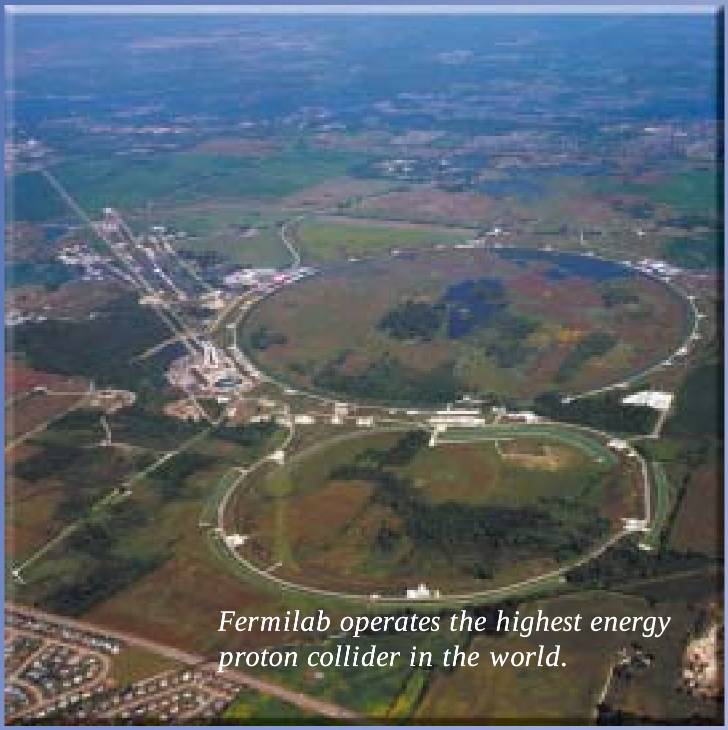


The **High Energy Physics** program's mission is to understand energy and matter at a fundamental level by investigating the



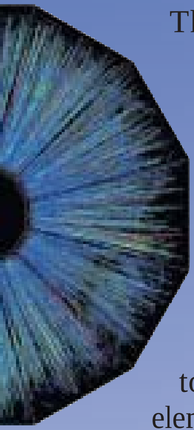
Computational simulations of magnetic fusion build a bridge between theory and experiment, leading to significant cost savings and improved performance in subsequent experiments.

elementary particles and the forces between them. This program is the major sponsor of high energy physics research in the US, providing 90% of the Federal support. Until the Large Hadron Collider in Europe is completed in 2007, the US will be the primary center of international activity for experimental research in the field of high energy physics. There is the potential for exciting new discoveries, and the program is positioning itself to take advantage of these opportunities.



Fermilab operates the highest energy proton collider in the world.

The mission of the **Nuclear Physics** program is to advance our knowledge of the properties and interactions of atomic nuclei and nuclear matter and the fundamental forces and particles of nature. The Nuclear Physics program provides about 85% of the Federal support for nuclear physics research. With this funding, the program seeks to understand how quarks bind together to form nucleons and nuclei, to create and study the quark-gluon plasma that is thought to have been the primordial state of the early universe, and to understand energy production and element synthesis in stars and stellar explosions.



The National Laboratory System

The Office of Science is the steward of 10 national laboratories that support the missions of its science programs. The national laboratory system, created over a half-century ago, represents the most comprehensive research system of its kind in the world. These laboratories perform research and development that is not well suited to university or private sector research facilities because of its scope, infrastructure, or multidisciplinary nature, but for which there is a strong public and national purpose.

Some of the national laboratories also house and manage the Office of Science's major user facilities, such as the National Synchrotron Light Source at Brookhaven, which provides the world's brightest continuous source of X-rays and ultraviolet radiation for research. The Spallation Neutron Source being built at Oak Ridge will provide the most intense pulsed neutron beams in the world for scientific research and industrial development.

A high level of collaboration among all of the national laboratories in the use of world-class scientific equipment and supercomputers, facilities, and multidisciplinary teams of scientists increases their collective contribution to DOE and the Nation, making the laboratory system more valuable as a whole than as the sum of its parts.

(continued from page 3)

scientist, or a biochemist. The work of such a team relies upon the availability of a high intensity light source, a neutron source, or a state-of-the-art nuclear magnetic resonance imaging machine. All of these instruments were the result of research in the physical sciences—and the Office of Science pioneered their development and use.

Science Education

The Office of Science has a long-standing role in the training of young scientists, engineers, and technicians for the Nation. The scientists and engineers at the national laboratories operate on the principle that complex problems are best solved by the power of many minds working as one. These researchers learned their craft under the close supervision of the teams of scientists that came before them. This mentor-intensive approach is one of the distinguishing characteristics of advanced science education and workforce development at the Office of Science's national laboratories.

