Fungus into Fuel

Researchers discover greener, cheaper alternative to gasoline

Quick read
Cleaner, cheaper biofuels are being created with help from a hungry fungus. T. reesei eats fibers and produces a simple sugar, which scientists ferment to produce ethanol.

A spidery fungus with a voracious appetite for canvas could hold the key to production of biofuels, efficiently bringing green energy to the public.

Los Alamos National Laboratory researchers and the U.S. Department of Energy Joint Genome Institute (JGI) announced that the genetic sequence of the fungus Trichoderma reesei has uncovered important clues about how the organism breaks down plant fibers into simple sugars. The finding could unlock possibilities for industrial processes that can more efficiently and cost effectively convert corn, switchgrass, and even cellulose-based municipal waste into ethanol. Ethanol from waste products is a carbon-neutral alternative to gasoline.

The fungus T. reesei rose to dubious fame during World War II when military leaders discovered it was responsible for rapid deterioration of clothing and tents in the South Pacific. T. reesei was later identified as a source of industrial enzymes and a role model for the conversion of cellulose and hemicellulose-plant fibers-into simple sugars.

The organism uses enzymes it creates to break down human-indigestible fibers of plants into the simplest form of sugar, known as a monosaccharide. The fungus then digests the sugars as food.

Researchers decoded the genetic sequence of T. reesei in an attempt to discover why the deep green fungus was so darned good at digesting plant cells. The sequence results were somewhat surprising. Contrary to what one might predict about the gene content of a fungus that can eat holes in tents, T. reesei had fewer genes dedicated to the production of cellulose-eating enzymes than its counterparts.

"We were aware of T. reesei's reputation as producer of massive quantities of degrading enzymes, however we were surprised by how few enzyme types it produces, which suggested to us that its protein secretion system is exceptionally efficient," said Los Alamos bioscientist Diego Martinez (also at the University of New Mexico), the study's lead author.

The researchers believe that T. reesei's genome includes "clusters" of enzyme-producing genes, a strategy that may account for the organism's efficiency at breaking down cellulose. On an industrial scale, T. reesei could be employed to secrete enzymes that can be purified and added into an aqueous mixture of cellulose pulp and other materials to produce sugar. The sugar can then be fermented by yeast to produce ethanol.

"The sequencing of the Trichoderma reesei genome is a major step towards using renewable feedstocks for the production of fuels and chemicals," said Joel Cherry, director of research activities in second-generation biofuels for Novozymes, a collaborating institution in the study. "The information contained in its genome will allow us to better understand how this organism degrades cellulose so efficiently and to understand how it produces the required enzymes so prodigiously. Using this information, it may be possible to improve both of these properties, decreasing the cost of converting cellulosic biomass to fuels and chemicals."

Researchers published a paper about this research in the esteemed journal Nature Biotechnology in May of 2008. Authors included LANL JGI researchers Thomas Brettin, David Bruce, Chris Detter, Cheryl Kuske, Olga Chertkov, Melissa Jackson, Cliff Han,

Monica Misra, Nina Thayer, Ravi Barbote, and Gary Xie. Authors from the JGI-PGF (Production Genomics Facility) in Walnut Creek, California were Jarrod Chapman, Igor Grigoriev, Isaac Ho, Susan Lucas, Nicolas Putnam, Paul Richardson, Daniel Rokhsar, Eddy Rubin, Asaf Salamov and Astrid Terry; and Pacific Northwest National Laboratory's Scott Baker and Jon Magnuson.
Other collaborating institutions include the U.S. Department of Agriculture's Forest Products Laboratory, Oregon State University, University of New Mexico, Vienna University of Technology, Catholic University of Chile, Finland's VTT Technical Research Center, and Universités d'Aix-Marseille I and II.

