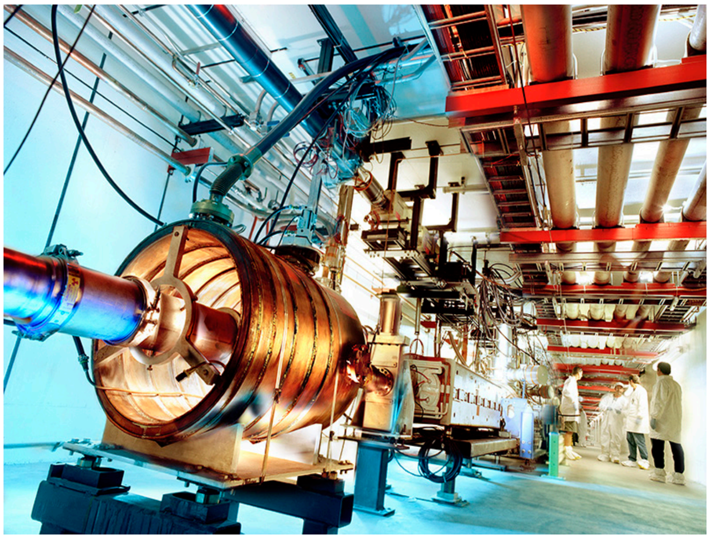
Building Tomorrow's Foundation through Discovery Science

U.S. DEPARTMENT OF ENERGY

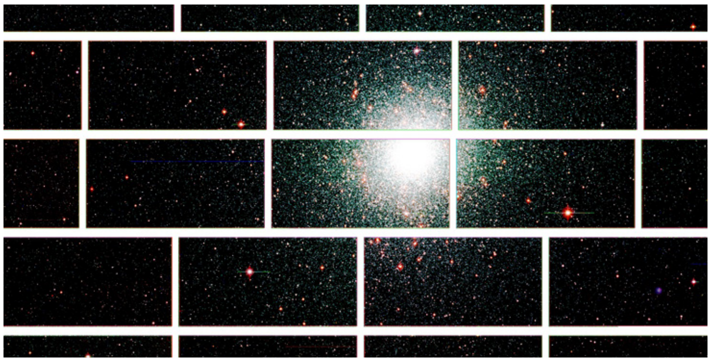
Transformational advances in knowledge and technology come from discovery science. As the nation's largest funder of basic research in the physical sciences, the U.S. Department of Energy (DOE) sponsors discovery science that is advancing human understanding in physics, chemistry, biology, environmental science, and computer science. Each year, DOE's National Laboratory System serves tens of thousands of scientists and engineers from across academia, government, and industry, providing the unique skills, highly specialized equipment, and world-class facilities needed to answer the most fundamental questions in science today. Acting as engines of discovery for the U.S. and global scientific communities, the National Labs play a critical role in sustaining America's leadership in science and innovation, incubating new technologies and industries, and educating the next generation of scientists and engineers.



Main injector particle accelerator: Each year, more than 2,000 scientists use the accelerator complex to carry out experiments to discover and understand the elementary forces and building blocks of the universe.

Understanding the Fundamental Nature of Matter

Dating back to the 1950s, National Lab scientists have made groundbreaking advances in our understanding of the fundamental nature of matter. Subsequent achievements, from the successful search for the elusive Higgs boson particle to the observation of entirely new states of matter – such as a quark-gluon plasma – have changed our view of how the material world works and unlocked a host of new technologies with applications in industry and medicine.



Zoomed-in image taken by the Dark Energy Camera of the center of the globular star cluster 47 Tucanae, which lies about 17,000 light years from Earth.

Probing the Far Reaches of the Universe

In 1992, National Lab detectors aboard a NASA satellite revealed the birth of galaxies in the echoes of the Big Bang. The subsequent discovery that the universe is expanding at an accelerating rate revolutionized modern cosmology and physics. Today, researchers at our National Labs are leading the search for "dark energy" and "dark matter"—mysterious, and as-yet-unseen, components that make up 96 percent of the universe and are thought to be driving this acceleration. This work, which includes building the largest digital camera ever constructed so that scientists can measure the universe's expansion and using powerful particle detectors, is key to deepening our understanding of the origins and fate of the cosmos.

