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# BREKTHROUGH

Since 1931, Berkeley Lab, a U.S. Department of Energy laboratory managed by the University of California, has convened teams of scientists to tackle the most urgent challenges of the day. Their work has saved lives, generated jobs, reduced energy costs by billions and sparked the imagination of several generations. That same commitment to new technologies for a changing world continues today.



**BERKELEY LAB**

Bringing Science Solutions to the World

# At Berkeley Lab, we've:

## Discovered 16 elements.

The periodic table would be smaller without Berkeley Lab.

Among the Lab's handiwork is an instrumental role in the discovery of technetium-99, which

has revolutionized the field of medical imaging. Another discovery, americium, is widely used in smoke detectors.

At Astatine (85)	Np Neptunium (93)	Pu Plutonium (94)	Am Americium (95)	Cm Curium (96)	Bk Berkelium (97)
43 Tc Technetium (99)	Cm Curium (96)	Bk Berkelium (97)	Cf Californium (98)	Es Einsteinium (99)	
Rf Rutherfordium (104)	Db Dubnium (105)	Sg Seaborgium (106)			

## Identified good and bad cholesterol.

The battle against heart disease received a boost in the 1960s when Berkeley Lab research unveiled the good and bad sides of cholesterol. Today, diagnostic tests that detect both types of cholesterol save lives.

## Turned windows into energy savers.

Americans save billions of dollars in energy bills each year thanks to a Berkeley Lab-developed window coating that prevents heat from entering in the summer and escaping in the winter. More than half of all windows sold each year have this coating.

## Confirmed the Big Bang, and discovered dark energy.

Lab detectors aboard a NASA satellite revealed the birth of the galaxies in the echoes of the Big Bang. And dark energy—the mysterious something that makes up three-quarters of the universe and causes it to expand at an accelerating rate—was discovered by Berkeley Lab's Supernova Cosmology Project.

## Unmasked a dinosaur killer.

Natural history's greatest whodunit was solved in 1980 when a team of scientists led by Berkeley Lab's Walter Alvarez pinned the dinosaurs' abrupt extinction on an asteroid collision with Earth.



## Explained photosynthesis.

Ever wonder how plants turn sunlight into energy? Berkeley Lab's Melvin Calvin determined the path of carbon through photosynthesis, a scientific milestone that illuminated one of life's most important processes. Today, this work allows scientists to explore how to derive sustainable energy sources from the sun.

## Derailed an ecological danger.

In the 1980s, Lab scientists linked the poisoning of birds at a reservoir in California's San Joaquin Valley to selenium contamination from agricultural runoff. Their work exposed a looming national problem and sparked environmental agencies to take action.

## Exposed the radon risk.

You can sleep easier thanks to Berkeley Lab research that quantified the health risk posed by radon gas in parts of the country. Subsequent EPA standards, coupled with radon detection and mitigation measures pioneered by the Lab, prevent the naturally occurring gas from seeping into basements, saving thousands of lives every year.

## Given fluorescent lights their big break.

Chances are you're reading this using energy-efficient fluorescent lighting, and chances are those lights use electronic ballasts, which control the current flowing through the light. Berkeley Lab developed the ballast in the 1970s with the lighting industry. A 2001 study found that electronic ballasts sold through 2005 would provide \$15 billion in energy savings.

## Pitted cool roofs against global warming.

Berkeley Lab leads the way in analyzing and implementing cool roofing materials, which reflect sunlight, lower surface temperature, and slash cooling costs. Think globally: If all the world's roofs and



pavement used cool materials, the reduction in carbon dioxide emissions would be equivalent to taking the world's 600 million cars off the road for 18 years.

## Built a better battery.

A new family of long-lasting rechargeable batteries was made possible when Berkeley Lab scientists invented a novel class of solid polymer cathodes. Now, Lab scientists are developing long-life, safe batteries for EVs.

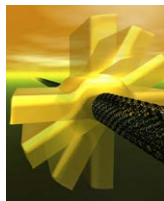
## Preserved the sounds of yesteryear.

Berkeley Lab scientists engineered a high-tech way to digitally reconstruct aging sound recordings that are too fragile to play, such as Edison wax cylinders from the late 1800s. Many of the millions of recordings in the world's sound archives, including those in the U.S. Library of Congress, are benefiting from the technology.



