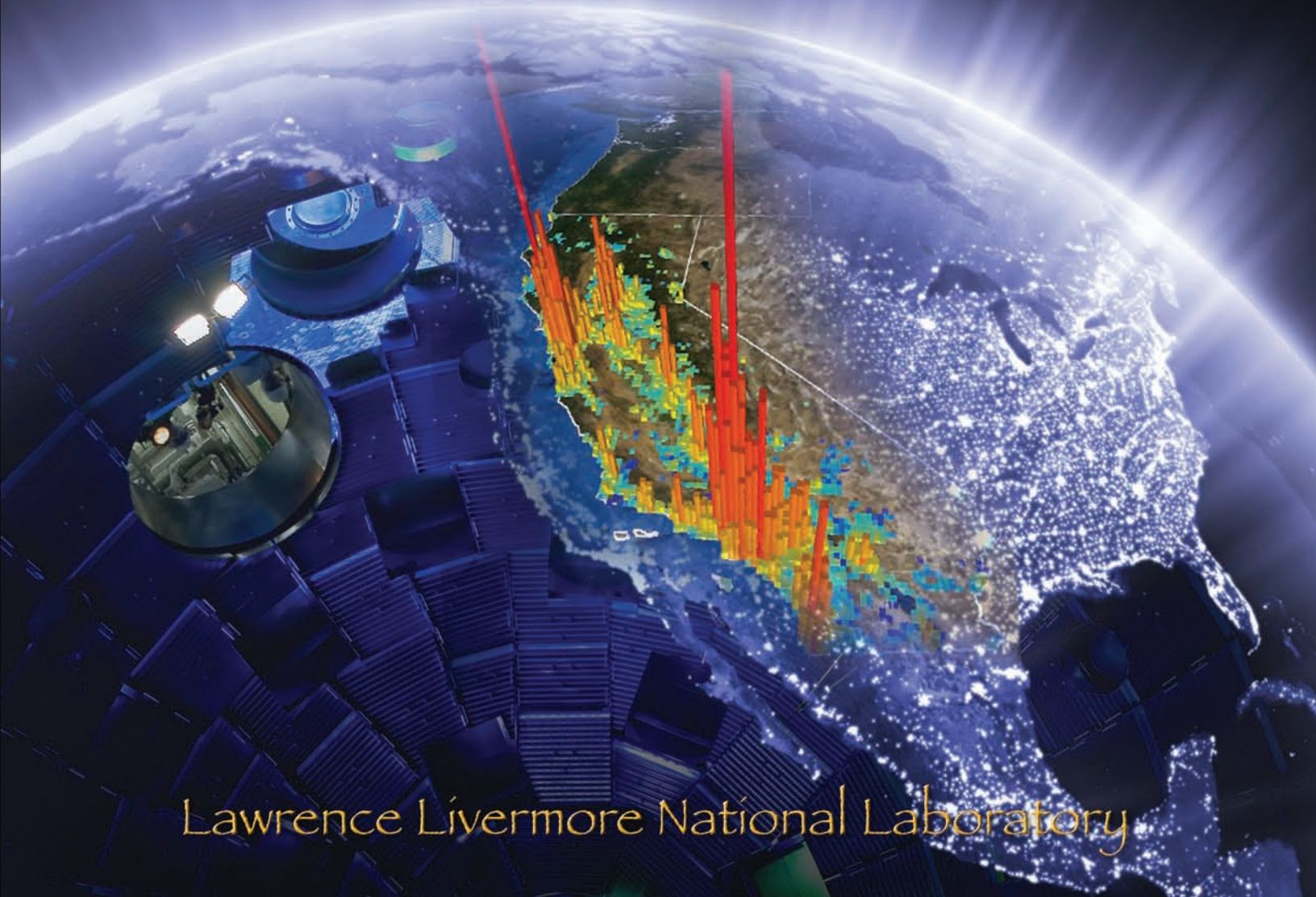
Science That Matters

Discoveries, Innovations & Breakthroughs



Lawrence Livermore National Laboratory

Serving the Nation . . .

Ernest O. Lawrence

Lawrence Livermore National Laboratory was founded in 1952 by Nobel Prize-winning scientist Ernest O. Lawrence and renowned physicist Edward Teller to enhance the security of the United States by advancing nuclear weapons science and technology. Over the years, we have made major breakthroughs in many facets of national security-related research.

