Volume VI, 2006

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JOURNAL OF UNDERGRADUATE RESEARCH

About the Cover

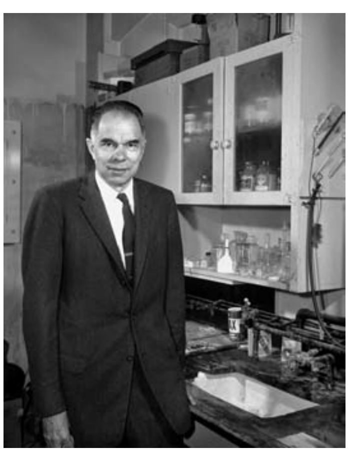
Mentoring Relationships in the Field of Science

This year's cover for Volume VI of the *Journal of Undergraduate Research* recognizes the importance of mentoring relationships in the fields of science to current students who are future scientists. Beyond the learning of science content, the mentor relationships that students experience are critical because they introduce those students to collaboration in research and to a network of scientists.

The "tree" of mentoring shows that mentors pass on the science legacy to their students, who in turn become mentors for other students. One successful mentor may have an impact on several students, who each may impact even more students, just like the branches on a tree.

The images on the cover reflect past and current activities at the Lawrence Berkeley National Laboratory in Berkeley, California. The Lab is one in a network of laboratories supported by the U.S. Department of Energy (DOE). Students who conducted research at DOE National Laboratories during 2005 were invited to include their research abstracts, and for a select few, their completed research papers in this *Journal*. This *Journal* is direct evidence of students collaborating with their mentors.

Lawrence Berkeley National Laboratory (LBNL), the oldest Department of Energy National Lab, is celebrating its 75th anniversary. LBNL was founded on August 26, 1931 by Ernest O. Lawrence, the inventor of the cyclotron, an accelerator of subatomic particles, and a 1939 Nobel Laureate in physics for that achievement. The Radiation Laboratory he developed at Berkeley during the 1930s ushered in the era of "big science," in which experiments are no longer done by an individual researcher and a few assistants on the table-top of an academic lab, but by large, multidisciplinary teams of scientists and engineers in entire buildings full of sophisticated equipment and huge scientific machines.



Glenn Seaborg

At the base of the tree of images is Marie Curie (1861-1934), followed by Ernest O. Lawrence (1901-1958), Glenn Seaborg (1912-1999), Al Ghiorso (1915-), Darleane Hoffman (1926-), and then followed by shots of recent educational groups. The claim to fame for these members of our "tree" is their contribution to the discovery of new elements from the 1940s to the 1970s. Lawrence was honored with Element 103, Lawrencium, in 1961; and Seaborg with Element 106, Seaborgium, in 1997. Curie created the phrase "radioactivity," and won two Nobel Prizes (1908 and 1911), the latter for the discovery of Radium and Polonium. Seaborg earned a Nobel Prize in 1951, codiscovered Plutonium, boldly predicted a new version of the Periodic Table, was an advocate for arms control and science education, and served as the Chairman of the Atomic Energy Commission (parent organization to the Department of Energy today). Ghiorso codiscovered 11 elements, a world record likely not to be matched. Darleane Hoffman took Glenn Seaborg's place on the UC Berkeley faculty and led the effort to confirm the discovery of element 106, paving the way for naming it Seaborgium.

The current Director of Education at the Lab, Rollie Otto, was mentored by Glenn Seaborg, and shared this reflection:

> "A mentor has a commitment to his or her life's work that is contagious. Certainly this was true of Glenn Seaborg. As I look back on my own career, I was guided by Glenn Seaborg's commitment and commitment to address critical problems and issues in nuclear science, energy independence and education.
>
> I learned from Glenn by example that mentors have a commitment to the successes of their students, as well as to raise students' expectations for what they can accomplish. Glenn Seaborg was a model mentor, who not only assigned his students to frontier projects, new element discoveries, but was a reliable supporter for these students' throughout their careers, creating a great legacy."

All photographs courtesy of Lawrence Berkeley National Laboratory. Darleane Hoffman photo taken by Roy Kaltschmidt.

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A NOTE FROM THE EDITOR: SCIENTIFIC PROGRESS

Progress in scientific thought has helped to create societies with widespread security and comfort. The means by which science progresses have resulted in its reputation for being unbiased in its search for understanding. Contrary to what many school books purport, progress in science takes various forms, and is akin to organized chaos. When new innovative ideas arise, their defense can be especially absorbing. Numerous scientists have spent entire careers pursuing evidence that couldn't be found. Even more dramatic are the shifts from one paradigm to another. Paradigm shifts in science are often provoked by the discovery of phenomena antithetical to ideas that were so fundamental to current beliefs as to be unassailable. Newton extended the highest praise to Kepler because he was so audacious as to propose elliptical planetary orbits rather than the circular orbits so customarily accepted by others. Proponents of new paradigms have seldom found their ideas eagerly received. They are often roundly dismissed by those passionately adhering to prevalent theories. By gathering strong empirical evidence and enduring tests of their thinking, they sometimes succeed in radically shifting the course of scientific inquiry. Such progress embodies the expansion of knowledge that we call science.

Thomas Kuhn wrote in his 1962 monograph, *The Structure of Scientific Revolutions*, that so called normal science "is predicated on the assumption that the scientific community knows what the world is like. Scientists usually take great pains to defend this assumption and will make a strenuous and devoted attempt to force nature into the conceptual boxes supplied by professional education." Paradigm shifts occur when an anomaly "subverts the existing tradition of scientific practice."[1] In *Ideas and Opinions*, Albert Einstein wrote "our notions of physical reality can never be final. We must always be ready to change the notions … in order to do justice to perceived facts in the most logically perfect way."[2] Scientists must embrace curiosity and feed the desire to question for these are the fuel that fires the engine of discovery.

