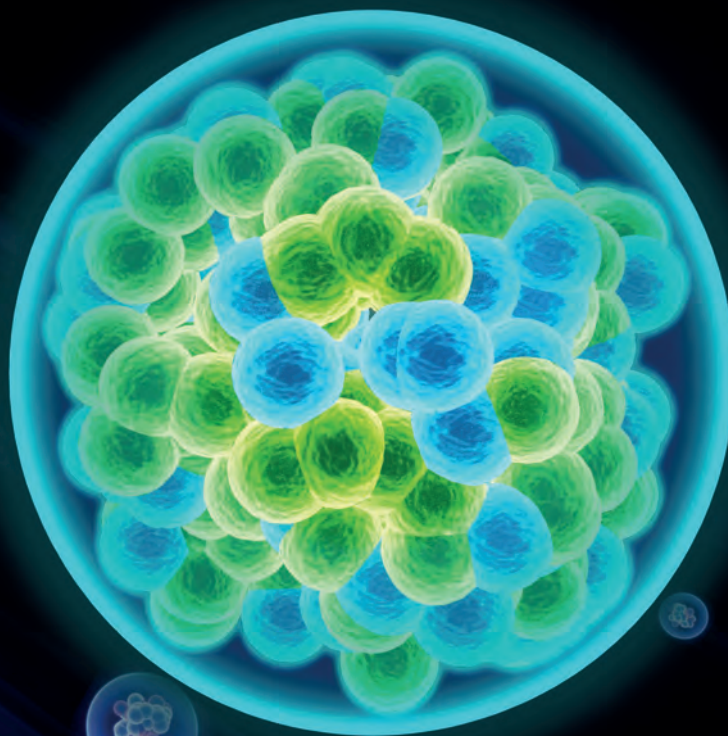




Lawrence Livermore
National Laboratory

retrospective | prospective

Past innovations inspiring future discoveries



Operated by Lawrence Livermore National Security, LLC,
for the U.S. Department of Energy's National Nuclear Security Administration

A VISION FOR THE LABORATORY

In October 2007, Lawrence Livermore National Security (LLNS), LLC assumed management and operation of Lawrence Livermore National Laboratory (LLNL), and the new management team articulated an ambitious vision: LLNL would serve the nation as a broad national security laboratory, embodying excellence in science and technology with an outstanding workforce and cost-effective, safe, and secure operations. Challenging goals were set to put action behind this vision—strong mission delivery, exceptional science and technology, leadership in transforming the National Nuclear Security Administration (NNSA) complex, and enhanced business and operational performance.

The achievements since 2007 are inspiring. Individual researchers and multidisciplinary teams have made vital contributions to ensuring the safety and security of the nation's nuclear deterrent and to preventing nuclear terrorism and proliferation. They have advanced the state of the art in high-performance computing and laser science and addressed critical issues in bio-, environmental, and energy security. They also have made high priorities of sustainability, environmental stewardship, best business practices, workforce development, and oversight transparency.

These accomplishments and many others have laid the foundation for even more exciting and significant achievements in the future.

STRONG MISSION DELIVERY

LLNL anticipates national needs and develops innovative solutions to meet critical challenges to U.S. and global security.

Accomplishments Remarkable progress has been made in all mission areas since 2007. Researchers used state-of-the-art computer modeling and experiments at the National Ignition Facility (NIF) to resolve a key weapons performance issue that for years drove the need for nuclear testing. The decade-long process to extend the lifetime of the W78 warhead began in 2011. NIF commenced operations in 2009 and has produced a stream of extraordinary scientific results for stockpile science and the National Ignition Campaign.

Laboratory leadership in high-performance computing continued with the 500-teraFLOP/s Dawn machine (delivered in 2009) and the 20-petaFLOP/s Sequoia supercomputer (delivered in 2012). LLNL provided advanced capabilities to the U.S. military, including a very-low-collateral-damage conventional weapon, and developed innovative detection systems that are helping protect national borders and combat terrorism. Other advances, such as a retinal prosthesis and catalysts for carbon capture, leveraged capabilities in biology, materials science, nanoengineering, and numerical simulation.

Future The Sequoia supercomputer will enable a new level of detail and complexity in modeling such phenomena as nuclear weapon performance and nuclear fusion. With its 192 laser beams, NIF will create the immense temperatures and energy densities required to attain fusion ignition and burn—monumental steps in the quest to harness the power of the stars and secure the planet's energy future.

EXCEPTIONAL SCIENCE, ENGINEERING & TECHNOLOGY

LLNL provides the nation with sustained excellence in science, engineering, and technology.

Accomplishments Science holds the key to solving many of the most serious challenges facing the country—deterring threats to national security, providing energy for the future, mitigating climate change, understanding the cosmos, curing disease, and even unlocking the secrets of life. Since 2007, Laboratory researchers have made scientific discoveries and technological advances in all of these mission areas.

Many LLNL breakthroughs have their origins in research supported by the Laboratory Directed Research and Development (LDRD) program. This program is LLNL's primary means for enabling the investigation of high-risk, potentially high-payoff concepts and, as such, is central to the Laboratory's ability to encourage creativity and innovation and to attract and engage top researchers. From 2008 through 2011, \$362 million in LDRD funding supported a total of 632 projects.

Future With its exceptional workforce and world-class facilities, LLNL is primed to achieve additional scientific and technological breakthroughs. The new Livermore Valley Open Campus (LVOC) will facilitate expanded partnership with industry and universities and help create a vibrant innovation hub with the Laboratory at its center.

LEADERSHIP IN NNSA COMPLEX INTEGRATION

Through cooperative projects, leadership in providing strategic direction, and changes at the Livermore site, LLNL is helping to make the NNSA complex more productive and cost-efficient.

Accomplishments The Laboratory has taken major steps to decrease its footprint and reduce its costs. More than 850,000 square feet of underutilized space has been eliminated. More than 90% of LLNL's highest security level nuclear material has been consolidated at other NNSA sites, and the entire deinventory will be completed in 2012.

Working with the NNSA production plants, LLNL developed new systems and technologies to improve the safety and efficiency of warhead surveillance and dismantlement. Laboratory staff also provided valuable technical support for the 2010 Nuclear Posture Review and the New START arms reduction agreement.

The joint Boards of Governors that manage the Lawrence Livermore and Los Alamos national laboratories have made it possible to achieve business efficiencies by aligning procedures and practices—for example, by sharing management of employee benefits. LLNL and Sandia-California also are sharing some routine functions to cut costs.

Future The W78 Life Extension Program (LEP) will increase the safety and reliability of the enduring nuclear stockpile and with the Sequoia supercomputer, it will be possible for the first time to include a quantitative understanding of performance margins in an LEP. NIF will continue to be a cornerstone capability for stockpile stewardship, energy research, and scientific discovery.

ENHANCED BUSINESS & OPERATIONS

Effective management, efficient business practices, and safe, secure, and environmentally responsible operations provide the essential foundation for the Laboratory's mission activities.

Accomplishments LLNL has made notable improvements in its business practices, assurance systems, and operations. A new performance-based financial and project management system was implemented. Security and emergency response preparedness were strengthened. The Laboratory's safety and environmental management systems were enhanced to meet international standards. Industry-leading work control practices were put in place, and a Contractor Assurance System was implemented to provide transparency to allow NNSA to streamline oversight. These systems enable LLNL to ensure that programmatic goals are being met, that employees, the public and the environment are protected, that Laboratory materials, property and information are secure, and that operations, facilities and business systems are efficient and effective.

In addition, partner organizations have conducted more than 80 reviews of LLNL operations, providing validation of existing practices and new ideas for continuous improvement. As a result of process improvement efforts across the Laboratory, LLNL has achieved a cumulative cost savings and cost avoidance of nearly \$300 million since 2007.

Future Continuous efforts are under way to identify opportunities for additional business and operational efficiencies at LLNL and demonstrate the Laboratory's responsible stewardship of the resources entrusted to it.

4 YEARS IN Review

"When you bring one of us to the table, you bring all of us to the table."

—Rob Allen, LLNL Computer Scientist

'08

Guarding Against Nuclear Proliferation

LLNL develops new technologies to locate and identify nuclear materials and devices, including an **antineutrino detector** that can be used to monitor plutonium production in a nuclear reactor.



Rightsizing the Nuclear Weapons Complex

The Laboratory begins consolidating nuclear material at other NNSA sites and eliminating more than 850,000 square feet of underutilized space, thereby **saving roughly \$20 million** per year.

Discovering a New Solar System

LLNL scientists are part of a large international team that captures the **first direct images** of a new solar system, located some 5000 light-years from Earth, with scaled-down versions of Jupiter and Saturn.

Understanding Climate Change

LLNL researchers make **major contributions** to the reports of the Intergovernmental Panel on Climate Change, which, together with former Vice President Al Gore, wins a Nobel Peace Prize.

Revealing a Comet's Secrets

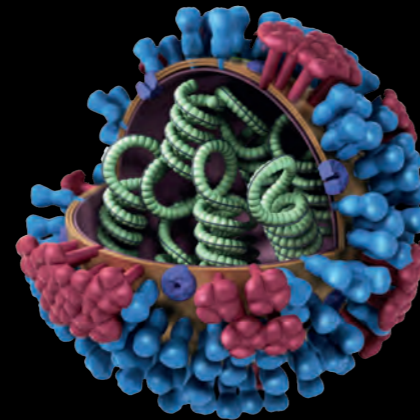
Contradicting scientists' expectations, analyses at LLNL reveal that the Wild 2 comet samples, returned to Earth in 2006 by the Stardust mission, have a composition **more like an asteroid** than a comet.



'09

Scientific Discoveries with NIF

The National Ignition Facility (NIF) begins operations. NIF experiments demonstrate **multiple "firsts"** in laser energy, x-ray drive, implosion symmetry, and other conditions necessary to achieve fusion ignition and energy gain in the laboratory.



Decoding a New Viral Threat

Laboratory researchers discover that the genes of the **H1N1 influenza virus** are considerably different, and less virulent, than those responsible for past deadly flu epidemics, helping to allay fears about this new strain.