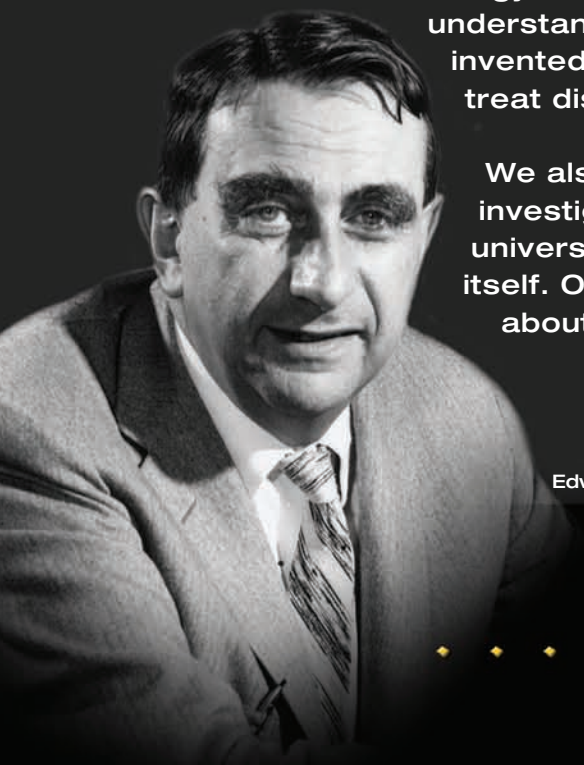
Today, our mission remains national security. We help ensure the safety and reliability of the country's nuclear deterrent. We work to prevent the spread or use of weapons of mass destruction. Our research and technologies strengthen U.S. military forces and homeland security.

The scientific expertise we have developed in our national security work enables our Laboratory to make valuable contributions in many other areas important to the country and the world.

In energy and environment, we are helping protect and preserve the natural world. We have advanced the quest for future sources of energy and elucidated the influence of human activities on global climate.

In biology and health, we are advancing the understanding of the building blocks of life. We have invented medical technologies that detect and treat disease and help people lead healthier lives.

We also push the frontiers of science as we investigate fundamental questions about how the universe evolved and what makes up matter itself. Our discoveries are expanding knowledge about the cosmos and our place in it.



Edward Teller

. . . Benefiting the World

Scientific Discoveries and A

National and Global Security

Star Power on Earth
The National Ignition Facility at LLNL is the largest and most energetic laser system in the world. With its 192 laser beams, NIF can create—for the first time ever in the laboratory—temperatures, pressures and energies that otherwise exist only in stars, giant planets and nuclear explosions. Experiments with NIF help assess the safety and reliability of U.S. nuclear weapons.

Super-Powerful Computers
LLNL is home to 22 supercomputers with a combined peak computing power of 1,689 teraflop/s, or trillion floating point operations per second. A calculation that took an entire day in 1995 now takes only one second!

Sim City
Livermore's JCATS simulation can model military conflicts covering half the globe down to battles inside a building, all the while keeping track of both sides' troops, weapons and equipment and even the soldiers' level of fatigue. The U.S. military and emergency responders use JCATS for planning and training.

Explosives Exposed
Lab scientists invented a credit card-sized detector called E.L.I.T.E.™ that can screen for more than 30 kinds of explosives in just minutes. Requiring no power and with no moving parts, E.L.I.T.E.™ is widely used by military, law enforcement and security personnel.

Light Saber
The Lab's solid-state heat-capacity laser is the most powerful laser of its kind and a possible future battlefield laser weapon. A few seconds' shot from this laser can bore an inch-diameter hole in an inch-thick plate of steel.

Eye in the Sky
Livermore researchers created the first high-resolution, wide-area, real-time video surveillance system. This airborne system can provide continuous imagery of an area the size of a small city with resolution sufficient to track up to 10,000 moving objects in its field of view. It is useful for battlefield surveillance, border monitoring and traffic observation.

Antineutrino Detector
Lab scientists and collaborators demonstrated that detecting antineutrinos—elusive neutral particles produced in nuclear decay—can be used to monitor reactors against the diversion of nuclear fuel. This technology has great potential for international nuclear safeguards and preventing nuclear proliferation.