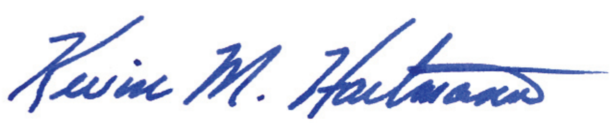
> ***"Science and society are as interwoven as are observers and the observed."***

Theories themselves can be viewed in different ways by different groups of scientists. Some see theories as a way to classify and systematize observations while others see them as attempts to describe the true nature of reality, even beyond the observable. These differing views can lead to diverse definitions of scientific progress. Those who adhere to theories as a way to systematize observations see scientific progress as an increase in the body of knowledge accessible to scientific thought. Adherents of this point of view often do not value theories as the genuine product of the scientific endeavor. Those who view theories as an attempt to describe the underlying truths of the universe see scientific progress as a never-ending movement towards a more valid description of the universe. A more inclusive description of scientific progress should avoid both of these extremes and incorporate aspects of each view.

Science, at its most basic level, is a human activity, and an integral part of human society. It is a way that we think about and rationally attempt to expose the underlying truth that confronts us. Progress in modern science is inextricably linked to societal affairs. Science and society are as interwoven as are observers and the observed. Throughout history, the intellectual freedom so prized by scientists has come with a price. For society, science is the bearer of security and well-being. Society typically grants science the freedom to explore and grow in almost any direction that discoveries warrant. As science has become more powerful and far-reaching, it has become the responsibility of all in society to understand the greater issues of science. Society guides the direction in which science is moving. Modern science relies on funds from government, industry, and private agencies in order to conduct research. It is through this funding that society is most able to exert its influence over scientific progress. Recent events, such as debates surrounding stem cell research and cloning, illustrate society's ability to exert such pressure.

In such an environment, science may need to address another of its long-standing paradigms – that within the bounds of ethical conduct, any question that is answerable should be open to scientific investigation. Given the extent to which science can affect the planet, it is no longer wise to ignore the concerns of society outside of the scientific establishment. The next generation of scientists will have to answer the question of whether or not we should pursue certain scientific developments simply because we can. Such discussions will require scientists to engage in dialogue with many different factions within society. This will present new and unique challenges to the scientists of the future.

Peter Faletra, Ph.D.
Director, Office of Workforce Development for Teachers & Scientists
Office of Science



Kevin M. Hartmann
Albert Einstein Distinguished Educator Fellow
Office of Science

References:

1. Kuhn, T. (1996). *The Structure of Scientific Revolutions*. Chicago: University of Chicago Press.
2. Einstein, A. (1954). *Ideas and Opinions*. New York: Crown Publishers.

SCIENTIFIC "GRANDCHILDREN"

Many things have been said about the value of mentoring, and in some sense not much can be added. A mentor is someone who is interested in the first steps of developing a student into a professional. There are many lessons that must be taught. For example, "Don't listen to orthodox explanations." Well, maybe listening is okay, but believing all you hear isn't okay. "Find the courage to stick to your conclusions." "Don't get discouraged when mistakes are made." "Understand what you are doing, and if things don't work you must evaluate what you did and make sure it's correct." The list goes on and on, and in some sense, a mentor must get the student through these obstacles.

In fact they are not obstacles, but really become a mind set for a scientist. Even though I could probably find more things to enumerate, I must emphasize that the most important thing to leave with a student is the sense of adventure in science, to try something no one has ever tried, and ultimately if your experiment or calculation goes well, to realize that you know more about something than anyone else in the world.

There was a very amazing surprise that happened a couple of summers ago. Noel Blackburn in our Office of Educational Programs indicated that he had a candidate in the Faculty and Student Team (FaST) program that might be a match for me, and was I interested. After looking at the credentials of Abebe Kebede of North Carolina A&T, he seemed to have experience in my area and I had a good project for him and his students. What's interesting is that in looking at his credentials he had reasonable publications, and better yet he got his Ph.D. with Jack Crow at Temple University. Jack Crow was a remarkable scientist with the vision to create the National High Magnetic Field Laboratory in Tallahassee Florida. Tragically, Jack died in September of 2004 from pancreatic cancer. In the memorial service information it says "The National High Magnetic Field Laboratory is truly the house that Jack built." It couldn't be put better.

So in the summer of 2004, Abebe Kebede, his students, and I agonized over Jack, as well as measuring the conductivity of percolating gold clusters. Interestingly, I had hired Jack when he left graduate school; we worked together for many years before he went to Temple. So, in some sense, Abebe, Jack's student, is really my scientific "grandson," which of course makes me a great-grandfather to Chris Jessamy and Tanina Bradley, the students who accompanied Abebe from North Carolina. Having a part in this as a mentor has been a great source of satisfaction for me as I see the excitement of science passed on to new generations.

> ***"...the most important thing to leave with a student is the sense of adventure in science..."***

There is another interesting aspect to this story, and that is the value of the FaST program where minority students can take part in some of the things that go on at a great laboratory. They can see ideas flying around, some good and some bad, and they get the feeling of how science is done and whether this is what they want as a career. It's important to them, and it's important to America. In looking through the Web, I noticed that Chris and Tanina expanded some of the work they did here and presented it in the University of North Carolina Student Research Program. I gather that Tanina is finishing up at the University of North Carolina at Charlotte and Chris is about to graduate from North Carolina A&T. I like to think that somehow we all came together through Jack.

Myron Strongin
Bookhaven National Laboratory

"They can see ideas flying around, some good and some bad, and they get the feeling of how science is done and whether this is what they want as a career."