Strategic S&T Investment

A **five-year roadmap** is developed to guide LLNL science and technology investments. The roadmap identifies strategic mission thrust areas, associated breakthrough goals, and foundational S&T pillars necessary to achieve those breakthroughs.

Detecting Underground Explosions

LLNL seismologists develop a new location method for the national Nuclear Detonation Detection Program. They use this method and other capabilities to characterize the May 2009 **nuclear test by North Korea**, locating the event roughly 2.8 km northwest from that country's 2006 test.

'10

Resolving a Nuclear Weapons Anomaly

LLNL resolves a long-standing anomaly about nuclear weapons performance that was one of the main drivers for nuclear testing. Recognized with a prestigious **E.O. Lawrence Award**, the work entails state-of-the-art experiments and modeling, including key tests at NIF.

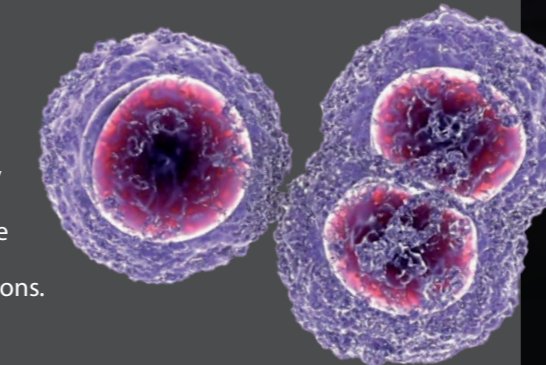


Supporting U.S. Policy Makers

Laboratory scientists and engineers provide valuable technical expertise that helps inform the 2010 **Nuclear Posture Review** and the **New START** arms reduction agreement.

Attacking Antibiotic-Resistant Bacteria

Researchers discover a way to use a bacterium's genes against itself, potentially **solving the problem** of antibiotic resistance. Testing is under way to evaluate the technique's potential for biodefense and public health applications.



Courtesy of U.S. Coast Guard

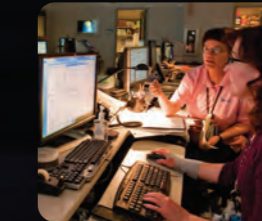
Responding to the Gulf Oil Spill

Scores of Livermore scientists and engineers help respond to the Deepwater Horizon oil rig disaster. They apply **LLNL capabilities** in fluid mechanics, diagnostic instrumentation, and signal and image processing to estimate the flow rate of gushing oil and assess well integrity and the condition of the blowout preventer.

'11

Sustaining the U.S. Nuclear Deterrent

LLNL and the U.S. Air Force begin the **Life Extension Program** for the W78 Minuteman III warhead. This decade-long effort will enable the system to remain in the stockpile for an additional 30 years.



Responding to Fukushima

LLNL provides critical support to U.S. and Japanese agencies responding to the Fukushima nuclear reactor disaster. For weeks, scientists at the **National Atmospheric Release Advisory Center** generate a constantly updated stream of plume projections and radiation dose estimates.

Detecting Cyber Intruders

Using LLNL's supercomputers, researchers devise a way to monitor for and **identify suspicious cyber behavior**, similar to the way antivirus software searches for suspicious content.

Demonstrating Near-Real-Time PCR

Laboratory researchers develop a new polymerase chain reaction (PCR) device that can achieve billion-fold amplification of DNA **in less than 3 minutes**, an advance that could soon make it possible to identify infectious diseases in the space of a doctor's office visit.



Promoting Partnerships

LLNL and Sandia-California open the Livermore Valley Open Campus (LVOC) to provide **expanded opportunities** for partnerships with universities and industry. The Laboratory also opens the High-Performance Computing Innovation Center at LVOC.

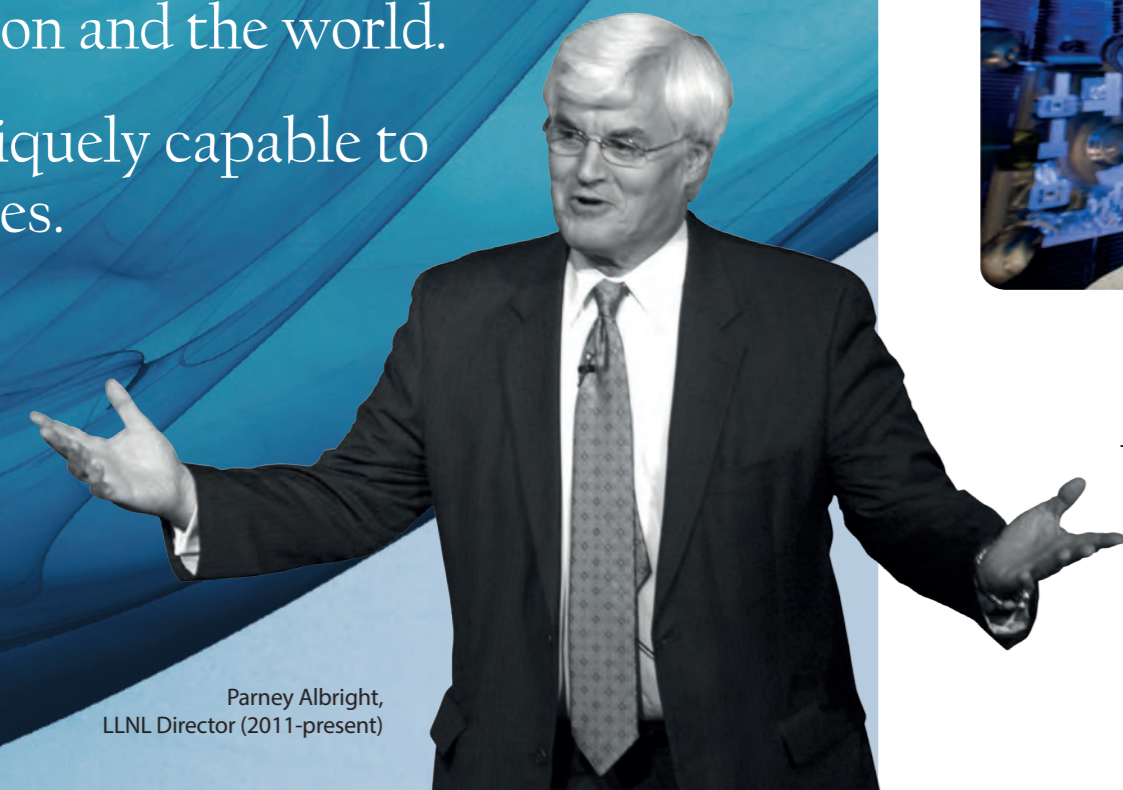
George Miller, LLNL Director (2005-2011)



MOVING Forward

The characteristics that have defined our laboratory for 60 years—passion for mission, commitment to excellence, and the ability to anticipate, innovate, and solve the really difficult problems—are central to our ability to tackle the daunting security issues that are facing the nation and the world.

We are poised and uniquely capable to take on these challenges.



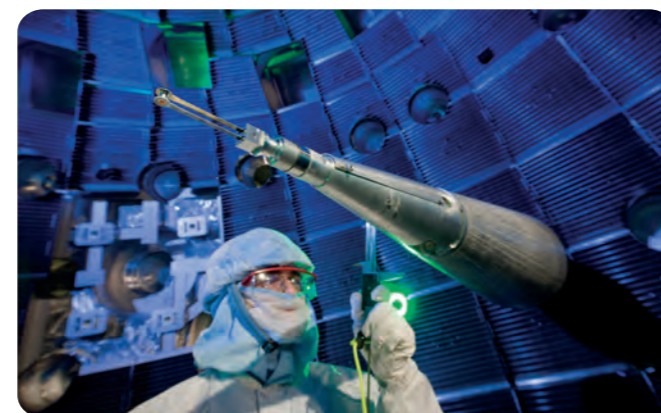
Parney Albright,
LLNL Director (2011-present)

“At Livermore our exceptional multidisciplinary teams and unique tools solve problems that can't be solved anywhere else in the world.” —Parney Albright, LLNL Director

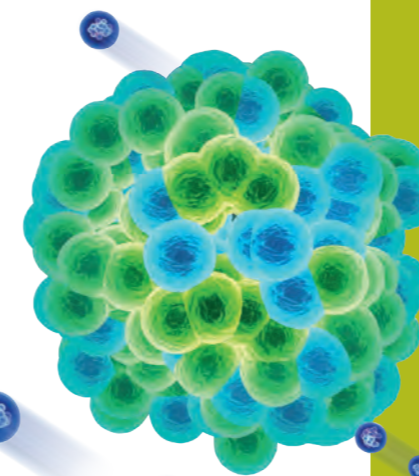
'12

Powering Up Sequoia

Working with IBM, LLNL brings into operation the 20-petaFLOP/s Sequoia machine, which will be a **world leader** in peak speed and power efficiency. The machine will perform high-fidelity 3D simulations to advance the understanding of nuclear weapons science and help maintain the nation's nuclear deterrent.



Breaking 2 Megajoules NIF produces a record-breaking **2.03 megajoules** of energy with all 192 laser beams—over 60 times more than any other laser. Close to 1.9 megajoules of ultraviolet light reaches the target chamber with the precision needed for scientific discovery and fusion experiments.



Adding New Elements to the Periodic Table

The name **Livermorium (Lv)** is formally approved for element 116. Since the late 1990s, a team of researchers from LLNL and the Joint Institute for Nuclear Research in Dubna, Russia, has discovered a total of six superheavy elements (113–118); element 117 was discovered most recently, in 2010.

MISSION, VISION AND Values

Our continuing mission is to strengthen U.S. security through world-class science and technology that enhance the nation's defense and reduce the global threat from terrorism and weapons of mass destruction, and, more broadly, to respond to scientific issues of national importance.

Our vision is for LLNL to lead the nation in stockpile science and innovation, to be the foremost national security laboratory delivering solutions to the most challenging problems, and to be the premier destination for the nation's best scientists and engineers.

A common set of values guides our Laboratory.

We are one Lab, with collective passion and responsibility.

We operate solely in the national interest and are focused on our sponsors' needs.

We are committed to the innovation and excellence that arise from a quality workforce and a diverse, multidisciplinary environment.

We encourage intense competition of ideas, rigor in our internal critiques, and collaboration and professionalism in our interactions.