Energy and Environment

Re-Constructing Seismic History
LLNL scientists built detailed computerized re-creations of the 1906 San Francisco earthquake and simulations of temblors along other local faults that could devastate the region. They use these models to study how the ground moves and how bridges, pipelines, power lines, dams and other structures would hold up in a quake.

Steam Cleaning
Environmental scientists at the Lab invented a technique for cleaning up the toughest underground contamination. Steam and electric current are used to heat the soil and groundwater, breaking down the contaminants and forcing them to the surface. Using this technique, one Superfund site in California was cleaned up 100 years ahead of schedule.

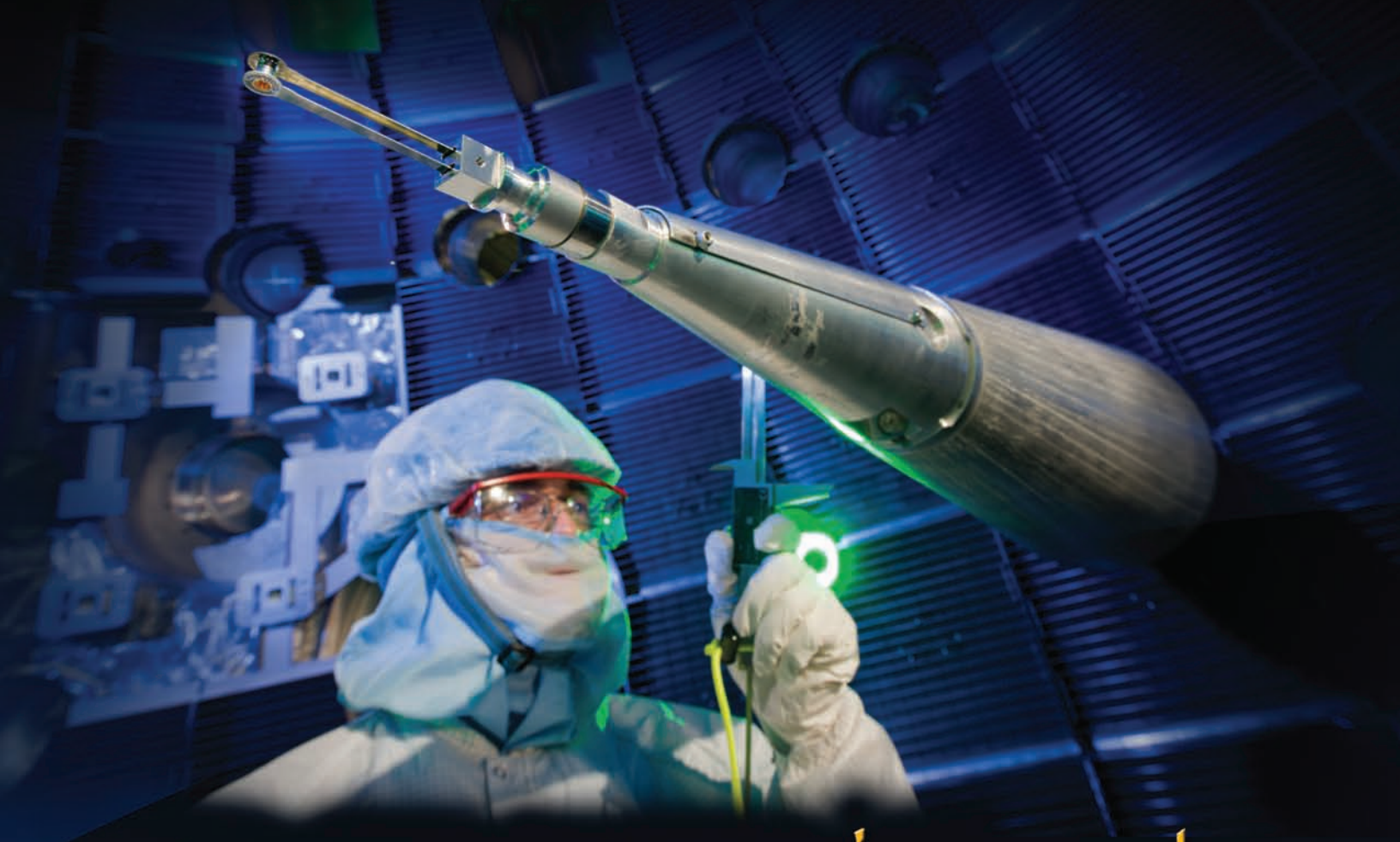
Understanding Climate Change
Livermore's atmospheric scientists have performed some of the world's most detailed and accurate assessments of climate change and its effects. Their work was central to the first international report to declare, in 1995, that "the balance of evidence suggests a discernible human influence on global climate." They also contribute to the work of the International Panel on Climate Change, which was a co-recipient of the 2007 Nobel Peace Prize.