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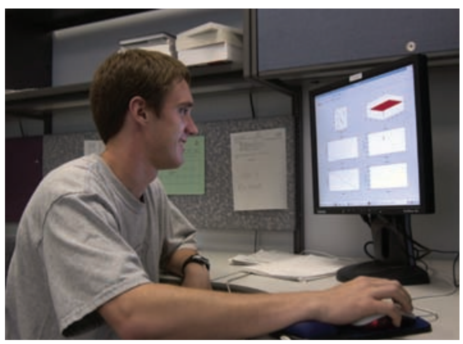
Selected Student Papers Continued:

AMES LABORATORY
Ames, Iowa



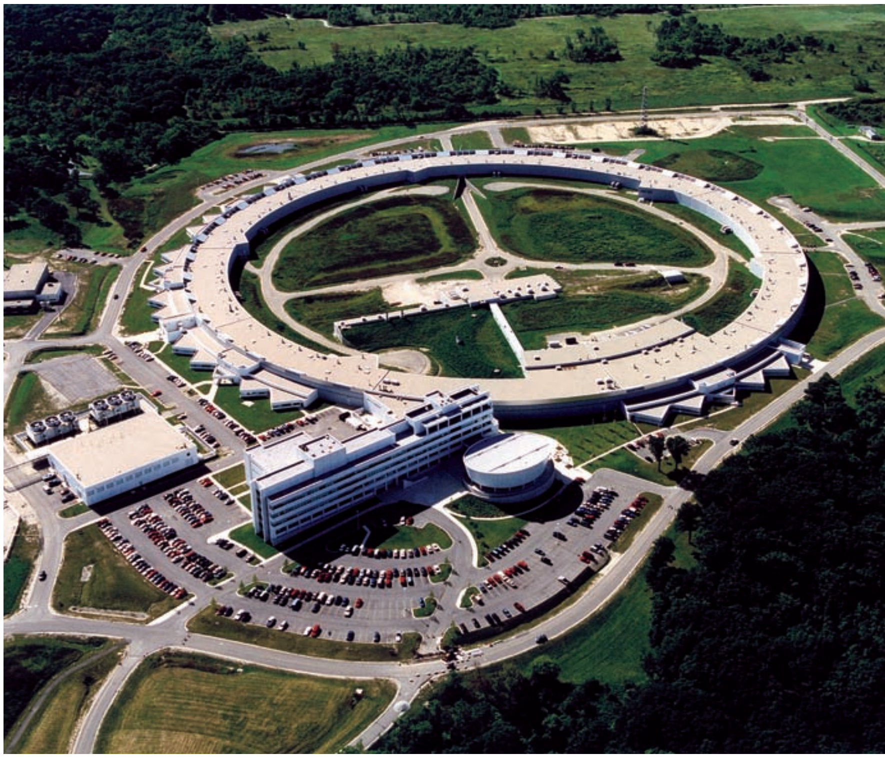
Scientists at the Department of Energy Office of Science's Ames Laboratory seek solutions to energy-related problems through the exploration of chemical, engineering, materials and mathematical sciences, and physics.

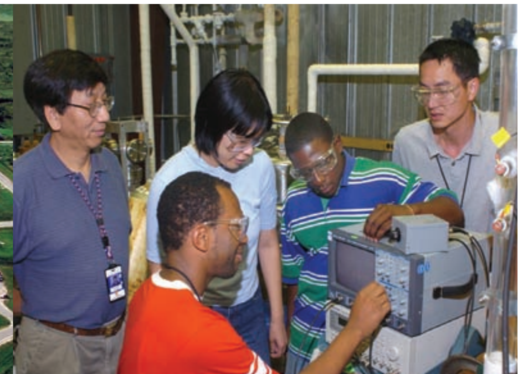
Established in the 1940s with the successful development of the most efficient process to produce high-purity uranium metal for atomic energy, Ames Lab now pursues much broader priorities than the materials research that has given the Lab international credibility.

Responding to issues of national concern, Lab scientists are actively involved in innovative research, science education programs, the development of applied technologies and the quick transfer of such technologies to industry. Uniquely integrated within a university environment, the Lab stimulates creative thought and encourages scientific discovery, providing solutions to complex problems and educating tomorrow's scientific talent.

Ames Laboratory is located in Ames, Iowa, on the campus of Iowa State University. Iowa State's 2,000-acre, park-like campus is home to more than 25,000 students. Ames is approximately 30 minutes north of Des Moines, Iowa's capital city.

ARGONNE NATIONAL LABORATORY
Argonne, Illinois





Argonne National Laboratory descends from the University of Chicago's Metallurgical Laboratory, part of the World War Two Manhattan Project. The laboratory has about 2,900 employees, including about 1,000 scientists and engineers. Argonne occupies 1,500 wooded acres in DuPage County, Illinois, about 25 miles southwest of Chicago's Loop. Argonne research falls into broad categories:

- Basic science seeks solutions to a wide variety of scientific challenges. This includes experimental and theoretical work in biology, chemistry, high energy and nuclear physics, materials science, and mathematics and computer science.
- Scientific facilities help advance America's scientific leadership and prepare the nation for the future. These facilities are used by scientists thousands of scientists and students from the U.S. and abroad. The laboratory is also home to the Advanced Photon Source, the Center for Nanoscale Materials, the Intense Pulsed Neutron Source, and the Argonne Tandem Linear Accelerator System.
- Energy resources programs help insure a reliable supply of efficient and clean energy for the future. Argonne scientists and engineers are developing advanced batteries and fuel cells, as well as advanced electric power generation and storage systems.
- Environmental management includes work on managing and solving the nation's environmental problems and promoting environmental stewardship.
- National Security has increased in significance in recent years for the nation and for Argonne research. Argonne capabilities developed over the years for other purposes are helping to counter the threats of terrorism.