We meet our commitments and strive to exceed expectations.

We are good stewards of the resources entrusted to us and a good neighbor in our community.

TURNING VISION INTO Reality

We **will deliver** on our stockpile stewardship mission, particularly the W78 Life Extension Program and National Ignition Campaign.

We will **enhance our mission** in the broad national security space.

We will sustain the **cutting-edge science**, engineering, and technology capabilities our sponsors need.

We will ensure **excellence** in mission execution and deliver on schedule and on budget.

We will ensure **excellence** in operations.

We will improve our **cost effectiveness**.

We will provide a **first-class workplace** environment.

We will **expand our contributions** to the local and national economy through university and industry partnerships.





SUSTAINING THE NATIONAL DETERRENT

LLNL's foremost national security responsibility is stewardship of the U.S. nuclear weapons stockpile. The capabilities developed for this mission are also applied to meet important warfighter needs.

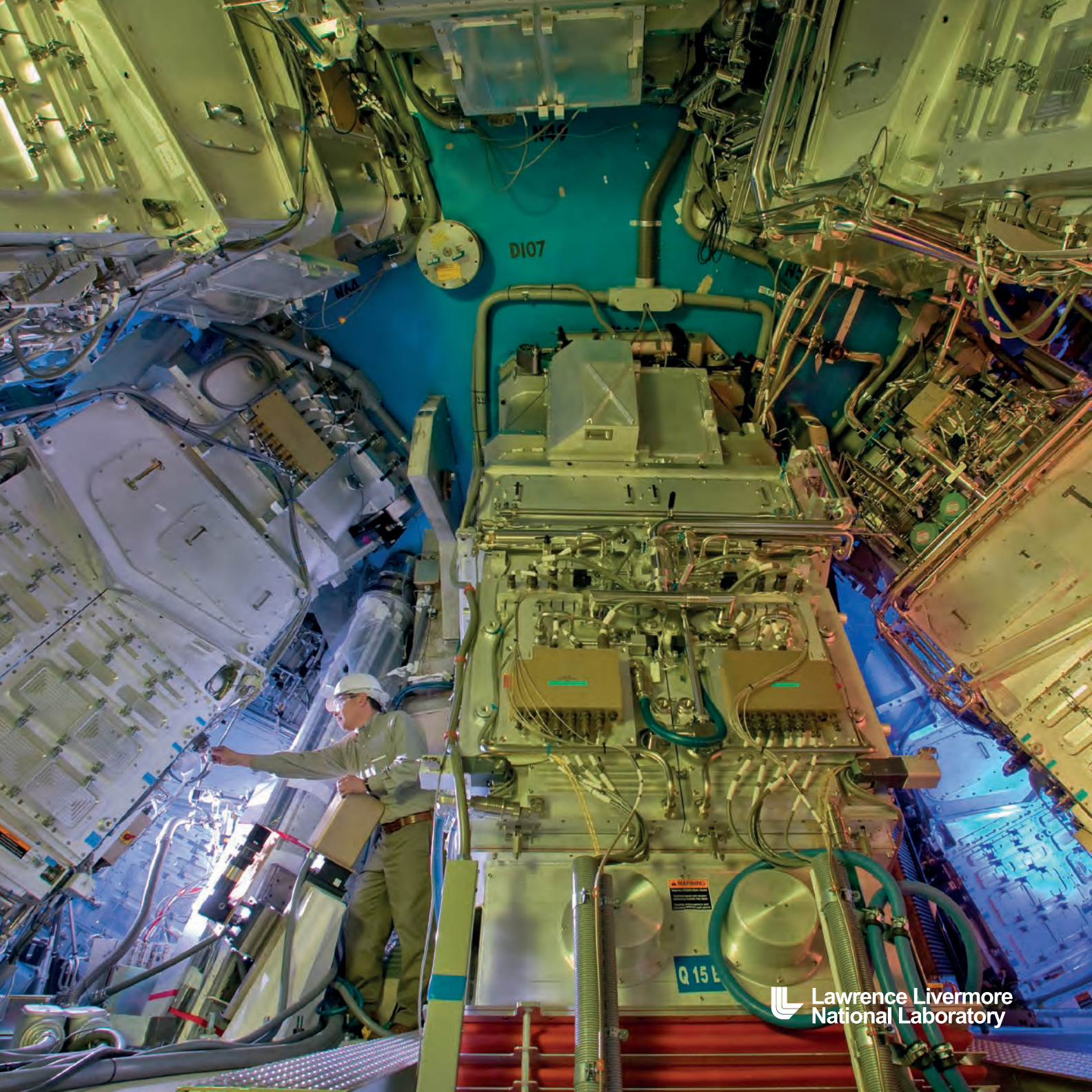
MAINTAINING THE NUCLEAR DETERRENT. The Laboratory's stockpile stewardship activities quantify with confidence the safety, reliability, and performance of U.S. nuclear weapons through a combination of theoretical advances, nonnuclear experiments, supercomputer simulations, stockpile surveillance, and annual assessment. In 2010, Livermore resolved a long-standing anomaly about nuclear weapon performance using state-of-the-art computational modeling and experiments at the National Ignition Facility. When necessary, life-extension programs (LEPs) are approved to prolong the service life of an aging warhead and enhance its safety and security. In 2011, LLNL and the U. S. Air Force began the LEP for the W78 Minuteman III warhead.

SUPPORTING THE WARFIGHTER. Using capabilities developed within the stockpile stewardship program, LLNL researchers have designed very-low-collateral-damage conventional weapons to support the nation's ongoing engagements and to meet future combat needs. Such weapons are particularly suited for military operations in urban terrain, counterinsurgency, and close air support.

NEW APPLICATION FOR WEAPONS CODES. Laboratory researchers combined experiments and computational simulations using LLNL codes for modeling fluid flow and elastic-plastic behavior of materials to better understand traumatic brain injury (TBI) in soldiers. One study revealed that the use of one-size-larger helmets with slightly thicker pads than currently used in the U.S. Army's Advanced Combat Helmet could significantly reduce the severity of TBI from blunt and ballistic impacts.

"We maintain our strength in order to deter and defend against aggression—to preserve freedom and peace." —Ronald Reagan, U.S. President

LLNL capabilities are key to sustaining the U.S. nuclear deterrent and enabling the nation to anticipate and respond to evolving threats.



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BRINGING STAR POWER TO EARTH

Scientists at LLNL and around the world have been striving to achieve self-sustaining nuclear fusion and energy gain in the laboratory for more than half a century. Experiments at the National Ignition Facility (NIF) have brought this goal within reach.



NIF target

By focusing its 192 intense laser beams on a target of hydrogen fuel, NIF can create the conditions needed to achieve fusion in the laboratory. NIF is a national resource and a unique experimental facility for addressing compelling national security, energy, and science missions.

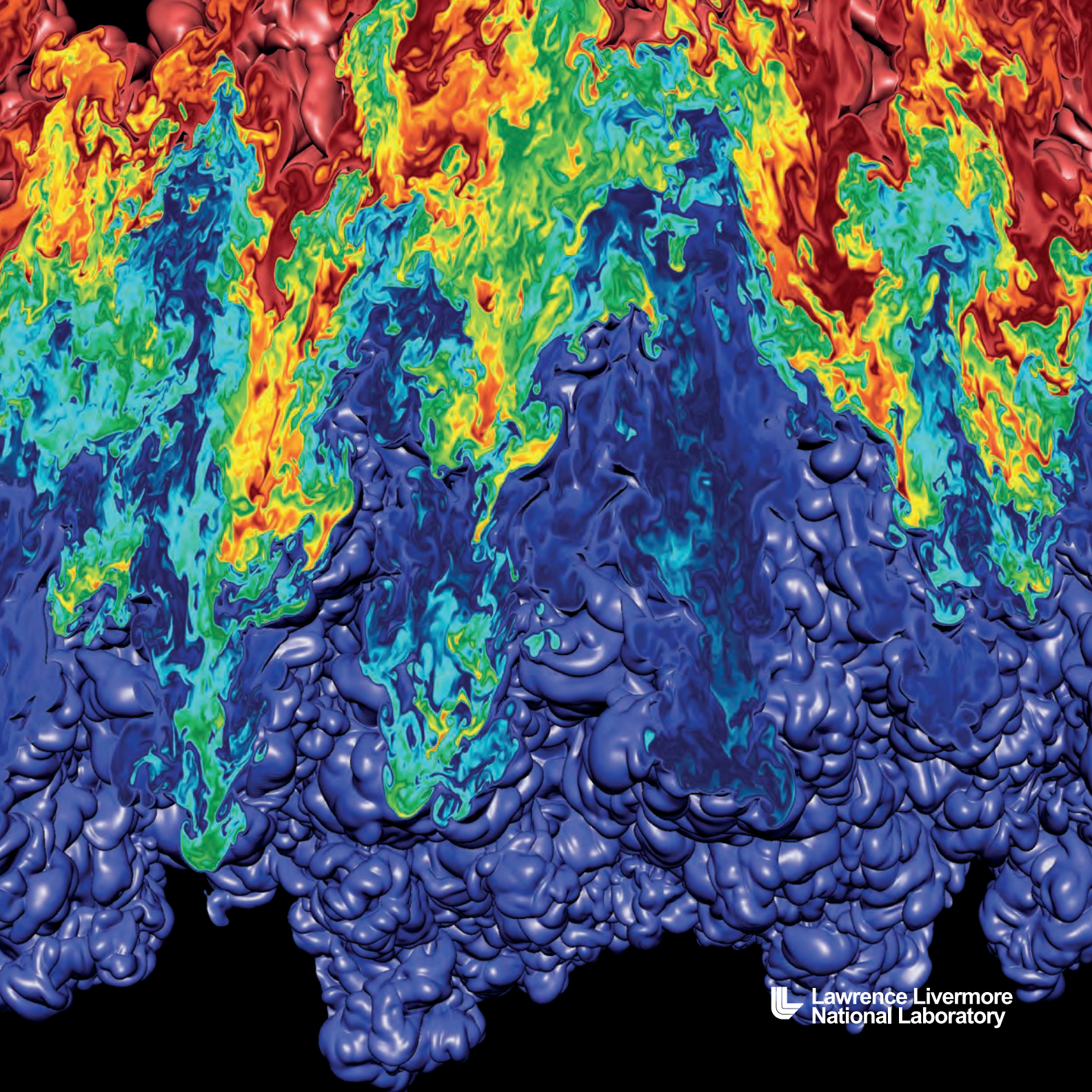
NATIONAL SECURITY. NIF can simulate the conditions that exist inside nuclear weapons, providing a unique experimental platform for assessing the safety and reliability of the nation's nuclear stockpile. These data help to inform and validate state-of-the-art weapons simulation codes and enable a deeper understanding of important weapon physics issues.