Blowin' in the Wind
Using state-of-the-art computer models, the National Atmospheric Release Advisory Center at LLNL can predict the spread of hazardous materials released into the atmosphere, providing emergency responders with essential information for ensuring public safety. NARAC has tracked, for example, smoke from the Kuwaiti oil field fires, chemical releases from leaking storage tanks following Hurricane Katrina and radioactivity from the earthquake- and tsunami-damaged Fukushima nuclear reactors.

Bringing LIFE to Fusion Power
The fusion of hydrogen atoms to create helium releases enormous amounts of energy with little waste and no greenhouse gas, and thus holds tremendous promise as a future energy source. Livermore scientists developed a concept for a laser inertial fusion energy (LIFE) power plant capable of demonstrating utility-scale electricity production that could be constructed within a decade.

Boosting Fuel Efficiency
Lab computer scientists and engineers used state-of-the-art computer codes to design more efficient internal combustion engines and identify ways to reduce the aerodynamic drag of semi-trucks. Calculations and experiments reveal that widespread use of properly placed drag-reduction devices could increase semi-truck fuel efficiency by as much as 12 percent, for a yearly cost saving of more than $10 billion.

Photo courtesy of Johns Hopkins University



mazing Inventions that Make LL

Biology and Health

Decoding DNA
Livermore, together with its sister lab in Los Alamos, was the first to build human chromosome-specific DNA libraries. This work laid the foundations for the Human Genome Project, the Joint Genome Institute and the entire field of genomics (understanding the genetic makeup of a species).

Color My Chromosomes
LLNL scientists invented a way to rapidly identify abnormal chromosomes so doctors can more easily diagnose genetic diseases and cancer. Called "chromosome painting," the technique colors individual chromosomes within cells, making it possible to rapidly spot those with defects.

Make Mine Rare
Lab research revealed how cooking meat at high temperature, like on a charcoal grill, can increase cancer-causing mutagens in the food. Research also showed that marinating meat before grilling greatly reduces the amount of carcinogens produced.

Rapid PCR
A Livermore breakthrough reduced the time for DNA analysis via polymerase chain reaction (PCR) from days to just minutes, making rapid, automated biodetection a reality. This technology has been widely commercialized and lies at the heart of the industry "gold standard" in biodetection instruments.

Sight for the Blind
Lab engineers developed a flexible, biocompatible microelectrode array as part of a national research team that is creating an implantable artificial retina to restore useful vision to people blinded by retinal diseases. Three models have been developed, two of which are in clinical testing.

Beating Super-Bugs
Lab researchers discovered a way to combat antibiotic-resistant bacteria by using the bacteria's own genes to produce a protein that destroys the bacterial cell walls. Because the protein is unique to each bacterial species, it only targets that specific species, leaving other cells unharmed. And because the bacteria need the protein

to divide and reproduce, they cannot develop resistance.

Fundamental Science

It's Elementary
LLNL scientists are part of the international research teams that discovered six new superheavy elements (numbers 113, 114, 115, 116, 117 and 118) in their quest for the "island of stability" that is predicted to exist beyond the outer edge of the periodic table.

Diamonds Light as Air (Almost)
Lab researchers created a new form of diamond—a nanocrystalline diamond aerogel. Aerogels are special materials that have the lowest density, thermal conductivity, refractive index and sound velocity of any bulk solid. Diamond aerogel could be used to improve the optics for something as big as a telescope or as small as the lenses in eyeglasses.

Messages from Mercury
The Lab developed a special gamma-ray spectrometer for the MESSENGER spacecraft that is orbiting the planet Mercury. Data from the LLNL instrument will help determine the elemental and mineral composition of Mercury's surface.