Argonne's Division of Educational Programs provides workforce development for faculty and students from universities to regional K-12 schools.

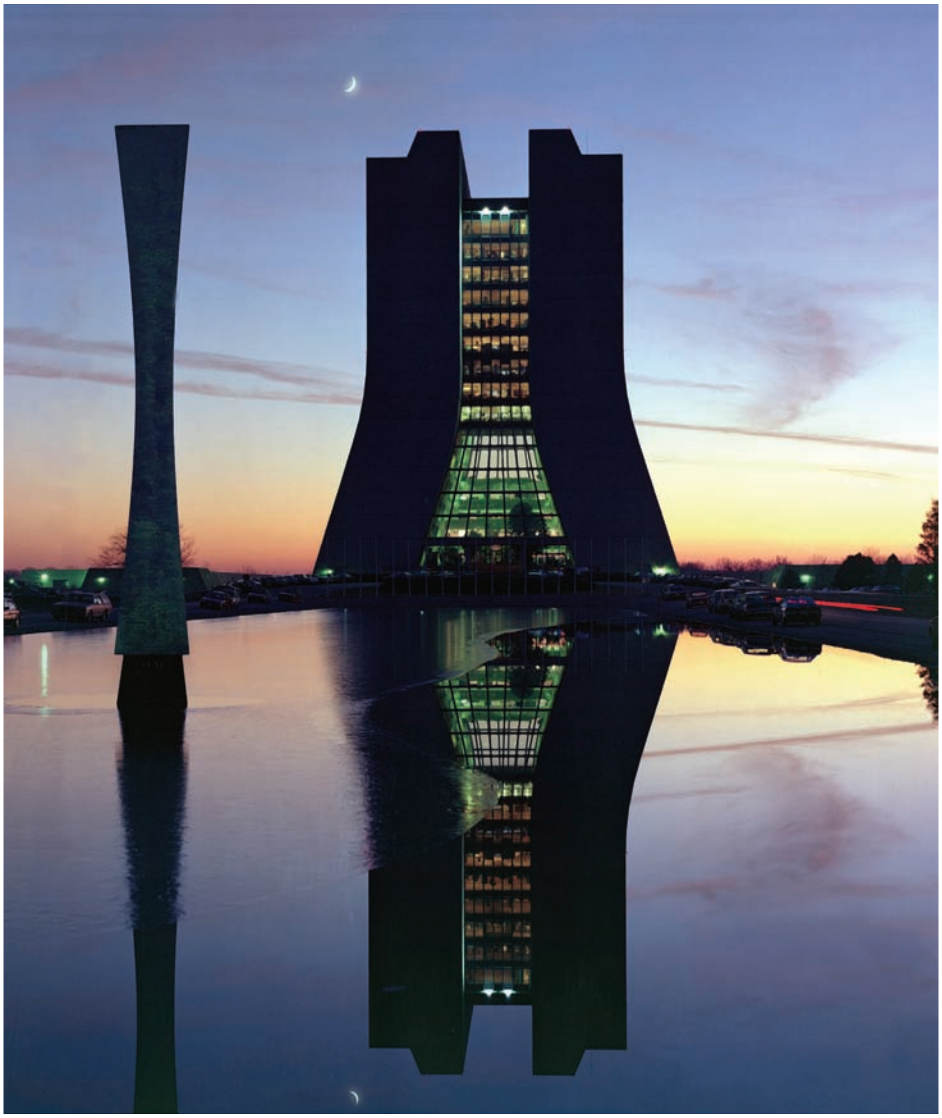
BROOKHAVEN NATIONAL LABORATORY
Upton, New York

Established in 1947, Brookhaven National Laboratory is a Department of Energy, Office of Science multidisciplinary laboratory managed by Brookhaven Science Associates, a company founded by Battelle and Stony Brook University. Home to six Nobel Prizes, Brookhaven conducts research in the physical, biomedical, and environmental sciences, as well as in energy technologies and national security.

Located on a 5,300-acre site on eastern Long Island, New York, Brookhaven builds and operates major scientific facilities available to university, industry and government researchers. Among those facilities are the world's newest accelerator for nuclear physics research, the Relativistic Heavy Ion Collider (RHIC), and the National Synchrotron Light Source (pictured here) where approximately 2,500 researchers use beams of light, from x-rays to ultraviolet and infrared, to study materials as diverse as computer chips and proteins. In the near future, the Center for Functional Nanomaterials will be built at Brookhaven, one of five Department of Energy centers where researchers will study materials on the scale of a billionth of a meter, or only a few atoms.

A wide variety of both basic and applied research is conducted at Brookhaven. For instance, scientists are investigating the building blocks of matter using RHIC, the roots of drug addiction and brain metabolism using positron emission tomography, the effects of space radiation on astronauts using the newly built NASA Space Radiation Laboratory, and the effects of increased carbon dioxide in ecosystems. Brookhaven researchers also develop new technologies as varied as detectors for national security and oil burners with improved efficiency.