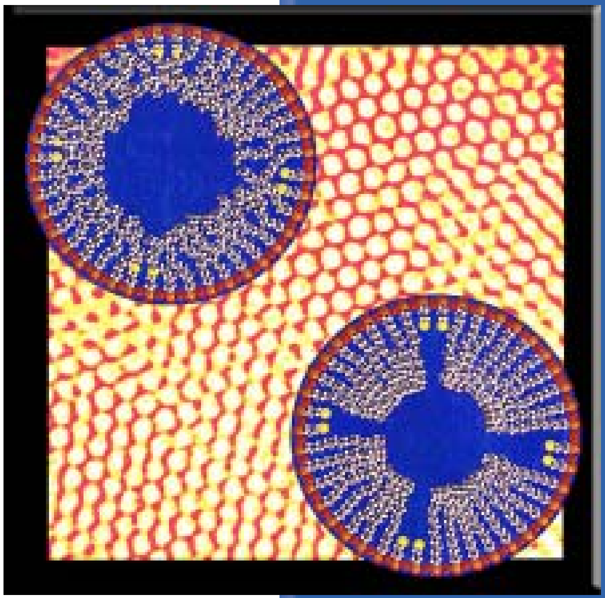
For many years, the Office of Science's national laboratories have accepted college undergraduate and graduate students and secondary school teachers in scientific fellowship and internship research positions. They have welcomed these participants into a scientifically and technically advanced environment seen in few other places, where multidisciplinary teams are the rule and not the exception, and where many of the world's best minds work cooperatively on massive projects to decipher the smallest and most hidden secrets of nature.

Through collaborations with the American Association of Community Colleges and the National Science Foundation, the Office of Science recently has expanded its efforts to increase the pipeline of students entering science and technology careers while promoting diversity in the workforce. All participants are tracked in their career paths and are encouraged to remain part of the scientific and technological community through continuing relationships with the laboratory scientists.

To attract and encourage students to choose an education in the sciences and engineering, the Office of Science also supports the National Science Bowl, which is an educational activity for high school students involving all branches of science. Each year, over 12,000 students participate and typically prepare for months to attend the national event in Washington, D.C.

A History of Success

Past investments in Office of Science basic research programs continue to pay off handsomely for US taxpayers. Researchers funded by these programs have explored some of the major scientific questions of our time, performing the basic research that is helping us understand the origins and fate of the universe, the diversity of life on this planet, and changes in our global climate.



The Office of Science plays an essential role in the National Nanotechnology Initiative.

The Office of Science has developed a list of the "Top 100" contributions to science from the basic research programs of the Department of Energy during the 24 years since DOE's founding. The list of these contributions, called *Decades of Discovery*, is available on the web at www.science.doe.gov.

That long history of scientific contributions is continuing:

- Office of Science investments in high energy and nuclear physics move us closer to a complete picture of the fundamental particles and interactions that dictate the nature of matter and energy and explain a myriad of natural and man-made phenomena.

- A new class of nanostructured materials has been created that can selectively filter molecules by their size and chemical identity. As a result, we may one day wear "breathing" fabrics that block hazardous chemicals while admitting harmless substances like oxygen.

- Investments in plasma physics and fusion energy sciences continue to expand our understanding of how to generate, control, and harness the energy of high-temperature, high-density plasmas here on Earth.

- Completion of the draft map of the human genome, one of the seminal discoveries of our age, was made possible by technologies developed by the Office of Science for sequencing the genetic code. The Office of Science is also responsible for completing the sequencing of three chromosomes in the human genome.

Office of Science Contacts

Dr. Raymond Orbach
Director, Office of Science
U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, D.C. 20585
Phone: 202-586-5430 Fax: 202-586-4120
E-mail: Ray.Orbach@science.doe.gov
Website: www.science.doe.gov

Dr. C. Edward Oliver
Advanced Scientific Computing Research
U.S. Department of Energy
19901 Germantown Road
Germantown, MD 20874-1290
Phone: 301-903-7486 Fax: 301-903-4846
E-mail: Ed.Oliver@science.doe.gov
Website: www.sc.doe.gov/ascr/index.html

Dr. Ari Patrinos
Biological and Environmental Research
U.S. Department of Energy, Headquarters
19901 Germantown Road
Germantown, MD 20874-1290
Phone: 301-903-3251 Fax: 301-903-5051
E-mail: Ari.Patrinos@science.doe.gov
Website: www.sc.doe.gov/production/ober/ober_top.html

Dr. Patricia M. Dehmer
Basic Energy Sciences
U.S. Department of Energy
19901 Germantown Road
Germantown, MD 20874-1290
Phone: 301-903-3081 Fax: 301-903-6594
E-mail: Patricia.Dehmer@science.doe.gov
Website: www.sc.doe.gov/production/bes/bes.html

Dr. Anne Davies
Fusion Energy Sciences
U.S. Department of Energy
19901 Germantown Road
Germantown, MD 20874-1290
Phone: 301-903-4941 Fax: 301-903-8584
E-mail: Anne.Davies@science.doe.gov
Website: www.ofes.science.doe.gov/

Dr. S. Peter Rosen
High Energy & Nuclear Physics
U.S. Department of Energy
19901 Germantown Road
Germantown, MD 20874-1290
Phone: 301-903-3713 Fax: 301-903-3833
E-mail: Peter.Rosen@science.doe.gov
Website: www.sc.doe.gov/production/henp/henp.html

The Office of Science's Technical Information Management Program leads the Department of Energy's government initiatives for disseminating information resulting from DOE's research and development programs. The Office of Scientific and Technical Information (OSTI) provides electronic access to worldwide scientific and technical information to DOE researchers, industry, academia, and the public from its web site: www.osti.gov

April 2002