Pushing Frontiers

In the second half of 2008, Los Alamos National Laboratory made significant advances in its primary mission: safeguarding the U.S. nuclear deterrent and pushing the frontiers of science on multiple fronts.
The national stockpile stewardship program achieved a major milestone in September with the production of the first life-extended W76-1 ballistic missile warhead for Trident submarines. The achievement culminated more than a decade of work by scientists and engineers at Los Alamos and across the nuclear weapons complex-including two crucial experiments conducted by the Laboratory's Hydrodynamic Experiments Division.
Another highlight: Roadrunner reached a new performance record of 1.105 petaflops, keeping it atop the list of the world's fastest supercomputers. Built by IBM for the Lab, Roadrunner was the first computer the crack the petaflop barrier: one thousand TRILLION operations per second. Initial applications will range widely: studying in great detail the evolution of HIV... exploring deeply the formation—as well as deformation—of metallic nanowires...and-toward producing biofuels more efficiently-unraveling the processes by which bacteria break down cellulose.
Safety and environmental stewardship were again a major theme for our work in the latter half of 2008. In November, the last group of unvented high-activity drums left Los Alamos for the Waste Isolation Pilot Plant near Carlsbad. That shipment fulfilled a commitment to the Defense Nuclear Facilities Safety Board to prioritize disposal of the highest-activity transuranic wastes stored at the Lab.
Los Alamos also strengthened security, ensuring that nearly six dozen classified and unclassified computing systems are managed and operated securely. The Lab has now complied with all 14 security actions mandated two years ago by the Department of Energy. And, through our program to recruit cognizant systems engineers, we met the crucial need for sufficient numbers of engineers to keep vital mechanical and electrical safety systems functioning properly in our nuclear facilities.
The latter half of 2008 proved once again why Los Alamos is the nation's premier institution for scientific research. Capping the list of accomplishments was a new technology called MagViz that could eventually provide increased security at major airports. Based on medical MRI technology, MagViz can identify contents of bottles and other containers, distinguishing potentially hazardous liquids from the harmless shampoos and perfumes a traveler might carry onboard a jet. MagViz was demonstrated successfully in December at Albuquerque's airport.
We continued a long tradition of supporting U.S. space exploration. A NASA mission, launched in October to probe the far edge of the solar system from a high Earth orbit, carried a Los Alamos device called the High Energy Neutral Atom Imager. Its goal: to detect atoms emitted from a region where the outermost reaches of our solar system meet the vast interstellar space-giving us a panoramic view of this gateway to the galaxy.
Closer to home, Los Alamos continues to explore solutions to the energy needs of tomorrow. For example, scientists at the Lab hope to use tiny semiconductors called quantum dots to convert sunlight to electricity more efficiently than is possible with current solar panels-and to create new, efficient solid-state lighting.
Equally electrifying, Los Alamos materials scientists are helping unravel the mysteries of superconductivity. During the latter half of the year, LANL researchers identified entirely new mechanisms for superconductivity that could form the basis for new superconducting materials.
Underscoring the wealth of scientific talent at the Lab, Bob Albers, Paul Johnson, and Kurt Sickafus were named Laboratory Fellows in December. These three Fellows represent diverse disciplines, including theoretical physics, energy science, and geophysics.
Los Alamos may be one of the world's great technology incubators, yet we also strive to

help others develop new ideas and products. In January, the Lab selected four young local companies as the newest recipients of awards from the LANS Venture Acceleration Fund. LANS, which manages and operates the Lab, supports the fund through donations from its earnings.
The Lab and LANS also teamed last September with a venture capital firm and a local venture capital fund to spin off technology developed by Lab scientists, with an emphasis on creating companies in Northern New Mexico. The Lab could contribute up to one million dollars to the initiative over the first three years.
We also are pushing to build top-flight research facilities for the future. In July 2008, workers hoisted the final steel beam atop the skeleton of what will be the Radiological Laboratory Utility Office Building, part of the Lab's Chemistry and Metallurgy Research Replacement Project. Once completed, the CMRR nuclear facility will house several of the Lab's mission-critical projects, including analytical chemistry, materials characterization, and actinide research and development capabilities. They'll be relocated from their current location in the historic—yet antiquated—Chemical and Metallurgy Research building at Technical Area 3.
In December, Los Alamos welcomed hundreds of employees who transferred from KSL, the subcontractor whose work the Lab brought in-house. The move was geared to improve efficiency and reduce costs associated with site-support services, including maintenance, waste removal, and custodial work.
Throughout the Lab's history, Los Alamos has helped play a vital role in the surrounding communities, and in 2008, that tradition continued. Lab employees pledged a million dollars, and LANS matched one hundred percent: a record Los Alamos contribution to United Way of TWO MILLION dollars. Contributions from the Lab and LANS also helped fund dozens of nonprofit organizations and scholarship programs, including a LANS donation of $500,000 to a LANL Foundation scholarship named for former long-time New Mexico Senator Pete Domenici.
These accomplishments and many more added up to a strong year. Our customer, the National Nuclear Security Administration, reached the same conclusion in its very favorable assessment of the Lab's performance for fiscal year 2008. It's unmistakable: the extraordinary talent, commitment, and creativity that Los Alamos employees dedicate every day to national security science and the betterment of their communities.

About Our Capabilities, Facilities, and Staff

"Los Alamos National Laboratory plays an indispensable role in building America as a science and technology powerhouse, and our staff are an incredible resource to the nation and the world." Michael Anastasio, Dir.

Solving Complex R&D Problems with Special Blend of Staff, Capabilities and Facilities
Now in its seventh decade, LANL remains among a very few laboratories that can bring great breadth of fundamental and discovery science, technology, and engineering rapidly together to create tangible solutions for national security needs.
Our staff, working with partners throughout science and industry, must be able to deliver today's solutions while maintaining the depth of capabilities to deliver the next generation of discoveries.
Los Alamos has demonstrated a cycle of innovation where we have developed world-leading capabilities and facilities in response to urgent, unique missions. We also spin out new discoveries that lead to emerging missions.
Being able to integrate and apply our capabilities rapidly to new challenges will be a key advantage in an increasingly competitive landscape.

Our Science, Technology and Engineering Priorities
Science that Matters

Information science and technology enabling integrative and predictive science
Experimental science focused on materials for the future
Fundamental forensic science for nuclear, biological, and chemical threats

How We Work

Collaborate, partner and team to make decisive contributions to our sponsors

Outstanding operational excellence for safety, security, and efficient pursuit of ST&E for our missions

Transform Our Scientific Campus

Campus for 2020 (consistent with complex transformation)
Modern science facilities: LANSCE refurbishment, CMR replacement, Science Complex
Signature facilities for experimental science (MaRIE) and computational science (Roadrunner)