FERMI NATIONAL ACCELERATOR LABORATORY
Batavia, Illinois

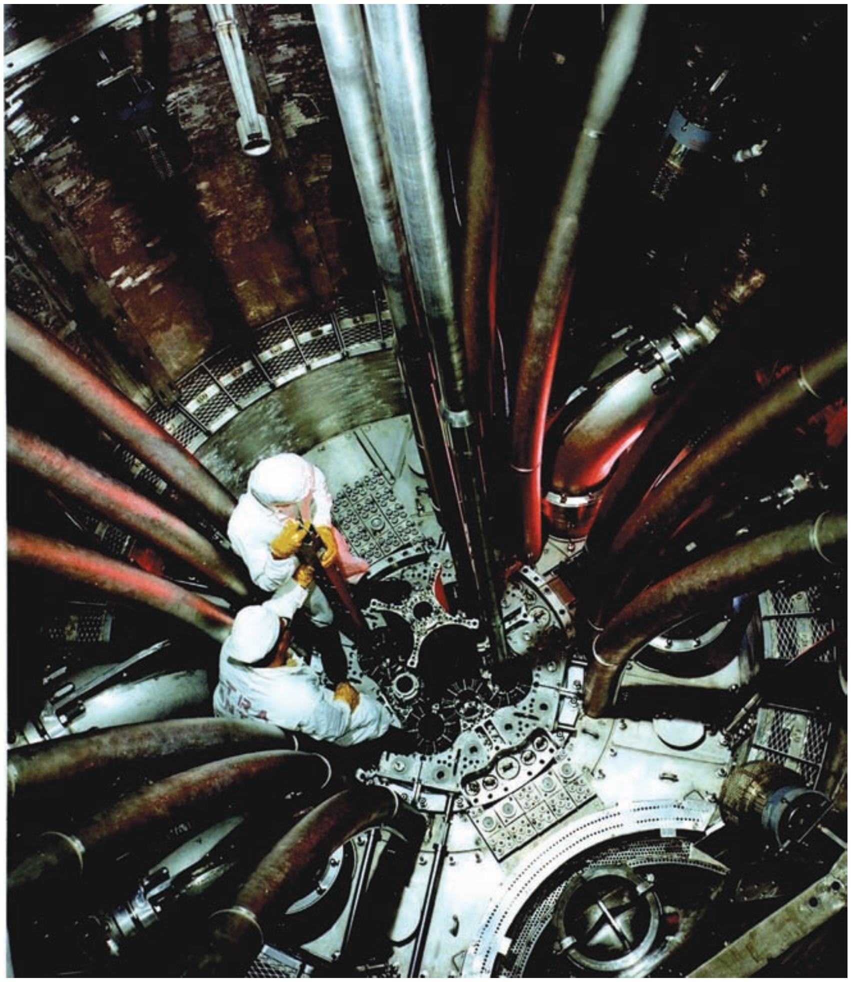


Fermi National Accelerator Laboratory (Fermilab) is one of the world's foremost laboratories dedicated to high-energy physics research. It is operated for the Department of Energy Office of Science by a consortium of 90 research-oriented universities. More than 3,000 scientists from around the world use Fermilab for their experiments.

Fermilab is located on a 6,800-acre site about 35 miles west of Chicago, Illinois. The laboratory is home to the Tevatron Collider, the world's highest-energy particle accelerator. Two large detectors analyze the Tevatron's proton-antiproton collisions to unveil the fundamental forces and particles of the universe. Scientists at Fermilab discovered the bottom quark and the top quark, and first observed the tau neutrino.

Fermilab operates the world's most powerful proton beam for creating neutrinos. The Center for Particle Astrophysics at Fermilab includes groups studying cosmic rays, supernovae, dark energy and other phenomena.

IDAHO NATIONAL LABORATORY
Idaho Falls, Idaho



In operation since 1949, The Idaho National Laboratory (INL) is a science-based, applied engineering National Laboratory dedicated to supporting the U.S. Department of Energy's missions in nuclear and energy research, science, and national defense.

INL stands out as a unique national and international resource. Notably, the Lab has been formally designated as the nation's command center for advanced civilian nuclear technology research and development, and is home to the unparalleled Critical Infrastructure Test Range, with assets as diverse as an isolable electric grid and wireless test bed. Leveraging these and numerous other distinguishing features, the Lab and its more than 3,300 scientists, engineers and support personnel build on the potential and promise of the theoretical for the benefit of the real world.

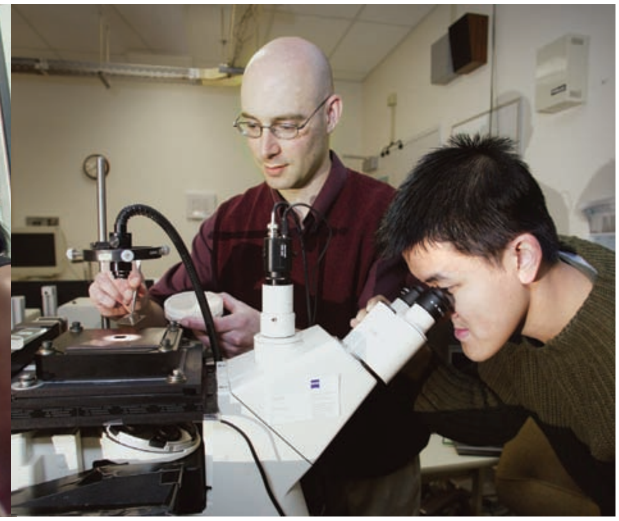
Located in southeast Idaho, INL covers 890 square miles of the Snake River Plain between Idaho Falls and Arco, Idaho. Offices and laboratories are also in the city of Idaho Falls (population 50,000), located about two hours from Grand Teton and Yellowstone national parks and other areas offering prime recreational opportunities.

LAWRENCE BERKELEY NATIONAL LABORATORY
Berkeley, California

Lawrence Berkeley National Laboratory's research and development includes new energy technologies and environmental solutions with a focus on energy efficiency, electric reliability, carbon management and global climate change, and fusion. Frontier research experiences exist in nanoscience, genomics and cancer research, advanced computing, and observing matter and energy at the most fundamental level in the universe.