# BERKELEY LAB: Bringing

## Fabricated the smallest machines.



The world's smallest synthetic motor—as well as radios, scales, and switches that are 100,000 times finer than a human hair—were engineered at Berkeley

Lab. These and other ground-breaking forays into nanotechnology could lead to life-saving pharmaceuticals and more powerful computers.

## Redefined the causes of breast cancer.

A new path in cancer treatment research was forged thanks to a revolutionary theory developed at Berkeley Lab that links breast cancer to a breakdown in the microenvironment surrounding breast cells.

## Given buildings an energy makeover.

Berkeley Lab wrote the book, or program rather, when it comes to wringing every penny out of a building's energy use. Software developed at the Lab is used worldwide to audit a structure's energy consumption. If you've set foot in the San Francisco Airport, Willis Tower, or the Nestle Headquarters in Switzerland, you've experienced energy savings thanks to Berkeley Lab.

## Created a pocket-sized DNA sampler.

A tool that identifies the microbes in air, water, and soil samples is fast becoming a workhorse in public health, medical, and environmental cleanup projects. The credit-card-sized PhyloChip is already pinpointing the diseases that kill coral reefs, and cataloging airborne bacteria over U.S. cities.



## Revealed the secrets of the human genome.

Berkeley Lab, no stranger to big science, played a key role in the landmark Human Genome Project. The Walnut Creek-based Joint Genome Institute, managed in part by Berkeley Lab, sequenced human chromosomes 5, 16, and 19, which are regions of the genetic library implicated in diabetes, atherosclerosis, asthma, and other diseases.

## Brought safe drinking water to thousands.



More than half a million people drink clean water, thanks to a fast and cheap purifier developed at Berkeley Lab.

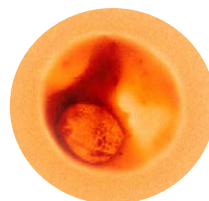
The device, called UV Waterworks, uses ultraviolet light to kill waterborne diseases such as dysentery, which is a major cause of child mortality in the developing world.

## Made appliances pull their weight.

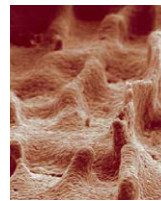
U.S. consumers save \$7 billion each year thanks to Berkeley Lab scientists who helped to develop the federal government's energy-efficiency standards for appliances. And those Energy Star labels you see on appliances? The Lab helped to implement those, too.

## Caught malaria in the act.

A never-before-seen view of the malaria parasite inside a red blood cell was obtained at Berkeley Lab's Advanced Light Source. The images led to a better understanding of how malaria changes red blood cells and may help scientists improve drugs that fight the deadly disease.



## Created the toughest ceramic.



Berkeley Lab scientists mimicked the structure of mollusk shells to create what may well be the toughest ceramic ever produced. The material

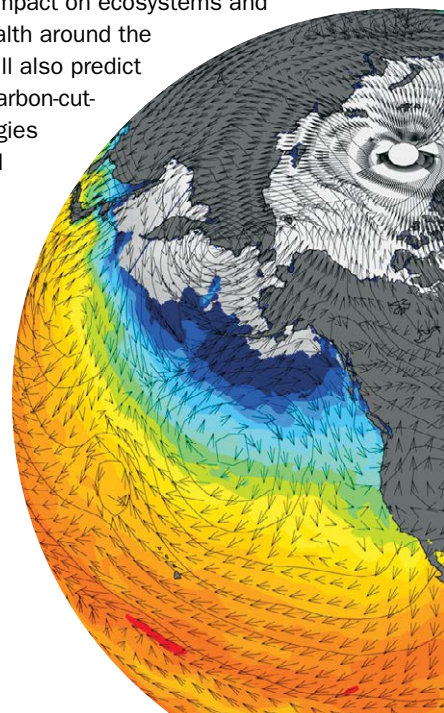
could lead to incredibly strong yet light composites that are perfect for energy and transportation applications.

## Helped bring energy efficiency to China.

Since 1988, Berkeley Lab scientists have worked to make China, the world's second-largest energy consumer after the U.S., as energy efficient as possible. Energy labels and appliance standards, developed with considerable support from Berkeley Lab, will reduce carbon emissions in China by about 9.1 billion tons between 2009 and 2030. The Lab has also helped improve energy efficiency in China's residential and commercial buildings, and in industries such as cement manufacturing.