Cosmic Dust
LLNL was part of the NASA Stardust Mission that in 2004 brought back dust from the tail of comet Wild 2. Lab scientists are helping analyze the cosmic particles and unlock their secrets to gain a better understanding of what was happening when the solar system was forming 4.6 billion years ago.

Dark Side of the Moon
The 1994 Clementine space mission used cameras developed at LLNL to map the entire surface of the moon, including the "dark side." Clementine data indicated the surprising presence of frozen water near the moon's south pole. In 2010, NASA's Lunar Crater Observation and Sensing Satellite (LCROSS) confirmed the presence of ancient ice there.

Guiding Light
LLNL pioneered research using a laser-generated "guide star" to help Earth-based telescopes sharpen their focus. Laser guide star systems are in use at the Lick and Palomar Observatories in California and the Keck Observatory in Hawaii.

Needle in a Haystack
Using Livermore's Center for Accelerator Mass Spectrometry (CAMS), scientists can detect a single atom of carbon-14 amidst a quadrillion (10^{15}) other carbon atoms. CAMS analyses of carbon and some two dozen other elements are used in research ranging from archaeology and global climate to the regeneration of heart muscle cells.

Economic Competitiveness

DYNA-mite Design Tool
The DYNA3D structural analysis computer code was developed at Livermore. It is used worldwide, where it is saving companies hundreds of millions of dollars annually in the design of everything from safer airplanes, trains and automobiles to better beverage cans.

The Little Radar that Could
The Lab's micropower impulse radar has been licensed for everything from home security systems to life-saving medical devices. It also was used in search efforts at the World Trade Center after 9/11 and following Hurricane Katrina.

Keeping Up with Moore's Law
Livermore scientists partnered with other labs and industry to develop extreme ultraviolet lithography as a next-generation technology for making computer chips that are much more powerful and have much more memory capacity than those made today.

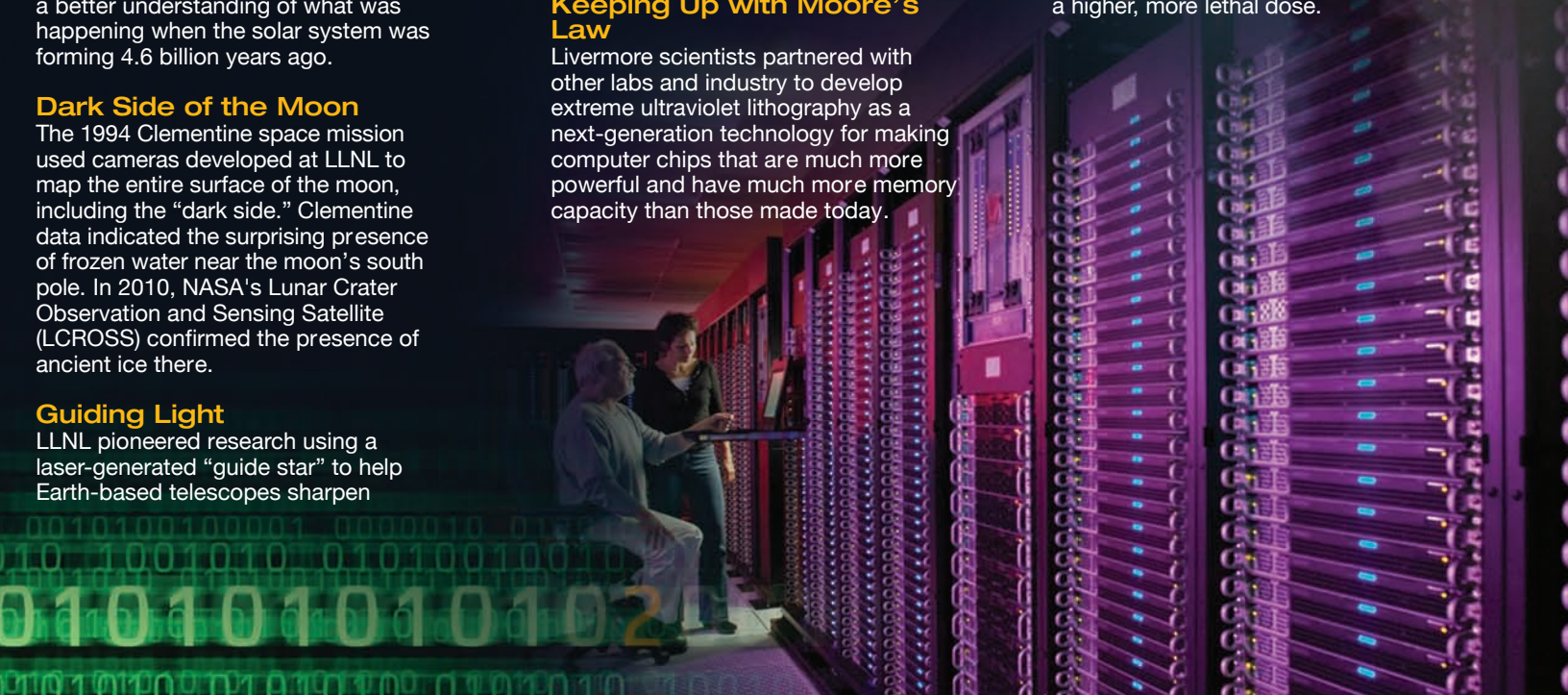
Laser Hammer
Laser peening is a technique developed by LLNL and industry to strengthen metal by bombarding it with laser pulses. It is saving the aircraft industry hundreds of millions of dollars in engine and aircraft maintenance expenses.