Ernest Orlando Lawrence founded the Berkeley Lab in 1931. Lawrence is most commonly known for his invention of the cyclotron, which led to a Golden Age of particle physics—the foundation of modern nuclear science—and revolutionary discoveries about the nature of the universe. Berkeley Lab's Advanced Light Source is its premier national user facility centrally located on the lab site overlooking the San Francisco Bay.

LAWRENCE LIVERMORE NATIONAL LABORATORY
Livermore, California



Lawrence Livermore National Laboratory (LLNL) is a premier applied science laboratory that is part of the National Nuclear Security Administration (NNSA) within the Department of Energy. With more than 8,000 employees, LLNL is located on a one-square-mile site in Livermore, California. A larger (10 square miles) remote explosives testing site (Site 300) is situated 18 miles to the east.

LLNL is managed by the University of California (UC) for the National Nuclear Security Administration. Being part of the University helps foster intellectual innovation and scientific excellence. This University connection allows LLNL to recruit and retain a diverse world-class workforce and partner with the UC's extensive research and academic community. These factors are essential to sustaining the laboratory's scientific and technical excellence.

Lawrence Livermore National Laboratory is a national security laboratory with responsibility for ensuring that the nation's nuclear weapons remain safe, secure, and reliable. LLNL also applies its special expertise and multidisciplinary capabilities to prevent the spread and use of nuclear and other weapons of mass destruction and strengthen homeland security.

The Lab has pioneered the application of many technologies, from high-performance computers to advanced lasers, to meet national security needs. Today, the special capabilities developed for our stockpile stewardship and nonproliferation activities enable us to also meet enduring national needs in conventional defense, energy, environment, biosciences, and basic science. Research programs in these areas enhance the competencies needed for the Laboratory's national security mission.

LOS ALAMOS NATIONAL LABORATORY
Los Alamos, New Mexico

The Los Alamos National Laboratory (LANL), located in the Jemez Mountains of northern New Mexico, offers the opportunity for students to work at a multi-disciplinary, world-class research facility while enjoying a truly unique environment. Long known for its artistic community, northern New Mexico also offers a variety of exciting outdoor recreational opportunities, including rock climbing and hiking in the adjacent mountains and canyons, proximity to the Rocky Mountains, and exceptional skiing opportunities at many nearby locations.

We offer a diverse research experience for undergraduate and graduate students as a means of assuring the continued vibrancy of the science, engineering, and technology at the laboratory. Serve your internship with us and you will have the opportunity to work in a team environment with some of the world's top scientists and engineers on critical issues involving our national security, environment, infrastructure, and security. We offer internship opportunities in areas that include: Biology, Chemistry, Computer Science, Physics, Mathematics, Materials Science, Environmental Science, and Engineering: Chemical, Civil, Computer, Electrical, Mechanical, Nuclear, and Software.

If you are a problem solver and independent thinker, a team player, a good communicator, like a hands-on approach, and are self-motivated, we offer you the challenge of an internship at Los Alamos National Laboratory.

NATIONAL RENEWABLE ENERGY LABORATORY
Golden, Colorado

The National Renewable Energy Laboratory (NREL) is the Department of Energy's primary National Laboratory for renewable energy and energy efficiency research and development. From harvesting energy from the sun and wind, to advancing automotive systems, to developing biodegradable plastics form corn stalks, NREL develops renewable energy and energy efficiency technologies and practices, advances related science and engineering, and transfers knowledge and innovations to address the nation's energy and environmental goals. NREL is home to three nationals centers of excellence: the National Center for Photovoltaics, the National Bioenergy Center and the National Wind Technology Center.

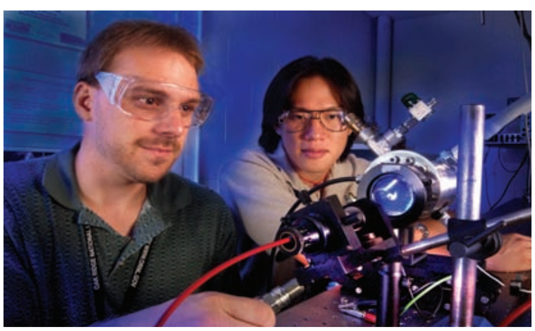
NREL research has been recognized with 39 R&D 100 Awards, ranking first among National Laboratories per researcher, as well as numerous honors from *R&D*, *Discover*, and *Popular Science* magazines and leading scientific organizations.

Innovative, challenging and dynamic—that's our culture. If you are interested in a research internship with an institution that believes creativity and individual uniqueness are at the core of our success, then explore your options at: www.nrel.gov. We value intern talent that adds to the rich pool of research findings produced by NREL each year. Intern accomplishments include:

- More than 24 students have been selected by the Office of Science to present major NREL research at the AAAS.
- More than 50 past student interns have been hired on to join the NREL family.
- Teacher researchers have produced over 50 renewable energy lessons for the classroom.
- NREL's Office of Education partners with over 75 universities throughout the nation.

NREL's main 327-acre site is in Golden, Colorado, just west of Denver. The Laboratory also operates the National Wind Technology Center on 307 acres about 20 miles north of Golden, adjacent to the Department of Energy's Rocky Flats Environmental Test Site. We are an equal opportunity employer committed to diversity.

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee



Oak Ridge National Laboratory is the Department of Energy's largest science and energy laboratory. Managed since April 2000 by a partnership of the University of Tennessee (UT) and Battelle, ORNL was established in 1943 as a part of the secret Manhattan Project to pioneer a method for producing and separating plutonium. More than 60 years later, ORNL's mission is to conduct basic and applied research that provides innovative solutions to complex problems.