From Photosynthesis to Genomics: Unlocking the Mysteries of Life's Most Important Processes

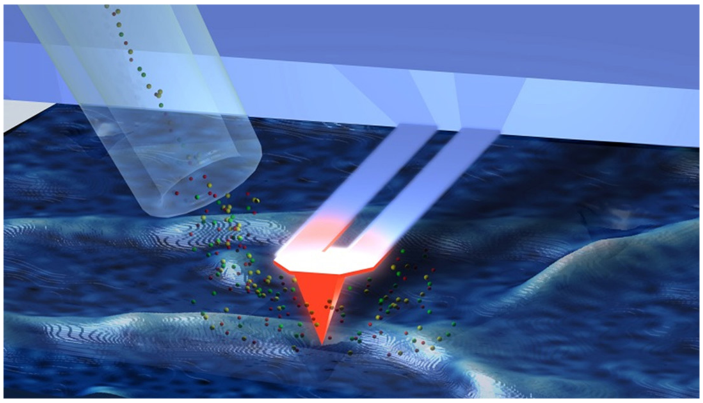
Earlier work by National Lab researchers determined how carbon is converted from an inorganic form (CO_2) into organic compounds through photosynthesis, a scientific milestone that revealed one of the most fundamental mechanisms in nature. More recently, the National Labs collaborated with the National Institutes of Health in a 13-year effort to fully map the human genome. Completed in 2003, the Human Genome Project has been succeeded by DOE's Genomic Science program, which is using microbial and plant genomic data, advanced analytical technologies, and modeling and simulation to develop a

An initial map of the human genome was completed in 2003. The Human Genome Project has been succeeded by DOE's Genomic Science program.

better understanding of how biological systems behave. This understanding is critical to address a range of energy and environmental challenges including bioenergy production, environmental remediation, and climate stabilization. National Lab-led research in the biological sciences will also help U.S. industries adapt to a rapidly changing planet. A current study of rootstock water transport in plants, for example, is aimed at developing sustainable water-use strategies for agricultural producers.

Materials Science and Nanotechnology

Breakthroughs in materials science—many of them pioneered at DOE's National Labs—are at the heart of countless technologies that have become indispensable to modern life. As part of DOE's Materials Genome Initiative, scientists are using supercomputers and other highly specialized tools to greatly accelerate the search for new materials with transformative promise in a host of applications. At the same time, scientists are also learning how to build specialized materials literally from the atom up. At DOE's Nanoscale Science Research Centers, interdisciplinary research is underway that could revolutionize fields ranging from energy to medicine. For example, nanoscale particles with specialized coatings that selectively attach to tumors could lead to more effective cancer treatments, while the ability to understand how materials degrade at the molecular level could open the door to better batteries and fuel cells.



A DOE National Laboratory technology that allows for simultaneous chemical and physical characterization could lead to advances in materials and drug development. The technique, a combination of atomic force microscopy and mass spectrometry, streamlines analytical processes vital to science and industry.

Designing, Building, and Operating the Essential Tools of Scientific Discovery

Many of the highly sophisticated instruments and tools in use at DOE's 30 national Scientific User Facilities have found spin-off applications in industry and medicine, where they are helping American companies bring new products to market and stay ahead in a globally competitive marketplace. For example:

- Particle accelerators built and operated by the National Labs were crucial to fundamental advances in particle physics. Today, these machines are also widely used in semiconductor manufacturing, brain imaging and cancer treatment, and to determine the structural integrity of materials in a range of industrial applications.
- X-ray light sources are so bright and focused that they allow scientists to "see" structures at the atomic and molecular level and even take "snapshots" of chemical reactions in real time. Pioneered at the National Labs, x-ray is now the premier tool for studying matter at the atomic and molecular scales, and is being used to create new materials, develop more effective batteries, and find new cures for disease.
- Neutron scattering facilities are used to study the fundamental properties and dynamics of physical and biological materials. The National Lab System includes the world's most powerful pulsed neutron scattering facility, providing capabilities that are essential to the development of cutting-edge energy technologies, from better methods of detecting natural gas for hydraulic fracturing to the ability to produce higher-power, longer-lasting batteries and more reliable components for advanced diesel engines.
- DOE's five Nanoscale Science Research Centers (NSRCs) are state-of-the-art User Facilities that offer access to advanced capabilities, tools, and expertise for design, synthesis, processing, fabrication, analysis and characterization, and theory and modeling of nanoscale materials. Most of the NSRCs are housed within complementary National Lab Scientific User Facilities for X-ray, neutron, and electron-beam scattering. Access to these centers is available to researchers at no cost for nonproprietary work through an external peer merit review process.

For more information about our National Laboratory System:

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