## Supercharged the climate model.

Climate simulations conducted at Berkeley Lab's National Energy Research Scientific Computing Center helped to make global warming a dinner table conversation. Lab scientists are now developing a more powerful model that forecasts climate change's impact on ecosystems and human health around the world. It will also predict how well carbon-cutting strategies curb global warming.



## Pioneered medical imaging.

In the 1950s, Berkeley Lab's Hal Anger developed a scintillation camera that enabled physicians to detect tumors by imaging gamma rays emitted by radioactive isotopes. The camera that bears his name evolved into modern imaging systems, such as PET, which enable doctors to detect many diseases early enough to save patients' lives.

## Brought the stars closer.



Scientists can glimpse supernovae billions of light years away thanks to revolutionary telescope technology developed at Berkeley Lab in the late 1970s. The segmented mirror design is used at many observatories worldwide, including the giant twin telescopes of the Keck Observatory on the summit of Mauna Kea in Hawaii, which are the most powerful ground-based telescopes in the world.

## Discovered a clock for dating artifacts.

How old is that bone? With a half-life of 5,730 years, carbon-14 is perfect for dating biological materials and organic remains from archaeological sites. The isotope was discovered at Berkeley Lab in 1940, opening the door to a better understanding of our past.

## Built the world's most powerful microscope.

The hidden world of atoms is now exposed thanks to a record-setting electron microscope called TEAM. Unveiled in 2008 at Berkeley Lab, it can produce images with a resolution of half an angstrom, which is less than the diameter of a single hydrogen atom.

## Made a tabletop accelerator.



Think of it as a Ferrari for physics. A Berkeley lab team has ramped up the energy of a laser-plasma "tabletop" accelerator, creating a world record in the process. By shrinking the size of particle accelerators, our researchers are paving the way for next-generation cancer treatments as well as answering fundamental questions of physics.

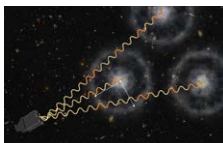
## Squeezed fuel from microbes.

In a milestone that brings advanced biofuels one step closer to your gas tank, a collaboration led by scientists with the Department of Energy's Joint BioEnergy Institute developed a microbe that can produce fuel directly from biomass. The team, which includes Berkeley Lab scientists, engineered a strain of *Escherichia coli* bacteria to secrete biodiesel fuel.

## Mimicked photosynthesis for clean energy.

A potential game-changer in artificial photosynthesis was achieved with a system that can capture carbon dioxide emissions and then, powered by solar energy, convert the carbon dioxide into chemical products such as plastics, pharmaceutical drugs, and even liquid fuels.

## Measured the scale of the universe to an accuracy of one percent.



The Baryon Oscillation Spectroscopic Survey (BOSS) Collaboration measured the scale of the universe to an accuracy of one percent, the most precise such measurement ever made. This and future measures at this precision are the key to determining the nature of dark energy.

## Confirmed that thirdhand smoke causes DNA damage.

Our researchers found for the first time that thirdhand smoke—the noxious residue that clings to surfaces long after the secondhand smoke from a cigarette has cleared out—causes significant genetic damage in human cells.

## Imaged the smallest life forms ever.



Our scientists captured the first detailed microscopy images of ultra-small

bacteria that are believed to be about as small as life can get. About 150 of these bacteria could fit inside an *Escherichia coli* cell and more than 150,000 cells could fit onto the tip of a human hair.

## Caught climate change in the act.

For the first time, our scientists observed an increase in carbon dioxide's greenhouse effect at the Earth's surface. They attributed this upward trend to rising CO<sub>2</sub> levels from fossil fuel emissions. The influence of atmospheric CO<sub>2</sub> on the planet's energy balance is well established, but this effect had not been experimentally confirmed outside the laboratory until now.

## Created a powerful genetic engineering tool.

Our scientists were at the forefront in developing a powerful new genetic engineering tool. Called CRISPR, it enables geneticists to precisely edit the instructions contained in a targeted genome and regulate the expression of the genes that are produced. Already being used to edit microbial genomes, the technique might one day be used to remove cancerous genes.