ORNL, with funding that exceeds $1 billion, has a staff of more than 4,000 and approximately 3,000 guest researchers who spend two weeks or longer each year in Oak Ridge. The Laboratory's six major scientific competencies, in support of DOE's Office of Science, include neutron science, energy, high performance computing, complex biological systems, advanced materials and national security.

ORNL is in the final stages of a $300 million project to provide a modern campus for the next generation of great science. A unique combination of federal, state and private funds is building 13 new facilities. Included in these new facilities will be the Functional Genomics Center, the Center for Nanophase Materials Science, the Advanced Microscopy Laboratory, and the joint institutes for Computational Science, Biological Science and Neutron Science. ORNL is the site of the Office of Science's National Leadership Computing Facility for unclassified high-performance computing. On budget and on schedule for completion in 2006, the $1.4 billion Spallation Neutron Source will make Oak Ridge the world's foremost center for neutron science research.

UT-Battelle has provided more than $6 million in support of math and science education, economic development and other projects in the greater Oak Ridge region.

PACIFIC NORTHWEST NATIONAL LABORATORY
Richland, Washington

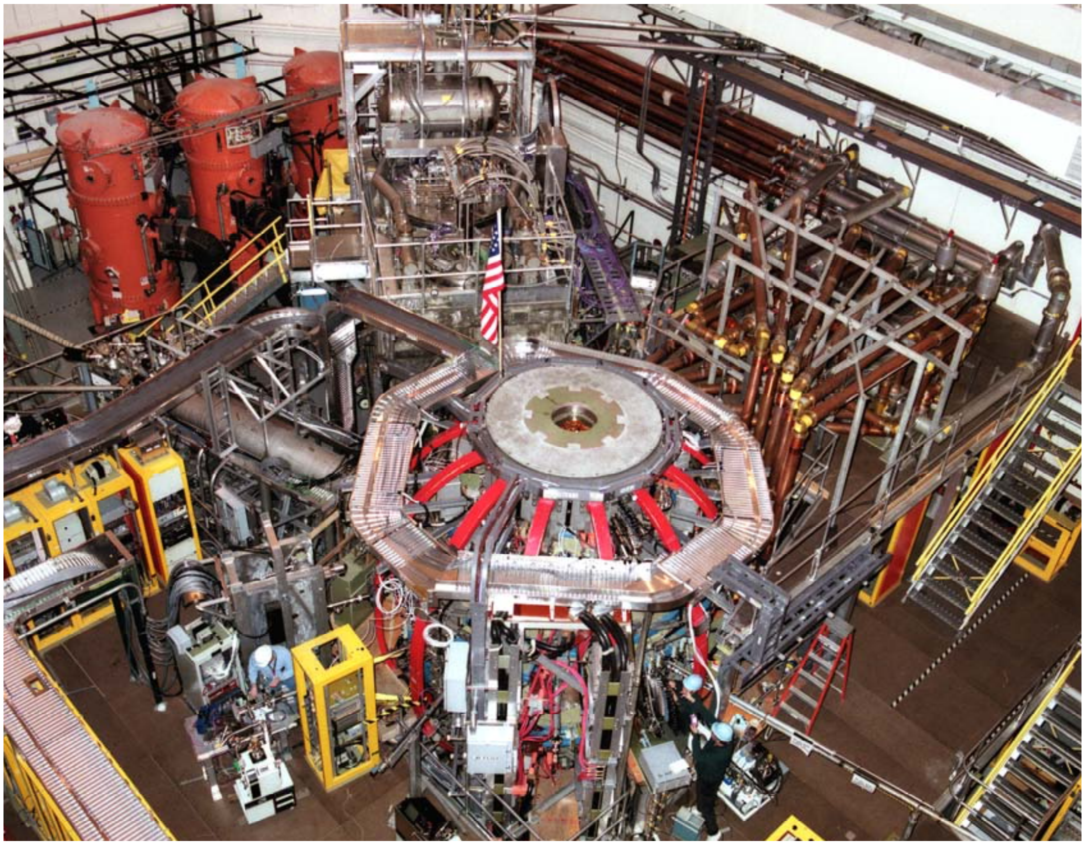
Pacific Northwest National Laboratory (PNNL) is a multi-purpose National Laboratory dedicated to delivering innovative science-based solutions to some of the nation's most pressing problems. PNNL conducts fundamental and applied research to address important issues including securing our homeland, reducing our dependence on foreign oil, transforming the energy system, making information access easier, and protecting our natural resources.

PNNL's facilities form a world-class campus, including many laboratories recognized as best-in-class for many research areas. With an international reputation for studies in chemistry, biology, computer sciences, and a wide range of other fields, award-winning PNNL researchers rapidly translate theory into concrete solutions. Many of the Laboratory's technologies have been developed into common consumer and industrial products including the compact disc (CD).

The Laboratory consistently attracts some of the world's leading scientific talents shaping the future of science through a variety of on-site educational programs. As mentors and research partners, the Laboratory's staff trains young scientists and engineers to become tomorrow's inventors. Student research opportunities at PNNL include appointments in atmospheric science and global change, computational sciences, experimental chemistry, marine sciences, molecular biology, environmental studies, remediation, environmental microbiology, wildlife and fisheries biology, materials research, process science and engineering, economics and political science.

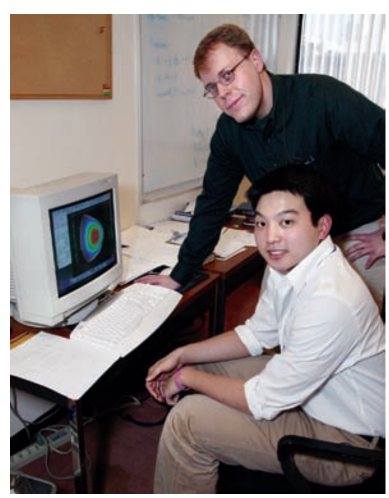
Located in southeastern Washington near the base of the Blue Mountains and the confluence of the Columbia, Snake and Yakima rivers, PNNL staff enjoy year around recreation, locally-produced fine wines, and the community's commitment to the arts.