ENERGY FOR THE FUTURE. Fusion research at NIF is opening the door to an endless supply of clean energy. Success in achieving fusion ignition and gain will be a historic step toward demonstrating inertial confinement fusion's potential to provide virtually unlimited carbon-free energy.

SCIENTIFIC DISCOVERY. Researchers at NIF are able to study the effects on matter of the extreme temperatures, pressures, and densities that exist naturally only in the stars and deep inside giant planets. Results from this relatively new field of research, known as high-energy-density science, are shedding light on such mysteries as how the universe began and how it works.

“Every great advance in science has issued from a new audacity of imagination.” —John Dewey, philosopher

The National Ignition Facility is making science and engineering breakthroughs as researchers close in on achieving fusion in the laboratory.



HIGH-PERFORMANCE COMPUTING

To maintain American preeminence in the 21st century, there is no more powerful tool than high-performance computing; LLNL will continue to lead.



Sequoia computer

The United States' national and energy security, economic growth, and preeminence among nations depend on its ability to out-innovate and, critically, out-compute its competitors. Renowned for a long history of computing successes, LLNL is installing a 20-petaFLOP/s BlueGene/Q system, called Sequoia, in support of its nuclear security mission. The BlueGene family of supercomputers consists of ultralow-power-consumption machines developed through a multi-decade partnership with IBM.

In addition to Sequoia, the Laboratory is expanding its Multiprogrammatic and Institutional Computing Program with the acquisition of a multi-petaFLOP/s unclassified companion to Sequoia. This system, along with other institutional computers, will serve computing efforts across LLNL as well as the new High-Performance Computing Innovation Center (HPCIC). Through the HPCIC, Laboratory scientists partner with industry and university researchers to apply LLNL's leading-edge computing capabilities to critical industry applications, with the goal of strengthening the country's economic competitiveness in the global marketplace.

"To raise new questions, new possibilities, to regard old problems from a new angle, requires creative imagination and marks real advance in science." —Albert Einstein, physicist

3D simulations provide insights into complex phenomena, such as turbulent thermonuclear burning as occurs in supernovas and nuclear weapons.



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LIVERMORE VALLEY OPEN CAMPUS

The Livermore Valley Open Campus promotes collaboration between world-class scientists at the two Livermore national laboratories and partners in industry and academia.



Ribbon cutting for Livermore Valley Open Campus

LLNL and Sandia-California have created an open, unclassified research and development environment—the Livermore Valley Open Campus (LVOC). Through public-private partnerships with government, industry, and academia, LVOC allows researchers from around the world access to unique facilities and resources as they engage in joint research and development efforts, industrial collaborations, educational programs, and technology incubators to address such pressing challenges as energy security, cyber security, nonproliferation, and economic competitiveness.

The first new facility at LVOC is the High-Performance Computing Innovation Center (HPCIC). This center offers industry and university partners access to a formidable combination of computing resources and technical expertise from LLNL and its HPCIC “ecosystem” in a readily accessible, business-friendly environment.

“My vision is that, several years from now, we’ll be in the midst of a vibrant innovation center, a technology hub with the Lab at its center.” —Parney Albright, LLNL Director

LLNL high-performance computing capabilities are applied to semi-truck aerodynamics to improve fuel efficiency.



COUNTERPROLIFERATION ANALYSIS & PLANNING SYSTEM

CAPS provides real-time answers to the warfighter's questions about facilities related to weapons of mass destruction.



The Counterproliferation Analysis and Planning System (CAPS) provides the U.S. Armed Forces with a critical tool for planning missions against facilities that support the production of weapons of mass destruction (WMD). CAPS analysts provide in-depth assessments of WMD facilities as well as a technical reachback capability for troops engaged in combat.

In 2011 alone, CAPS answered hundreds of technical reachback queries from warfighters in the field, supported the Commands during the Arab Spring uprisings, offered unique insights during natural disasters, and supported numerous operational planning efforts. In 2009, the CAPS team launched EleCent, a web-accessible worldwide database that identifies critical infrastructure and organizations that could be used in a state or non-state WMD program. EleCent can be used alone or with other tools for decision-making.

“All the business of war, and indeed all the business of life, is to endeavor to find out what you don’t know from what you do.”

—Arthur Wellesley, Duke of Wellington

CAPS provides military planners and warfighters in the field with in-depth information about WMD-related facilities.



AN “IMPOSSIBLE” PLASTIC NEUTRON DETECTOR

Laboratory researchers developed the first plastic scintillator that can efficiently distinguish neutrons from gamma rays, something long thought to be impossible.



Cargo container inspection

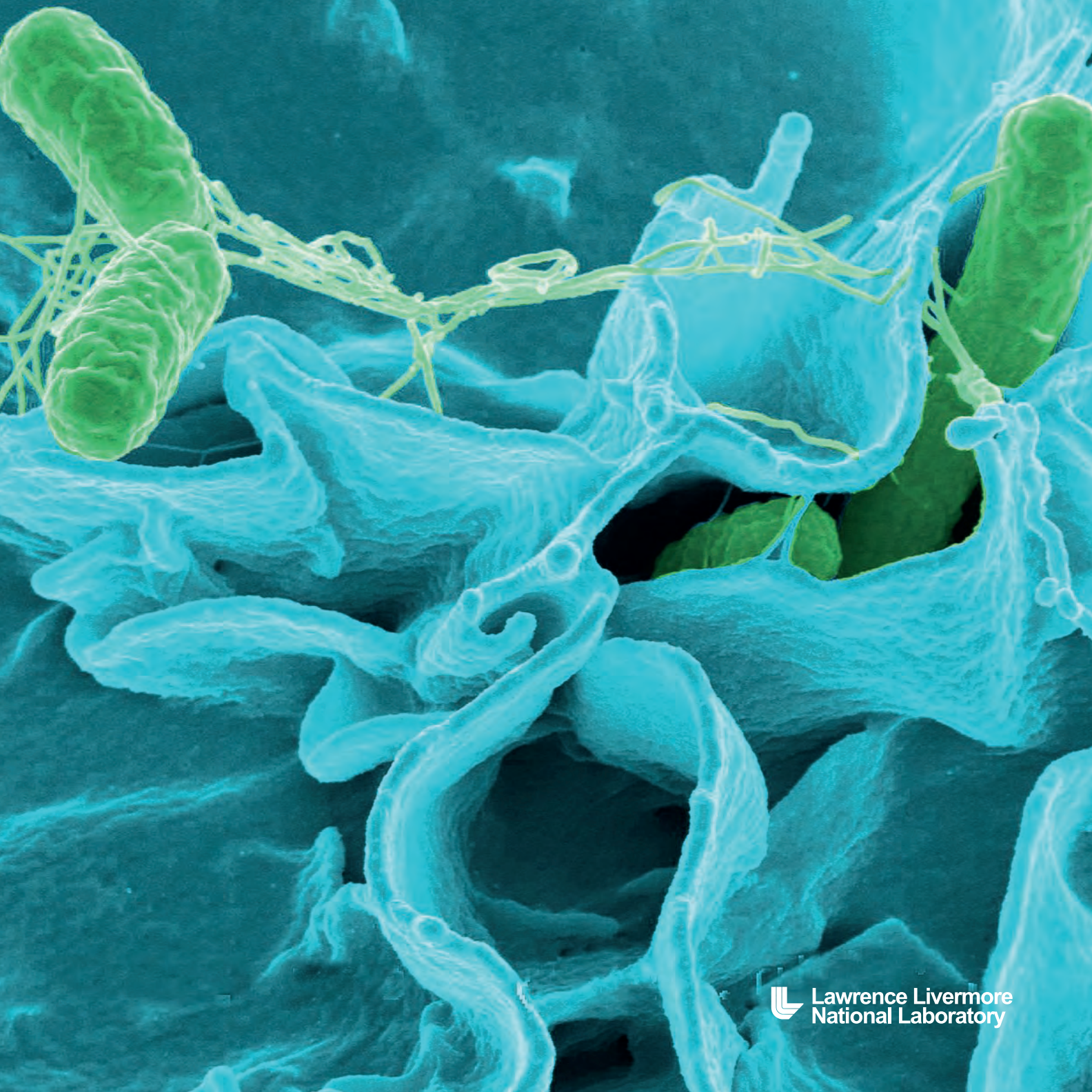
Plastic scintillators have been used for decades to detect radiation, but they could not distinguish neutron radiation from gamma rays. The ability to distinguish neutrons is essential for identifying specific radioisotopes and particularly for differentiating uranium and plutonium.

LLNL has solved this problem. The new material is rugged and inexpensive. It can be easily fabricated as huge plastic sheets that provide dramatically larger surface areas than other neutron detectors. The material is ideally suited for use as large-scale detectors for the protection of ports, stadiums, and other public facilities.

“I have learned to use the word ‘impossible’ with the greatest caution.”

—Wernher von Braun, rocket scientist

A new plastic scintillator developed by LLNL makes it possible to cost-effectively fabricate large neutron detectors.



FAST DETECTION OF PATHOGENS

New rapid-detection technologies developed by LLNL are enhancing U.S. biosecurity and public health.