Micro Fuel Cells
The Lab developed the technology for a miniaturized fuel cell that uses hydrogen and oxygen to produce electricity. More powerful and lighter weight than batteries, these devices are ideal for military and civilian applications, including powering laptops, communication and surveillance equipment, and electronics in vehicles, aircraft and boats.

Fabulous Filter
Carbon nanotube membranes, with pores 100,000 times smaller than a human hair, can rapidly filter water and separate out salts and contaminants. Water purification and seawater desalination are two of the most promising applications for this Lab-developed material.

Targeting Tumors
A Lab invention is making it possible to greatly reduce the size and cost of proton therapy machines. Unlike conventional radiation therapy, proton beams deposit almost all of their energy in the target tumor, with little radiation to healthy tissue, which allows doctors to hit the cancer with a higher, more lethal dose.

LLNL One Incredible Place...



Knowledge

Determination

Vision

Integrity

Nobel Prize
Presidential Medal of Freedom
MacArthur Fellowship Award
Hans A. Bethe Prize
James Clerk Maxwell Prize
Glenn Seaborg Award
Ernest Orlando Lawrence Awards
Edward Teller Awards
Beatrice Tinsley Prize
Bernard Lewis Gold Medal
George Pake Prize
Helmholtz-Rayleigh Interdisciplinary Silver Medal
Sidney Fernbach Memorial Award

Our People Make the Difference

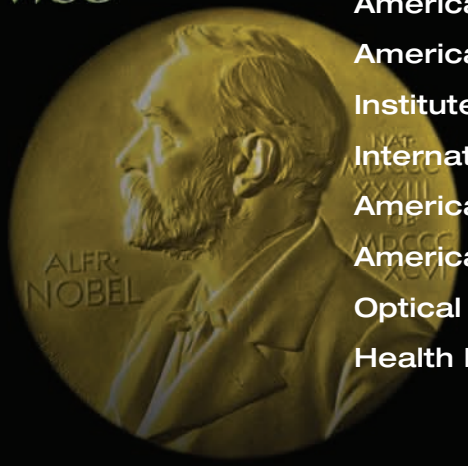
Innovation

Commitment

Achievement

Service

Steven A. Coons Award
Will Allis Prize
R&D 100 Awards
Nanotech 50 Awards
Federal Laboratory Consortium Awards
Fulbright Scholar Awards
Presidential Early Career Awards for Scientists and Engineers
Presidential Awards for Excellence in Science, Mathematics and Engineering Mentoring
Secretary of Defense Outstanding Public Service Awards
American Association for the Advancement of Science Fellows
American Physical Society Fellows
American Chemical Society Fellows
American Nuclear Society Fellows
Institute of Electrical and Electronics Engineers Fellows
International Society for Optical Engineering Fellows
American Society of Mechanical Engineers Fellows
American Geophysical Union Fellows
Optical Society of America Fellows
Health Physics Society Fellows



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