PRINCETON PLASMA PHYSICS LABORATORY
Princeton, New Jersey



The world's reliance on fossil fuels is imperiling our environment. Fusion, the energy source of the sun and the stars, offers an inexhaustible alternative. A fusion-powered electric generator would not produce hydrocarbon emissions, greenhouse gases, or long-lived radioactive waste; nor would it emit chemicals that cause acid rain. Consequently, the U.S. Department of Energy (DOE) Office of Science has made the development of commercial fusion power one of its highest priorities.

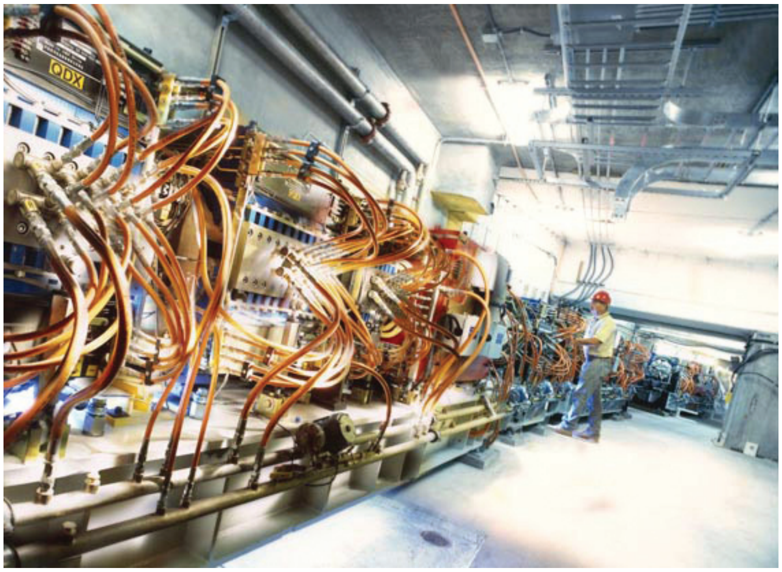
DOE's Princeton Plasma Physics Laboratory (PPPL) is one of the world's leading facilities for fusion R&D.



Currently the PPPL is operating the National Spherical Torus Experiment (pictured above) and is building the National Compact Stellarator Experiment, both use magnetic fields to confine hot ionized gas (plasma) that serves as the fusion fuel. PPPL's theoretical physicists are developing computational physics models that can predict how various plasma configurations will perform, saving time and money.

PPPL experimental physicists collaborate with their colleagues worldwide in a free, mutually beneficial, exchange of information. Princeton researchers and engineers are using knowledge and skills gained in fusion research to solve other problems, including the development of plasma-based propulsion systems for space vehicles, studies of plasma phenomena that occur in the sun's corona and the earth's magnetosphere, and research on plasma sterilization of plastic food and beverage containers. PPPL is located about three miles from Princeton University's main campus in Princeton, NJ.

STANFORD LINEAR ACCELERATOR CENTER
Menlo Park, California



The Stanford Linear Accelerator Center (SLAC) is one of the world's leading laboratories for research in high-energy physics (HEP), particle astrophysics and cosmology, and synchrotron radiation research.

SLAC's HEP program seeks answers to fundamental questions about the ultimate structure of matter and the forces between these fundamental particles. The BABAR experiment investigates matter/anti-matter asymmetry and is the current focus of the HEP program. In addition, a vigorous R&D program is focused on realizing the next generation electron collider—the International Linear Collider, as part of a world-wide effort.

The Kavli Institute at SLAC for Particle Astrophysics and Cosmology bridges theoretical and experimental physics communities, and brings their combined strengths to bear on some of the most challenging and fascinating problems in particle astrophysics and cosmology to help us understand the birth and evolution of the universe.

The Stanford Synchrotron Radiation Laboratory (SSRL) at SLAC, provides high intensity x-ray beams for molecular and atomic scale studies in physics, biology, chemistry, medicine, and environmental science. The Linac Coherent Light Source (LCLS), a facility to provide even more intense x-ray capability is now under construction. Pioneering experiments at LCLS will advance our understanding of everything from the hidden physics inside planets, to how proteins function as the engines of life, to building nanotechnology devices for the backbone of future industry and technology.

THOMAS JEFFERSON NATIONAL ACCELERATOR FACILITY
Newport News, Virginia

The Thomas Jefferson National Acceleration Facility, or Jefferson Lab, is a nuclear physics research laboratory located in Newport News, Virginia. Nuclear physics research scientists who use Jefferson Lab are on a journey of discovery into the nucleus of the atom. Their goal is to develop a roadmap of matter that helps unlock the secrets of how the universe is put together. Nuclear physics funding from the Department of Energy provides Jefferson Lab with leading-edge instrumentation, world-class facilities and training and support for the people involved in these pursuits. Forefront nuclear physics research conducted at Jefferson Lab provides solid foundations for other fields. The accumulation of new results and the intellectual training of new generations of scientists foster important advances in medicine, chemistry and other sciences.

Scientists at Jefferson Lab use the Continuous Electron Beam Accelerator Facility — the first large-scale application of superconducting radiofrequency technology — to conduct physics experiments. Using accelerated electron beams, experimenters probe the sub-nuclear realm. Using this same technology, Jefferson Lab has built the world's brightest high average power Free Electron Laser that offers unique capabilities for defense, industry, basic research and medicine.