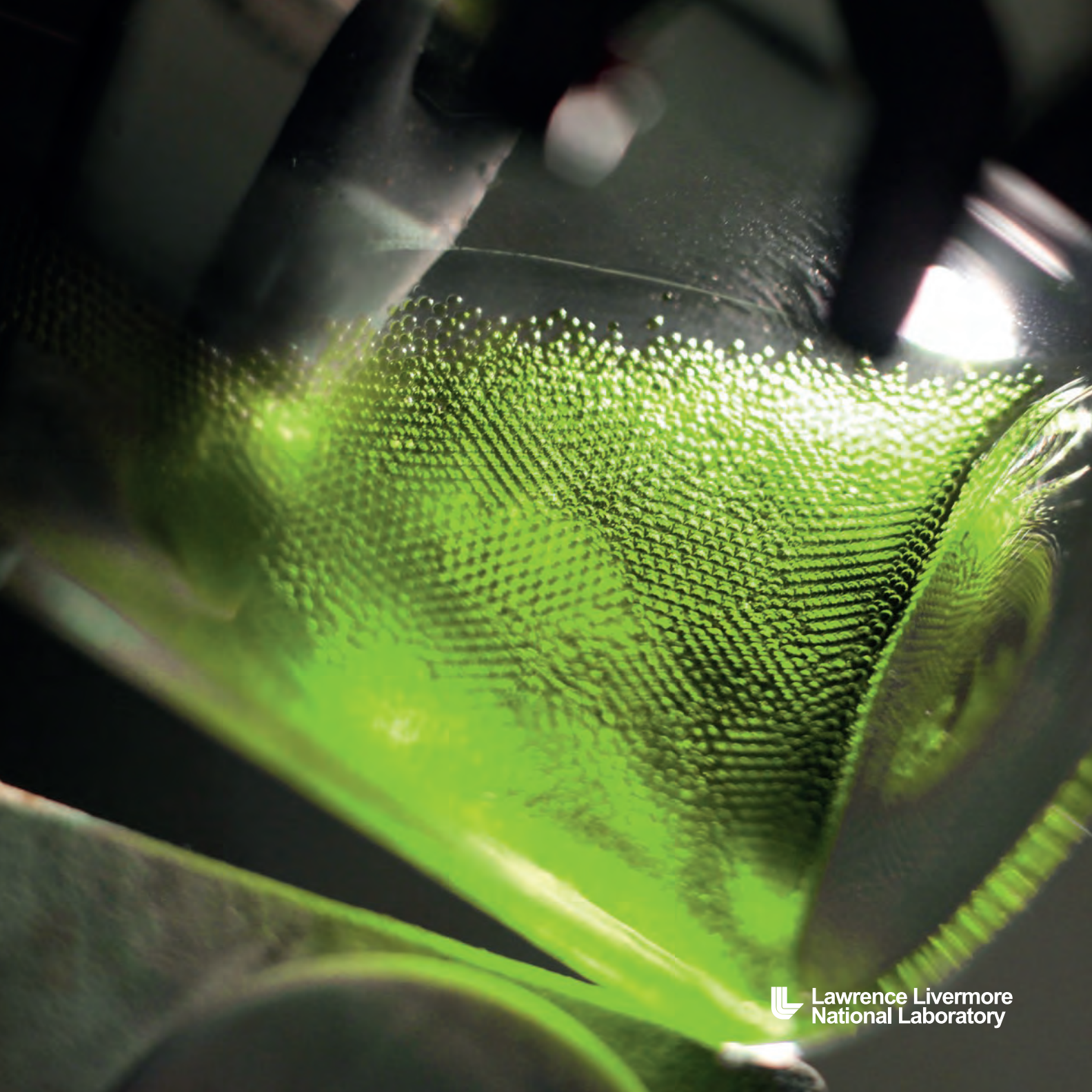
SUB-3-MINUTE PCR. LLNL engineers developed the fastest-known polymerase chain reaction (PCR) device, capable of billion-fold amplification of DNA in less than 3 minutes. With this advance, it may soon be possible to identify infectious diseases in the space of a doctor's office visit. The device would also be very useful in the meat, agricultural, and processed food industries for ensuring food safety.

LAWRENCE LIVERMORE MICROBIAL DETECTION ARRAY (LLMDA). This device can identify within 24 hours more than 2,200 viruses and over 900 bacteria—essentially every virus and bacteria whose genome has been sequenced—and can even identify similarities of unknown pathogens with known organisms. LLMDA has been licensed to several companies and is currently being used by the Defense Department to screen battlefield wounds for infection.

“The greatest remaining source of danger to U.S. national security in the 21st century—and to mankind as a whole—is disease.”

—Richard Falkenrath, senior fellow, Brookings Institute

Livermore is a leader in the field of biosecurity, developing instruments, assays, and techniques for the rapid detection of pathogens.



MIMICKING NATURE TO CAPTURE CO₂

Using computational biology and synthetic chemistry, LLNL scientists are designing a catalyst that can extract CO₂ from power-plant emissions.

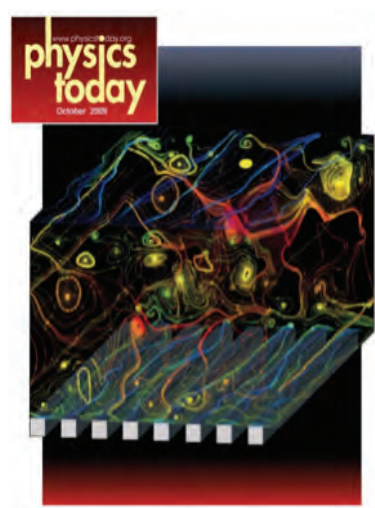
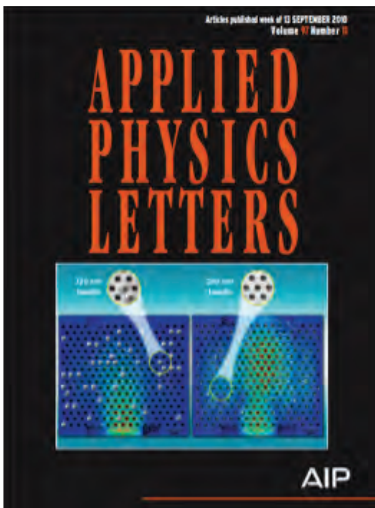
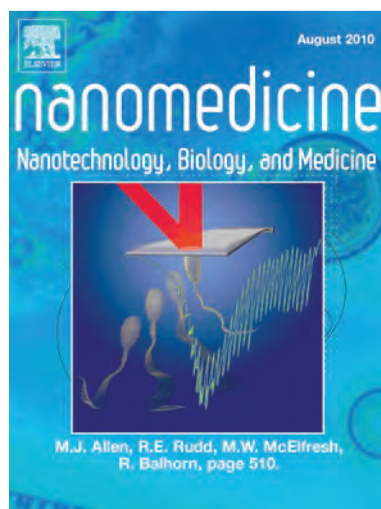
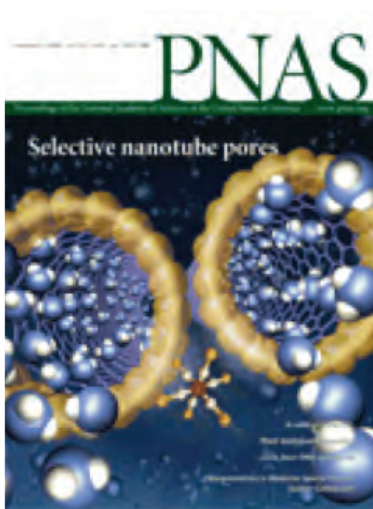
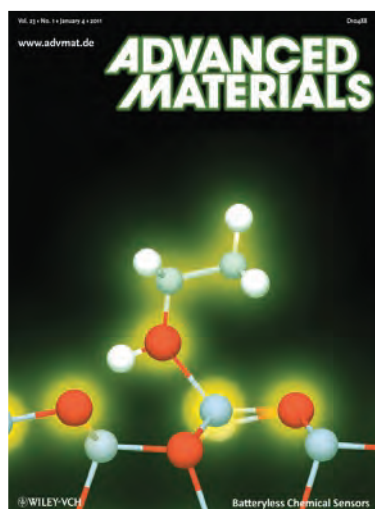
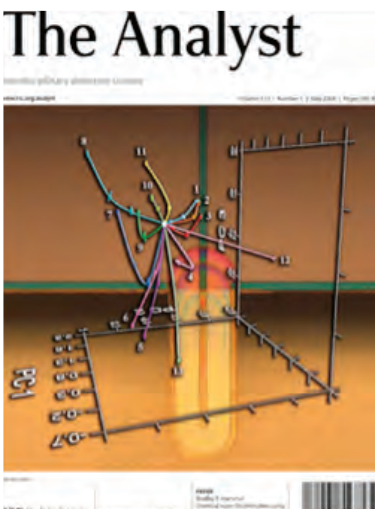
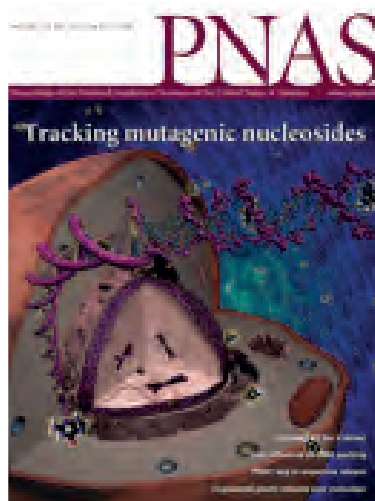


One concept for mitigating global warming is to extract carbon dioxide (CO₂) from the atmosphere and store it deep underground. Scientists are using nature as a guide for the first step in this process. Specifically, the human respiratory enzyme, carbonic anhydrase, is incredibly effective at capturing CO₂ from tissues and blood and transporting it to the lungs where it is exhaled.

A Laboratory-industry-university partnership is developing synthetic catalysts that mimic this natural enzyme for use in capturing CO₂ from power-plant emissions. Using LLNL's computational biology and synthetic chemistry expertise, the team is able to synthesize and test up to 20 candidate catalysts a year. Based on results obtained to date, the final selected catalyst is expected to capture CO₂ a thousand times more effectively than current chemical scrubbing processes.

“Our responsibility is to do what we can, learn what we can, improve the solutions, and pass them on.” —Richard Feynman, physicist

A new approach to reducing factory CO₂ emissions uses a special carbon-capture catalyst contained in tiny silicone shells that measure about half a millimeter in diameter.



WIDE SCIENTIFIC IMPACT

Laboratory researchers play a significant role in the broad scientific community and in the education of the next generation of scientists.



SCIENTIFIC PUBLISHING. Laboratory research is published in the peer-reviewed scientific literature (often as cover articles), presented at international conferences, and highlighted at technical workshops. It also is featured regularly in national and local print media and on television and radio. Such communication helps to advance multiple scientific fields and educate the public about the Laboratory's work.

AWARDS FOR EXCELLENCE. LLNL scientists receive high recognition for their work, including since 2007 a National Medal of Science, two Edward Teller Medals, two E.O. Lawrence Awards, a membership in the National Academy of Sciences, a Presidential Early Career Award for Scientists and Engineers, numerous fellows of professional societies, and a score of R&D 100 Awards.

TECHNOLOGY COMMERCIALIZATION. Laboratory technologies find success in the commercial sector. For example, four companies based on LLNL technologies have a market capitalization of \$8.4 billion. In 2011, more than \$350 million in goods and services based on LLNL intellectual property were sold. Several new programs have been initiated to facilitate the transfer of LLNL technologies to the marketplace.

SCIENCE EDUCATION. LLNL's science outreach activities are immensely popular. In 2011 alone, the Laboratory hosted 1,300 Discovery Center visitors, 1,860 Fun with Science students, and 7,500 Super Science Field Trip participants. In addition, nearly 5,000 students and parents attended the annual Science on Saturday lecture series, more than 400 students participated in the Laboratory-sponsored Tri-Valley Science and Engineering Fair, and more than 650 students and faculty took part in research opportunities at LLNL.

“Leadership and learning are indispensable to each other.”

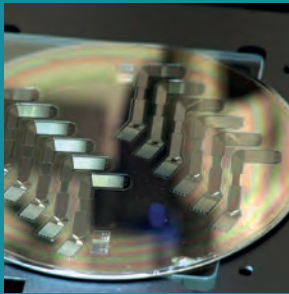
—John F. Kennedy, U.S. President

Laboratory research is frequently featured on the covers of prestigious scientific journals.



SCIENCE FOR BETTER LIVING

Many Laboratory technologies developed for its national security mission find widespread use addressing important health care issues.



Wafer with artificial retina electrode arrays

SOLUTION TO ANTIBIOTIC RESISTANCE. Laboratory biologists have discovered a way to turn a bacterium's genes against itself, isolating the genes that code for proteins essential for cell division. When applied to a bacterial culture, these proteins destroy the cell walls, killing the bacteria. Because bacteria need these proteins for reproduction, they cannot become resistant to them.

IMPROVED CANCER THERAPY. Proton therapy has many advantages over other forms of radiation therapy, and a new compact accelerator design invented by LLNL has made it possible to shrink the size and reduce the cost of proton therapy machines. The technology has been transferred to an industry partner for commercialization.

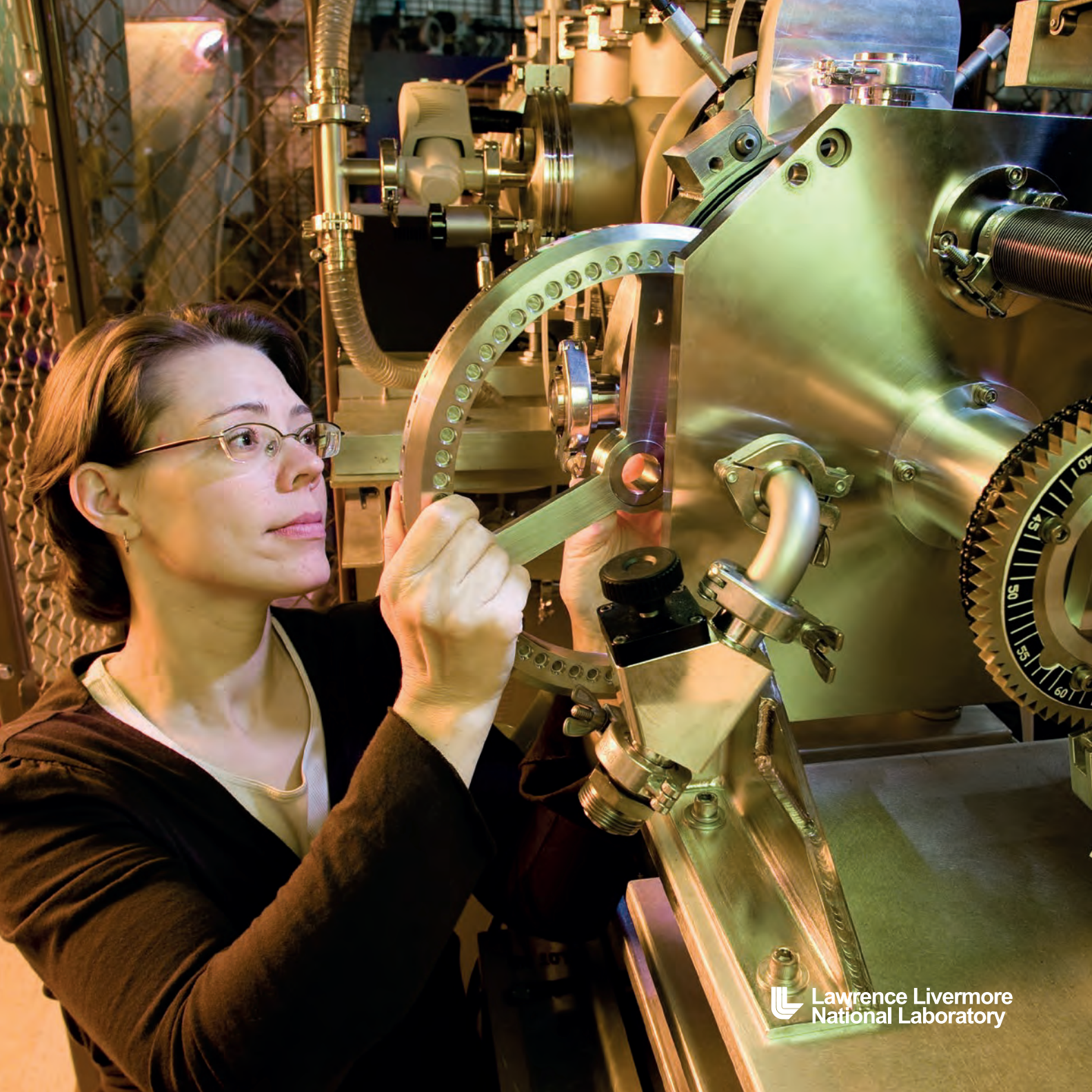
SIGHT FOR THE BLIND. LLNL is part of a major research team that has created a retinal prosthesis—an artificial retina—that can restore vision to people blinded by degenerative eye diseases. Clinical trials are under way even as researchers develop next-generation models with enough resolution to read large type and recognize faces.

SAVING LIVES. Devices based on LLNL's ultra-wideband technology are saving lives. A vital signs monitor can detect the breathing of living individuals trapped amidst piles of debris, and two noninvasive detectors allow first responders invaluable tools to quickly detect life-threatening pneumothorax (air trapped in the chest cavity) or intracranial hematoma (bleeding in the brain).

“Technology shapes society, and society shapes technology.”

—Robert W. White, environmental scientist

LLNL technologies, such as this retinal prosthesis are improving human health and saving lives.



ONE-OF-A-KIND RESEARCH FACILITIES

Together with its world-class computing resources and specialized centers of excellence, LLNL's research facilities enable breakthroughs in science and technology. Among the Laboratory's more unusual facilities are the following.

THE CENTER FOR ACCELERATOR MASS SPECTROMETRY (CAMS) is the most versatile and productive accelerator mass spectrometry facility in the world. It is used for research ranging from nuclear forensics to paleo-climatology to drug metabolism.

THE NATIONAL ATMOSPHERIC RELEASE AND ADVISORY CENTER (NARAC) is a national resource for predicting the spread of hazardous materials released into the atmosphere. NARAC can provide plume predictions within minutes of a release for emergency managers to use in responding to the incident.

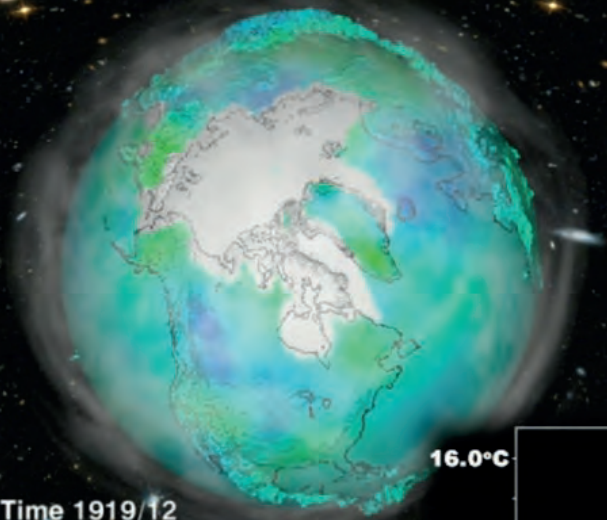
THE HIGH EXPLOSIVES APPLICATION FACILITY (HEAF) is a state-of-the-art facility for research, development, and testing of energetic and explosive materials. Larger quantities of explosive materials can be tested at the Contained Firing Facility (CFF), located at LLNL's remote Site 300.

THE FORENSIC SCIENCE CENTER (FSC) has unmatched capabilities for chemical analysis and forensic characterization of unknown samples for law enforcement, homeland security, counterterrorism, intelligence, environmental, and public health applications. It is one of only two laboratories in the United States to be internationally certified to identify chemical-warfare agents under the Chemical Weapons Convention.

"An experiment is a question which science poses to nature, and a measurement is the recording of nature's answer." —Max Planck, physicist

LLNL is home to an array of unique facilities, including the Center for Accelerator Mass Spectrometry.

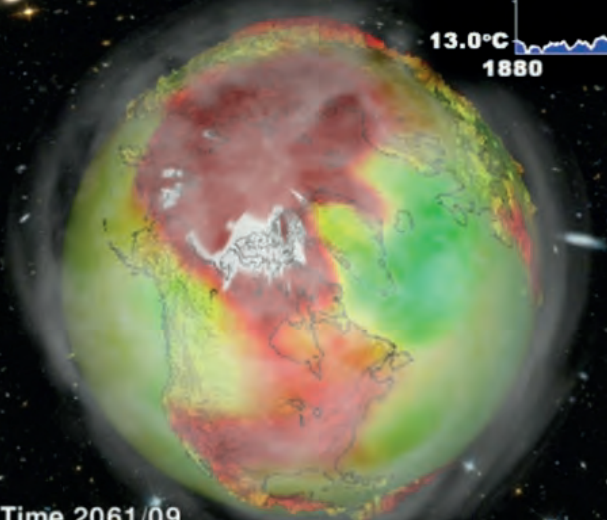
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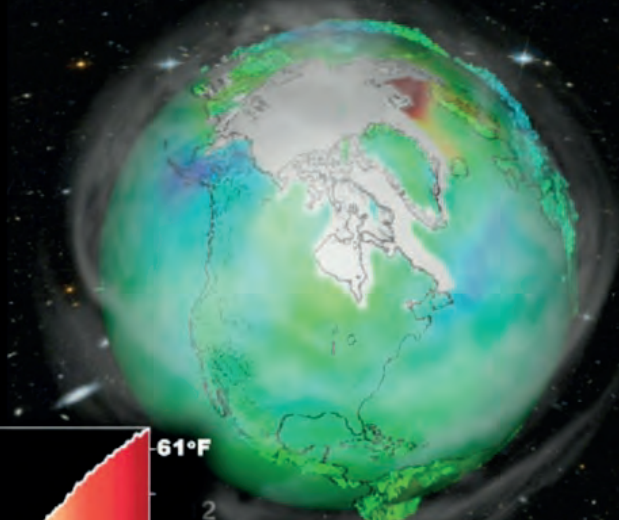
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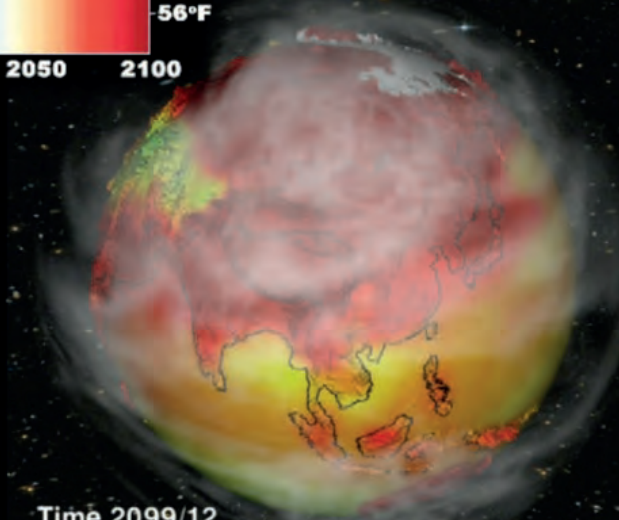
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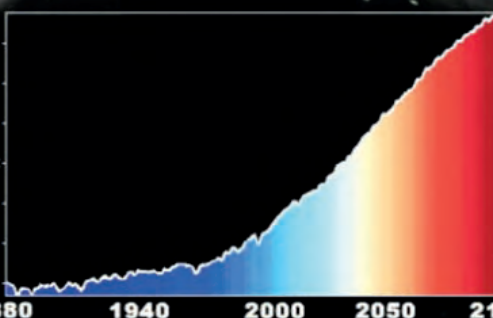
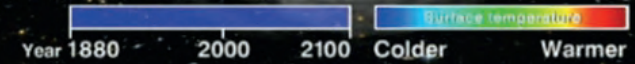
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UNDERSTANDING GLOBAL CLIMATE

LLNL is an international leader in the field of climate change science and a key contributor to the Intergovernmental Panel on Climate Change.

Leading-edge capabilities in atmospheric science, climate modeling, and accelerator mass spectrometry enable Laboratory researchers to advance the scientific understanding of climate change and the impact of human activities.

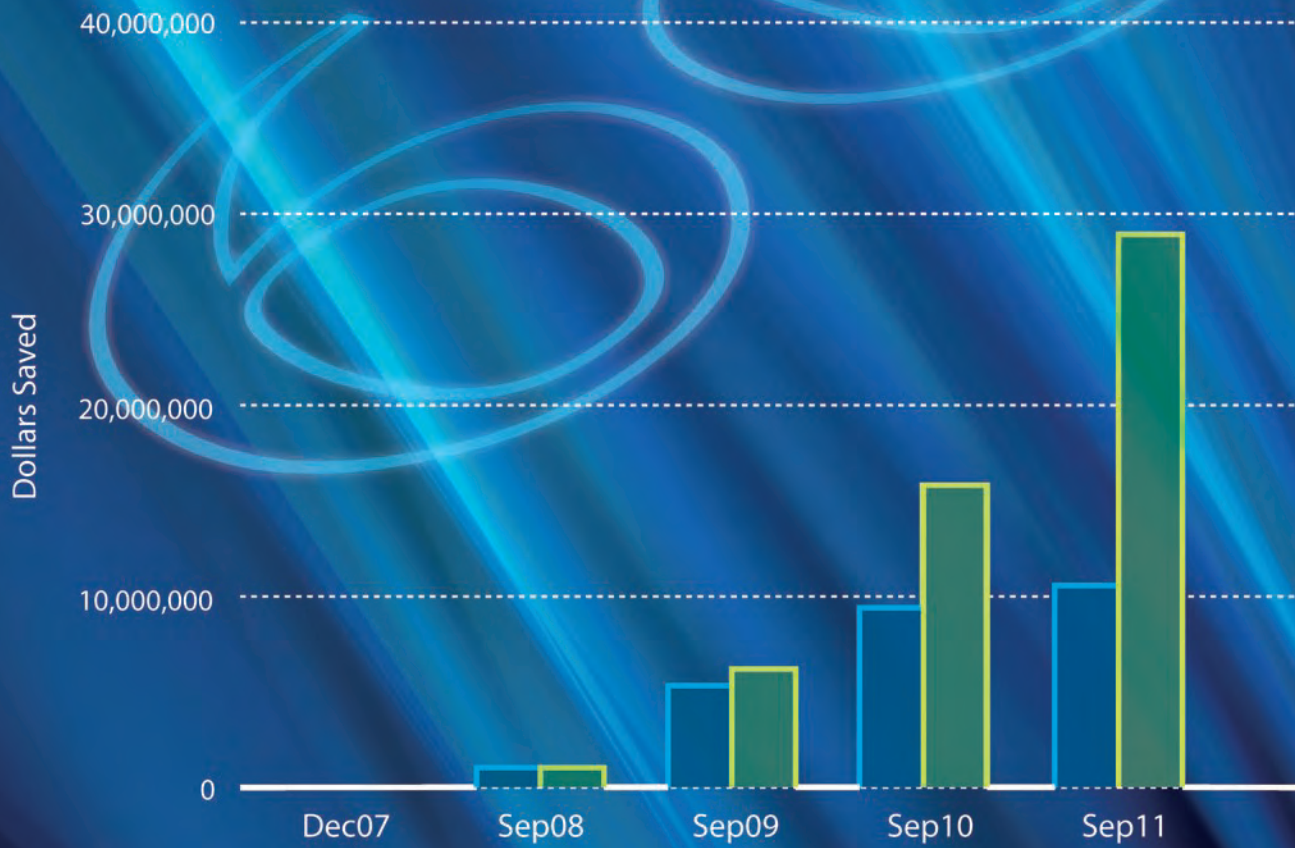
CLIMATE CHANGE MODELING. Laboratory researchers use output from state-of-the-art climate simulation models to address key science questions, such as the relative importance of human and natural influences on climate. They are leaders in studying the role of clouds, aerosols, and feedback mechanisms in climate change.

CARBON CYCLE AND EARTH SYSTEM MODELS. LLNL scientists are developing Earth System Models that can simulate the atmospheric, oceanic, and terrestrial sources and sinks of CO₂ and source-sink transport (the carbon cycle). Carbon-14 analyses of ice core, lake sediment, and other field samples, performed at CAMS and elsewhere, are essential for validating these simulations.

CLIMATE MODEL INTERCOMPARISON. LLNL hosts DOE's Program for Climate Model Diagnosis and Intercomparison (PCMDI), which develops improved methods and tools for evaluating and comparing global climate models constructed by research institutions around the world. LLNL also leads the international Earth System Grid Federation, which stores and distributes terascale datasets from multiple coupled ocean-atmosphere global climate model simulations. Extensive analysis of these simulations by the global climate community will provide an important scientific basis for the Intergovernmental Panel on Climate Change's Fifth Assessment Report on Climate Change (to be published in 2013).

“When one tugs at a single thing in nature, he finds it attached to the rest of the world.” —John Muir, naturalist

Modeling and simulation using state-of-the-art computer codes are helping scientists understand the myriad factors that influence global climate.

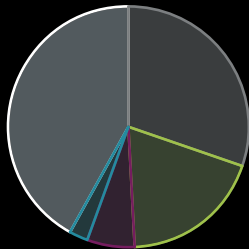


Benefits to LLNL

CONTINUAL IMPROVEMENT OF WORK PROCESSES

Excellence in operations and business practices is achieved through the use of such tools as Lean and Six Sigma as well as performance-based leadership and benchmarks with other laboratories and private industry.

Procurement by
Socioeconomic Category



Total value of procurements \$573,163,579



CONTINUOUS IMPROVEMENT THROUGH LEAN AND SIX SIGMA. Lean and Six Sigma process improvement teams have markedly improved the efficiency and effectiveness of Laboratory work processes. Since 2007, LLNL has conducted more than 50 process improvement projects on such topics as procurement, property management, financial processes, information technology, and NIF target fabrication, which have yielded a cumulative cost benefit of more than \$29 million. Additional savings will accrue from the 15 Lean and Six Sigma projects that are under way.

COST-EFFECTIVE PROCUREMENTS. The Laboratory has cut the cost of procuring services and supplies through the adoption of leading-edge acquisition strategies, including eProcurement tools and strategic sourcing methodologies. Since 2007, these strategies have saved roughly \$55 million. LLNL is committed to supplier diversity. In 2011 alone, the Laboratory awarded more than \$573 million in procurements to a diverse group of businesses in California and across the nation, including more than \$333 million in procurements to small businesses.

“Excellence is doing ordinary things extraordinarily well.”

—John W. Gardner, founder of Common Cause

Lean and Six Sigma process improvement projects are yielding significant efficiencies and cost savings.



ENVIRONMENTAL SUSTAINABILITY

The Laboratory is committed to environmental sustainability and has active efforts in water and energy conservation, recycling, and greenhouse gas reduction.



Great horned owls regularly nest at NIF

LEED CERTIFICATION. Since 2007, five LLNL facilities have achieved Leadership in Energy and Environmental Design (LEED) certification from the U.S. Green Building Council, recognizing the buildings' superior performance in sustainable site development, water savings, energy efficiency, waste management, sustainable purchasing, and indoor environmental quality.

REUSE AND RECYCLING. Through a robust recycling program, the Laboratory annually diverts nearly two-thirds of all routine solid waste generated, preventing nearly 2,500 tons per year of material from going to landfill. Between 2007 and 2011, municipal solid waste sent to the landfill was reduced by 26%. LLNL's waste reduction efforts have been recognized by the California Department of

Resources Recycling and Recovery's Waste Reduction Award Program for four years in a row.

WATER CONSERVATION TESTBED. A new rainwater harvesting system captures runoff from the roof of the Central Café (90,000-210,000 gallons annually), which is then used to irrigate the surrounding landscaping. The project received an NNSA Pollution Prevention award for environmental stewardship in 2010.

SUSTAINABILITY CAMPAIGN. Since 2007, the Laboratory's greenhouse gas emissions have been reduced 9%, saving 21,000 equivalent metric tons of CO₂. Energy consumption has decreased 53 million kilowatt-hours (12.4%) compared to 2003 usage, and water consumption has been reduced 33 million gallons compared to 2007 usage. Alternative fuel vehicles now comprise 75 percent of LLNL's fleet.

"I encourage people to make environmentally conscious choices because we all have to solve this climate crisis." —Al Gore, U.S. Vice President

LLNL's sustainably managed main site and Site 300 support a variety of wildlife.



LIFEPAK 500

If patient is unresponsive, not breathing and has no signs of circulation: Stop

- 1 Turn on Device
- 2 Bare Chest and Apply Electrode Pads
- 3 Follow Prompts

See Rescuer For CPR Instructions

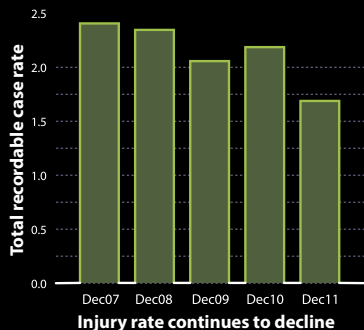
COLLINS O+

PFD Training

Ambu
Res-Cue Mask
First Responder Kit

GOVERNANCE AND OVERSIGHT

LLNL's governance and oversight ensure worker health and safety, environmental management, and security.



The Laboratory's system for managing its operational activities provides clear understanding of performance goals and progress toward milestones, enabling LLNL to keep its employees safe, protect the environment, and ensure security at the Laboratory. This governance system has also formed the basis for a more streamlined oversight partnership with NNSA's Livermore Site Office.

CONTRACTOR ASSURANCE SYSTEM. This system embodies the core processes and tools that enable LLNL to continuously improve performance and ensure that mission objectives and contract requirements are met.

THIRD-PARTY ACCREDITATION. LLNL's worker health and safety management system and its environmental management system have achieved international accreditation (OHSAS 18001 and ISO 14001, respectively).

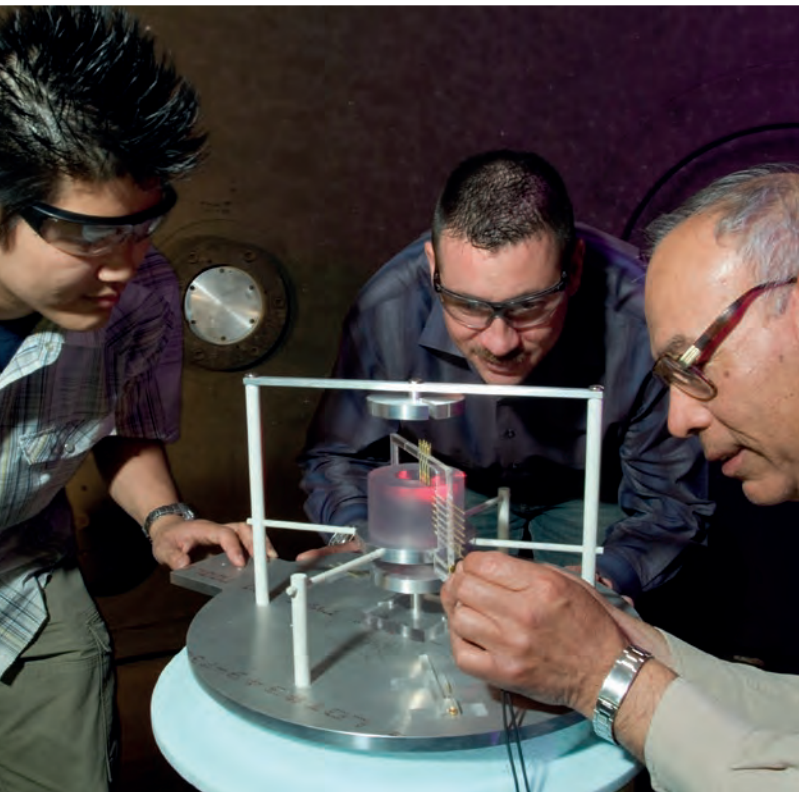
ETHICS OFFICE. LLNL's Ethics Office reinforces the Laboratory's culture of integrity and its commitment to conducting all activities in a manner that is professionally, economically, socially, and environmentally responsible.

SECURITY. Since 2008, a series of initiatives has strengthened physical security, protective force, classified material protection, and cyber security at LLNL.

"The measure of success is not whether you have a tough problem to deal with, but whether it is the same problem you had last year."

—John Foster Dulles, U.S. Secretary of State

A Laboratory employee who suffered a heart attack on site was revived by Protective Security Officers using an automated external defibrillator.



OUTSTANDING WORKFORCE

The Laboratory's critical and challenging national security mission requires a workforce of exceptionally talented and dedicated employees.

ENHANCED RECRUITMENT AND STREAMLINED HIRING. LLNL improved its employment process with an innovative recruitment program and a state-of-the-art applicant tracking system. In addition, an expanded orientation program welcomes and engages new employees from their first day.

VIBRANT POSTDOC PROGRAM. LLNL employed more than 200 exceptionally talented young scientists as postdoctoral employees in 2011. Following their appointments, nearly half of LLNL's postdocs find career positions at the Laboratory, and most others continue to collaborate with the Laboratory as they continue their careers at other academic and research institutions.

CONTINUOUS LEARNING. New leadership development programs have been introduced for future senior-level managers, first-line supervisors, and all employees. These programs augment a diverse portfolio of career and professional development programs, including award-winning online learning resources.

WORK-LIFE BALANCE. LLNL work-life programs include flexible work options, health and fitness activities, and a childcare center. The Laboratory also supports numerous community engagement initiatives, including a \$1 million employer match for employee donations through the annual Helping Others More Effectively (HOME) Campaign; the 2011 campaign surpassed \$3.6 million.

"No individual is alone responsible for a single stepping stone along the path of progress, and where the path is smooth progress is most rapid." —E. O. Lawrence, LLNL co-founder

Laboratory employees are encouraged to maintain a healthy work-life balance.



EFFICIENCIES AND COST SAVINGS

More efficient processes implemented across the Laboratory have yielded significant cost savings.

INFORMATION RESOURCES MANAGEMENT saved \$44 million via a new institutional data center and virtualization, centralized computer desktop services, standardized information technology products, consolidated business applications, and renegotiated site licenses and long distance charges.

FACILITIES AND INFRASTRUCTURE MANAGEMENT achieved an annualized cost savings of \$32 million by consolidating shops and reducing machine tools, centralizing the management of buildings and facilities and reducing the footprint by closure of buildings. A total of \$128 million has been saved over four years.

SUPPLY CHAIN MANAGEMENT saved \$45 million by implementing electronic procurements, utilizing an eSourcing Portal, restructuring the organization by function, renegotiating the food services contract, and reducing the vehicle fleet.

JOINT MANAGEMENT OF PENSION PLANS with Los Alamos National Laboratory enabled a cost avoidance of \$11 million over the past four years.

LEAN AND SIX SIGMA efforts saved or avoided costs of \$29 million through 50 process improvement projects. An additional 15 projects are under way.

BUSINESS EFFICIENCIES saved \$17 million via reduced computer purchases, a new travel system, a virtual warehouse that enables reuse of furniture, consolidation of blanket purchase orders, and elimination of printed payroll stubs.

ENERGY CONSERVATION efforts saved nearly \$7 million in 2010 and 2011.

HUMAN RESOURCES saved \$8 million in 2011 through renegotiation of health and wellness plans.

TOTAL SAVINGS OR COST AVOIDANCE achieved through these and myriad other efforts exceeds \$292 million.

Actions taken over the past four years have streamlined processes, improved efficiency, and yielded significant cost savings.



OFFICE OF STRATEGIC OUTCOMES

LLNL's Office of Strategic Outcomes (OSO) focuses on bringing the same kind of can-do innovation to the broad national security community that the Laboratory has long brought to the nuclear weapons enterprise.

OSO seeks to strengthen national security both within and outside of LLNL's traditional sponsor base, especially in the areas of biosecurity, counterterrorism, defense, energy, intelligence, and nonproliferation.

OSO's program directors, who are selected based on their sustained sponsor relationships and their record of delivering on national security priorities, ensure that LLNL and sponsor goals are aligned and that the Laboratory's portfolio is based on projects that are both strategically important and executable.

Since its creation in 2009, OSO has expanded the Laboratory's international security mission, developed LLNL's national role in cyberdefense and network intelligence research and development, and established long-term strategic partnerships with key industry leaders.

"To win the future, America needs to out-educate, out-innovate, and out-build the rest of the world." —Barack Obama, U.S. President

OSO is enhancing LLNL's mission in the broad national security space.